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Clinical Evaluation of Wheat Bran Bread for Dietary Management of Diabetics Through Glycemic Index

Kamaliya Keshav B.*, Rema Subhash**

Abstract

The incidence of Diabetic Mellitus (DM) is increasing at an alarming rate especially in developing countries like India. Bakery products are highly popular and lend themselves easily for modification into therapeutic products. Therefore, the present study was planned to develop high fiber (wheat bran) bread and testing it for possible use in the dietary management. Wheat bran bread (WBB) was developed in the laboratorythrough various trials. Bread prepared with maximum 7.5 % replacement found acceptable sensorily and used for further study. A total of 25 subjects (20 type II diabetics and 5 non diabetics) of average age 53 years were fed white bread (WB) and WBB (approximately 5 slices, weighing 97.84 g for WB and 104.40 g for WBB, providing 50 g carbohydrate) on 2 different days. Blood glucose levels were determined at fasting, 60, 120 and 180 min. The glucose increments were estimated by area under the curve (AUC) and expressed as GI. The GI for non-diabetics was found to be significantly lower (69.16 $\pm$ 1.75) when compared to diabetics (77.04 $\pm$ 3.84). Similar trend was observed in females (75.05 $\pm$ 9.50) when compared to males (77.70 $\pm$ 4.24) within the diabetic group. The average GL calculated for the WBB was found to be 38.20 g for diabetics and 40.97g for non diabetics. It may be concluded that the bread prepared by supplementing 7.5% wheat bran is acceptable and could be useful in the dietary management of diabetics as well as healthy subjects.

Keyword: Glycemic Index; Glycemic Load; Diabetes; Health Food; Bakery Products; Bread; Wheat Bran; High Fiber Food; Sensory Evaluation; Blood Glucose.

Introduction

WHO reports that there are over 175 million "people with diabetes" in the world and the number is expected to increase to well over 350 million people by the year 2025 (Bailey, 2004). In India, the figure will be 57 million. At present the cases of cardiac heart diseases are nearly 15 million in our country (Bamji 2003). Anderson and Akanji (1993) examined the results of 53 studies and concluded that fiber supplements and high fiber diets improve glycemic control, increase sensitivity to insulin, lower serum lipids, decrease blood pressure and assist in weight management. Changes in the socio-economic conditions have increased the domestic demand and consumption of bakery products. The industry is presently growing at about 10 % p.a. in our country. Normally bakery products are calorie dense and bearing negligible fiber and therefore, continuous consumption of these may lead to major chronic diseases like obesity, hypercholestremia, diabetes mellitus and hypertension etc. (Kamaliya, 2005). Increasing health consciousness and easy modification of bakery products has led to their development as therapeutic products suitable to individual needs. Matz (1996) has suggested the use of bran to increase the fiber content in bakery products. The idea of classifying carbohydrates according to their effect on blood glucose concentrations, i.e. glycemic index(GI), was first proposed in 1980 (Wolver et al. 1991). This concept was developed to predict postprandial increases in blood glucose concentration in patients (Bell and Sears 2003).The glycemic load (GL) represents the qual-ity of the carbohydrate containing food (i.e. GI) and the quantity con-sumed of that food (weight). As a result,

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the GL is a better predictor of the impact of a carbohydrate containing food on postpran-dial insulin secretion (Bell and Sears 2003). The present study was planned for testing high fiber bread prepared using wheat bran for its possible use in the dietary management of diabetics by estimating GI and GL.

Materials and Methods

Product Development

Wheat bran bread was developed in the laboratory. For that, various trials of bread preparation were carried out by replacing white flour with wheat bran from 3 to 15 % and evaluated using a 9 point hedonic scale (8 judges X 3 replications) followed by a composite scoring test for the bread prepared by replacing 7.5%, 9% and 10% white flour with wheat bran (by a panel of experts – 8 judges X 3 replications) on the day of preparation and after 24 hrs. White bread was prepared using the commercial formula (i.e. 0 % wheat bran) (Kamaliya and Kamaliya, 2001).The bread prepared using 7.5% replacement of WB, ranked highest in all the sensory characteristics for both the days thus it was considered as the WBB for subsequent study. The WBB contains about four and half times more fiber as compared to WB. To assess the real effect of WBB on GI, feeding trials of both the breads were carried out on human subjects as depicted out in Figure 1.

Subject Selection

To check the beneficial affect of WBB on diabetes using GI, 25 subjects were selected through purposive random sampling technique. For this local doctors were contacted and requested to provide a list of diabetic patients. They were also requested to contact and convince the patient to become volunteer for the study. The patients were than individually contacted and convinced to become volunteers. A few non-diabetic subjects were also contacted and convinced for the same purpose. In all a total of 52 persons were contacted out of which 25 adult human subjects agreed to enrolled for the study. Classification of enrolled subject is given in Table 1. Subjects aged 35-70 years from a similar socio economic status, belong to the local area and most were employees of Sardar Patel University. They had a more or less similar physical activity, patterns, lifestyle and food consumption pattern.

Feeding Trials and Blood Collection

The enrolled subjects were asked to maintain an approximately constant activity level, dietary pattern (avoidance of sweets and party meals- especially for a couple of days before GI measurements) and a general life style during the feeding period. All the enrolled subjects were requested to report to the laboratory of P. G. Department of Home Science, Sardar Patel University, Vallabh Vidhyanagar.

Collection of data on general information, general dietary pattern, daily routine schedule (life style, exercise etc.), basic medical history and present drug therapy were obtained through a simple questionnaire. The dietary information (diet on the previous evening, period of fasting etc.) were also collected at this time.

Blood samples (finger prick) of the subjects were collected in the fasting condition. Immediately after that, they were fed 5 slices of WB (weighing 97.84 g and providing 50 g carbohydrate). The blood collection were repeated after at 1, 2 and 3 hrs of WB ingestion. Within a period of 2 week, the subjects were once again requested to report to the laboratory in the same manner followed earlier. This time subjects were fed approximately 5 slices weighing 104.40 g of WBB. The blood was collected similar to earlier.

Blood samples (0.1 ml) of the subjects were collected in a test tube containing 1 ml of 0.05 M NaOH, mixed well and used for analysis using the glucose oxidase method. For each subject, blood glucose response curve was plotted. Area obtained weather above or below the fasting line were included for calculation. The area was split in to right angle triangle and than its area was calculated. On that bases the GI and GL of WBB was determined.

The standard SPSS program was run to analyse the data. All the data were tested for significance using the ANOVA / Duncan's test (Steel and Torrie, 1980).

Results

Blood Glucose Level

Results for fasting and postprandial blood glucose levels (1 hr, 2 hr and 3 hr) as well as percent change in blood glucose levels after the ingestion of WB are presented in Table 2. Both the male and female non diabetic groups showed lower fasting blood glucose levels as compared to both the diabetic (male and female) groups. These results were as expected. None of the groups showed significant differences, between each other. After 1 hr of feeding WB all the four groups showed a rise in blood glucose level. The trend in blood glucose levels remained similar, i.e. lower in non diabetics as compared to diabetics, as expected.

Both male and female diabetic groups showed more or less similar increase in percent glucose at the end of one hour. The reason for the increase is well known that after ingestion of food, by about 1 hr the blood glucose level is increased to the maximum. However, non diabetic males and females showed lower blood glucose values one hour after the ingestion of WB, females showing a slight increase compared to males. When blood glucose level was analyzed at 2 hrs postprandial period, a non significant decreasing trend was observed in all the groups. Comparing the fall in blood glucose levels between 1 hr and 2 hr values it was seen that diabetics showed an average fall of 46.50 mg while the non diabetics showed a fall of 55.23 mg. In diabetic groups the retardation was lower as compared to non diabetic groups. The 3 hr postprandial blood glucose concentrations came back to it's original fasting levels in the case of non diabetic female group. However, in the case of non diabetic males it was found to be slightly higher than the fasting value. It may be because of reduced efficiency of insulin due to older age. In both the diabetic groups the blood glucose level did not come back to their fasting concentrations. During the 3rd hr all the groups showed a similar decrease in blood glucose concentration except the non diabetic male group.

Results for fasting and postprandial blood glucose concentrations as wellas percent change in blood glucose concentrations at 1, 2 and 3 hrs after ingestion of WBB are presented in Table 3. Percent change in blood glucose is also presented in Fig. 2. Fasting blood glucose levels of all the 4 groups were similar to levels observed for the testing of WB previously. The reason is that the subjects again came back for the feeding trial within a period of one week. After 1 hr, the same trend was observed as that obtained after feeding WB. However, the percent increase was lower for WBB as compared to WB in diabetics indicating the beneficial effect of wheat bran supplementation. Similar trend was observed in non diabetics also. The 2 hr postprandial blood glucose level were reduced with an average percent decrease of 14.95% for diabetics and 24.78 % for non diabetics. The highest decrease was found in non diabetic males followed by non diabetic females. Both the diabetic groups showed a lower decrease in blood glucose concentration as compared to the non diabetic groups. However the difference was non significant. The 3 hr blood glucose concentrations fell close to that of the fasting blood glucose concentrations. However, in both the diabetic groups, the blood glucose levels did not come down to fasting values. Low levels of insulin and their inefficiency invariably attribute for the slower fall in diabetics.

A change in blood glucose concentration of combined diabetics groups after feeding control and experimental bread is presented graphically in Figure 3.

Glycemic Index and Glycemic Load

Values obtained for blood glucose concentrations of each individual were plotted on a graph and the AUC was calculated separately for both the breads. On the basis of this data GI as well as GL were calculated. The results obtained are presented in Table 4. Area under the curve for WBB was observed to be low in all the groups as compared to the respective AUC obtained for WB. It clearly indicates that when wheat bran was added to the bread it reduced the blood glucose absorption which resulted in lowering of the AUC. Area under the curve for WB and WBB showed no significant differences. GI for WBB ranged from 77.04 to 81.25% within an average of 77.04% for diabetics and 81.93% for non diabetics. The average GL calculated for the WBB was found to be 38.20 g for diabetics and 40.97g for non diabetics. However, it ranged from 37.53 to 38.85 g for diabetics and 40.62 to 41.20 g for non diabetics.

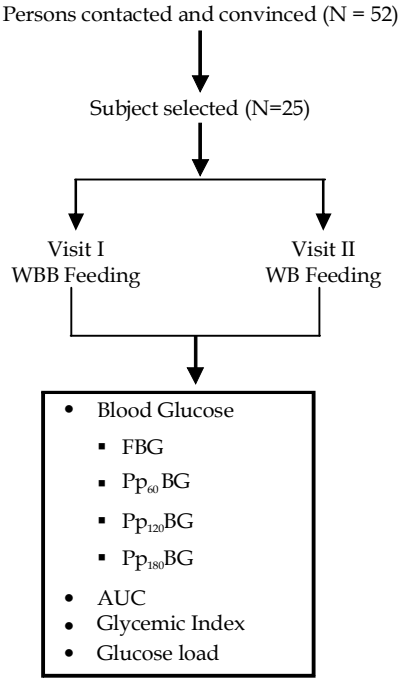

Fig. 1: Experimental Design for Clinical Trials for Bread Evaluation

WBB= Wheat Bran Bread, WB= White Bread, FBG = Fasting Blood Glucose
PP_{60}BG= Postprandial blood glucose after 1 hr of bread ingestion
PP_{120}BG = Postprandial blood glucose after 2 hr of bread ingestion
PP_{180}BG = Postprandial blood glucose after 3 hr of bread ingestion

Table 1: Classification of subjects enrolled for glycemic index measurements

	Type II Diabetes			Normal			Total		
	No.	Age (Yrs.)		No.	Age (Yrs.)		No.	Age (Yrs.)	
		Range	Avg.		Range	Avg.		Range	Avg.
Male	15	41-66	54	03	42-66	50	18	41-66	52
Female	05	49-70	55	02	35-58	47	07	35-70	51
Total	20	41-70	55	05	42-58	49	25	35-70	53

Table 2: Fasting and postprandial as well as percent change in blood glucose levels after feeding white bread

Group	Fasting	1 hr	% ch (1 hr)	2 hr	% ch (2 hr)	3 hr	% ch (3 hr)
Diabetic male	161.07 [a]	302.31 [a]	102.30 [a]	264.35 [a]	-15.71 [a]	194.00 [a]	-29.43 [a]
(15)	± 20.16	± 21.80	±10.72	± 31.96	± 4.97	± 29.52	± 3.15
Diabetic female	167.52 [a]	317.43 [a]	100.78 [a]	262.84 [a]	-18.44 [a]	190.72 [a]	-27.29 [a]
(5)	± 32.70	± 35.32	± 19.20	± 41.20	± 5.00	± 28.32	± 2.73
Diabetic	162.68 [a]	306.09 [a]	101.92 [a]	263.97 [a]	-16.39 [a]	193.18 [a]	-28.90 [a]
Total (20)	± 16.77	± 18.18	± 9.10	± 25.57	± 3.88	± 22.89	± 2.43
Non diabetic male	109.93 [a]	212.89 [a]	94.07 [a]	163.76 [a]	-21.00 [a]	125.93 [a]	-22.35 [a]
(3)	± 4.14	± 17.88	± 16.58	± 23.13	± 16.40	± 14.09	± 3.80
Non diabetic	131.04 [a]	237.02 [a]	82.29 [a]	175.69 [a]	-27.36 [a]	129.42 [a]	-24.71 [a]
female (2)	± 21.61	± 28.21	± 8.53	± 50.08	± 12.48	± 27.70	± 5.69
Non diabetic Total	118.37 [a]	222.54 [a]	89.36 [a]	168.53 [a]	-23.55 [a]	127.33 [a]	-23.30 [a]
(5)	± 8.86	±14.50	± 9.91	± 20.49	± 9.94	± 11.71	± 2.81
'F' Value	1.55 [NS]	1.61 [NS]	0.17 [NS]	1.00 [NS]	0.26 [NS]	0.60 [NS]	0.44 [NS]

NS = Non significant, % ch = Percent change, Values are Mean±SEM
Means bearing the same superscript within the column do not differ significantly ($p \leq 0.05$)
Values in parentheses indicate number of subjects

Table 3: Fasting and postprandial as well as percent change in blood glucose levels after feeding wheat bran bread

Group	Fasting	1 hr	% ch (1 hr)	2 hr	% ch (2 hr)	3 hr	% ch (3 hr)
Diabetic male	166.70 [a]	248.67[ab]	55.56[a]	216.19 [a]	-15.60 [a]	197.39 [a]	-7.82 [a]
(15)	± 16.75	± 16.33	± 7.37	± 24.28	± 5.35	± 22.36	± 2.70
Diabetic female	174.61 [a]	306.59 [b]	84.37 [a]	267.45 [a]	-13.01 [a]	203.97 [a]	-27.33 [a]
(5)	± 32.53	± 35.36	± 16.20	± 33.45	± 3.14	± 46.03	± 7.39
Diabetic	168.67 [a]	263.15 [a]	62.76 [a]	229.00 [a]	-14.95 [a]	199.04 [a]	-12.70 [a]
Total (20)	±14.54	± 15.70	± 7.22	± 20.27	± 4.05	± 19.70	± 3.26
Non diabetic male	101.09 [a]	182.42 [a]	80.84 [a]	130.98 [a]	-26.83 [a]	104.51 [a]	-16.77 [a]
(3)	± 1.75	± 8.33	± 11.18	± 22.97	± 16.33	± 5.12	± 9.79
Non diabetic female	133.11 [a]	203.11 [a]	56.90 [a]	161.04 [a]	-21.71 [a]	138.03 [a]	-14.13 [a]
(2)	± 28.85	± 18.78	± 19.89	± 36.62	± 10.79	± 30.31	± 0.71
Non Diabetic	113.90 [a]	190.69 [a]	71.26 [a]	143.00 [a]	-24.78 [a]	117.92 [a]	-15.72 [a]
Total (5)	± 12.07	± 9.04	± 10.56	± 18.62	± 9.66	± 12.93	± 5.40
'F' Value	1.15[NS]	2.91 [NS]	1.57 [NS]	1.87 [NS]	0.39 [NS]	1.30 [NS]	3.22 [NS]

NS = Non significant, % ch = Percent change, Values are Mean±SEM
Means bearing the same superscript within the column do not differ significantly ($p \leq 0.05$)
Values in parentheses indicate number of subjects

Table 4: Glycemic index and glycemic load of wheat bran bread

Group	AUC of Control bread (cm^2)	AUC of Experimental bread (cm^2)	Glycemic$ Index (%)	Glycemic@ Load (g)
Diabetic male	74.03[ab]	56.36 [a]	77.70 [a]	38.85 [a]
(15)	± 5.67	± 4.43	± 4.24	± 2.12
Diabetic female	84.15 [b]	60.67 [a]	75.05 [a]	37.53 [a]
(5)	± 8.77	± 6.69	± 9.50	± 4.75
Diabetic	76.56 [a]	57.44 [a]	77.04 [a]	38.2 [a]
Total **(20)**	± 4.78	± 3.66	± 3.84	±1.92
Non diabetic male	61.66[ab]	50.93 [a]	82.39 [a]	41.20 [a]
(3)	± 5.69	± 5.41	± 1.46	±0.73
Non diabetic female	46.03 [a]	37.42 [a]	81.25 [a]	40.62 [a]
(2)	± 0.66	± 2.04	± 3.24	±1.62
Non Diabetic	55.41 [a]	45.52 [a]	81.93 [a]	40.97 [a]
Total (5)	± 4.94	± 4.49	± 1.33	± 0.07
'F' Value	2.03 [NS]	1.15 [NS]	0.15 [NS]	0.15 [NS]

AUC = Area Under Curve, NS = Non significant
Means bearing the same superscript within the column do not differ significantly ($p \leq 0.05$)
Values in parentheses indicate number of subjects
$ = AUC of experimental bread/ AUC of control bread X 100
@ = GI X Carbohydrate content of food / 100

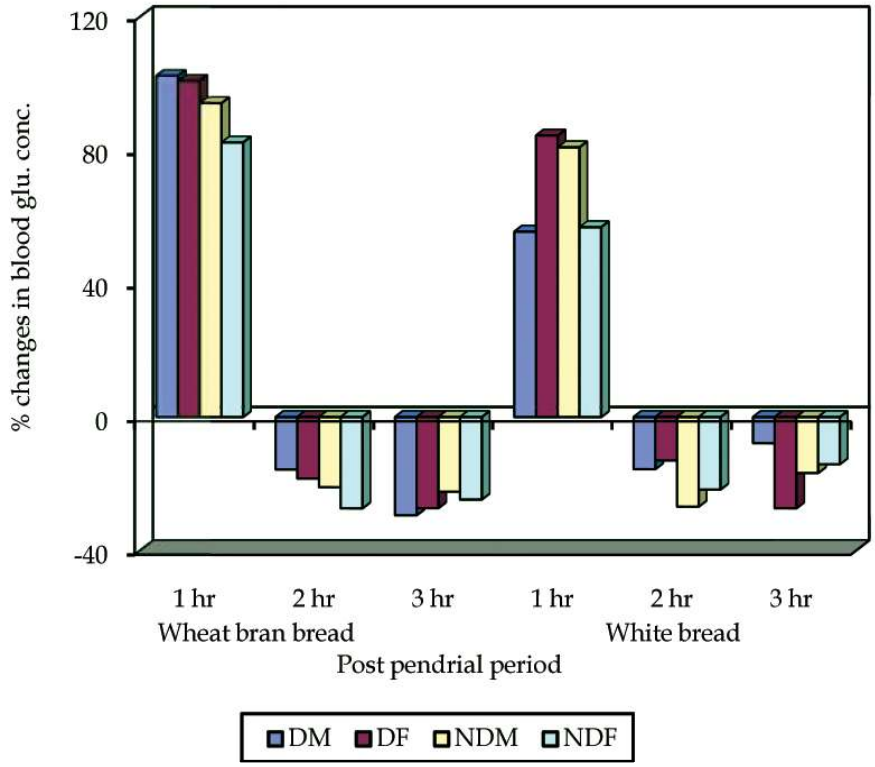

Fig. 2: Percent changes in postprandial blood glucose levels as compared to fasting after feeding white and wheat bran bread

WBB = Wheat bran bread, WB = White bread, DM = Diabetic male group, DF = Diabetic female group, NDM = Non diabetic male group, NDF = Non diabetic female group

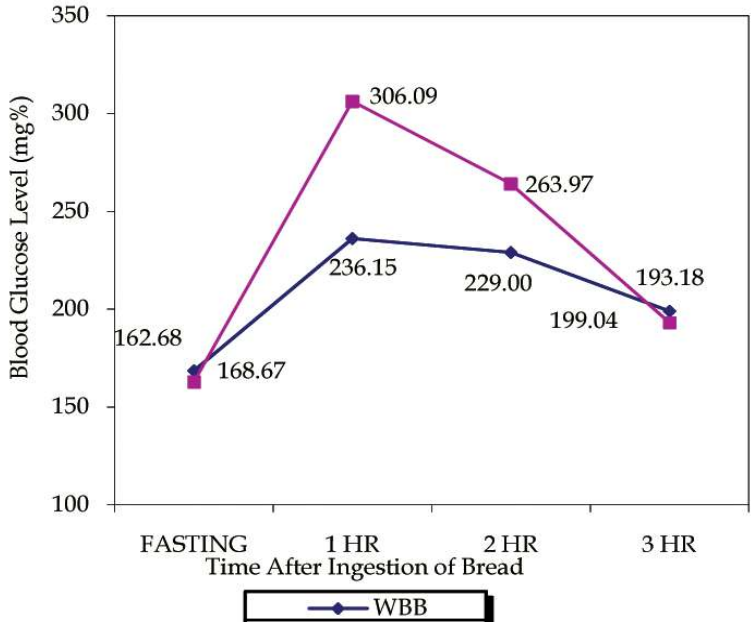

Fig. 3: Average glycemic response of diabetics for white and wheat bran bread

WBB = Wheat bran bread, WB = White bread

Discussion

Results for blood glucose levels are in concurrence with the high fiber bakery produts developed by other workers. Dubois et al. (1995) reported that adding oat bran to the test meals markedly reduced the post meal insulin rise ($p \pounds 0.05$). Ellis et al. (1988) reported that a significant insulin sparing effect in non diabetic subjects was achieved using a palatable guar biscuit containing less than 3 g of guar flour. Smith et al. (1982) reported that guar containing biscuit has been found to be effective in reducing the postprandial rise in blood glucose level.

Values for GI of WBBfound at par with Bell and Sears (2003) reported 81% GI for whole grain dark rye bread. Bell and Sears (2003) reported 13 and 15 g GL for whole grain brown rice and whole grain dark rye bread. Powel (2002) also reported the GL for different types of wheat breads to vary between 10 to 12 g. In the present study although the GI was similar to the other reported studies the GL was surprisingly high.

Conclusion

Considering the low GI obtained for WBB in comparison to WB in both diabetics as well as non diabetics, 7.5% wheat bran fortified bread may be recommended as a replacement for the commercially available white flour bread in the daily diet of diabetic as well as normal human subjects.

Future Scope

Like bread other bakery products such as biscuits, cookies, cakes and pastries could be modified to make it useful for diabetics.

References

1. AndersonJW and Akanji AO. Treatment of diabetes with high fiber diets in : Dietary fibre in human nutrition, 2nd edn spiller GA, CRC Press, Boea Raton FL. 1993; pp 443.
2. Bailey R. Diabetes prevention in Japan : an update. Nutraceuticals World. 2004; 7(9): 22-23.
3. Bamji MS, Pralhad RN and Reddy V. Text Book of Human Nutrition, 2nd edn. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi. 2004; pp 341.
4. Bell SJ and Sears B. Low GLdiets : Impact on obesity and chronic diseases. Critical Reviews in Food Science and Nutrition. 2003; 43(4): 357-377.
5. Dubois C, Armand M, Senft M, Portugal H, Pauli AM, Bernard PM, Lafont H and Lairon D. Chronic oat bran intake alters postprandial lipemia and lipoproteins in healthy adults. Am J ClinNutr 1995; 61(2): 325-333.
6. Ellis PR, Kamalanathan T, Dawoud FM, Strange RN and CoultateTP. Evaluation of guar biscuits for use in the management of diabetes : tests of physiological effects and patability. Eur J ClinNutr. 1988; 42(5): 425-435.
7. Kamaliya MK and Kamaliya KB (2001) Baking Science and Industries. 1st edn. MK Kamaliya, Anand, India. 2001; pp 474 - 586.
8. Kamaliya KB. Nutritional modification of commercially available bakery products and their evaluation. Ph.D. thesis submitted to Sardar PatelUniversity, VallabhVidhyanagar. 2005; pp 6-7.
9. Matz SA (1996) Ingredients for Bakers. 2nd edn. Pan-Tech International, Inc, Texas Powell KF, Holt S HA and Miller J CB (2002) International table of glycemic index and glycemic load values. Am J ClinNutr. 1996; 76(5): 56.
10. Smith CJ, Rosman MS, LevittNS and Jackson WP. Guar biscuits in the diabetic diet. S Afr Med J 1982; 61(6): 196-198.
11. Steel, RGD and TorrieJH. Principles and procedures of statistics, Mcgraw Hill Publication, New York.1980; 25-27.
12. Wolever, TMS, Jenskins, DJA, Jenkins AL and Josses RG. The glycemic index methodology and clinical importance Am J ClinNutr.1991; 54: 846-854.

Original Article

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Nutritional Status of Urban Child Aged 1 to 5 Year

Sunil Mhaske*, Amit Italiya, Liza Bulsara****

Abstract

Background: Nutrition of pre-school children (0-5 years age group) is of paramount importance because the foundation for lifetime health, strength and intellectual vitality is laid during this period. Malnutrition among under-five children is an important concern for the health authorities in India. *Aim and Objectives*: To assess the burden of under-nutrition and over-nutrition, its determinants and strategies required to tackle malnutrition among under-five children in India. The information retrieved was reviewed and analyzed for discrepancies. *Study Design*: Cross-sectional study. *Material and Methods*: Distribution of various types of risk factors and its influence on nutrition status of children in a given set up should be analyzed for planning the control measures. Strengthening public health interventions for mild malnutrition cases and vulnerable groups, effective implementation and evaluation of the strategies at regional level, research on overweight, obesity and its etiological factors and steps for improving socioeconomic development are the prerequisites for tackling malnutrition among under-five children in India. *Result*: Existing evidence shows that the prevalence of under-nutrition among under-five children was high and varied widely (under-weight: 39-75%, stunting: 15.4-74%, wasting: 10.6-42.3%) depending on the assessment methodology adopted. Studies on assessment of over-nutrition status among under-five children were limited. *Conclusion*: Malnutrition among under-five children appears to be a sustained crisis instead of an acute, self-limited problem linked to the post-election violence.

Keywords: Malnutrition; Strategies; Under-Five Children.

Introduction

Nutrition is the cornerstone of socioeconomic development of a country. It is an essential component of millennium development goals (MDGs) and Primary Health Care (PHC). Better nutrition means stronger immune systems, less illness, better health and a productive community.

Malnutrition among under-five children is a major public health problem in India. This is reflected by the fact that the prevalence of under-weight children in India is among the highest in the world, and is nearly double that of Sub-Saharan Africa [1]. It is also observed that the malnutrition problem in India is a concentrated phenomenon that is, a relatively small number of states, districts, and villages account for a large share of the malnutrition burden — only 5 states and 50% of villages account for about 80% of the malnutrition burden [1]. Each year approximately 2.3 million deaths among 6-60 months aged children in developing countries are associated with malnutrition, which is about 41% of the total deaths in this age group [2]. A recent study, among children aged between 3 months and 3 years of age conducted in 130 districts through Demographic and Health Surveys in 53 countries over a period from 1986 to 2006 found that — variance in mild under-weight has a larger and more robust correlation with child mortality than the variance in severe under-weight [3]. The study concluded that the prevalence of mild under-weight deserves greater attention as a useful signal of changing public health conditions among preschool children in developing countries. Therefore, it is important for the health system to detect malnutrition at an early stage for planning and implementing timely interventions at the community level.

Millennium Development Goal 1 (Target 2) aims to halve, between 1990 and 2015, the proportion of people who suffer from hunger as measured by the

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prevalence of under-weight among under-5 years children.[4] The burden of under-nutrition among under-five children has not changed much even though various intervention programs are in operation in India. Current changing dietary patterns are also affecting the nutrition status of under-five children resulting in increased prevalence of adult noncommunicable diseases such as obesity, diabetes, hypertension and coronary heart disease. The need of the hour is to examine the burden of under-nutrition and obesity, study it's determining factors and assess the effectiveness of the various approaches to combat malnutrition among under-five children. The present review article discusses the issues and strategies for strengthening service delivery to under-five malnourished children.

Materials and Methods

This cross-sectional study was carried out .One hundred children of 1–5 years of age were included in the study selected through simple random sampling.

The heads of households were taken into confidence and after obtaining informed, written consent data was collected. They were assured of confidentiality of the data.List of children from 1 to 5 years was obtained from the lady health workers (LHWs) of the region.

The variables which were studied were age, sex, conjunctiva, nails, hairs lustre, skin, oedema, history of ARI, history of diarrhoea, weight for age, height for age, weight for height, mid upper arm circumference (MUAC). The investigator himself collected all the data to take care of inter-rater bias. The instruments used in the process of data collection like measuring tapes, weighing machines and Shakir's tapes were the same for all data collection. Weighing scale was calibrated on daily basis.

Composite indices like Weight for Age, Height for Age, and Weight for Height were compared with the WHO reference data and categorised accordingly. Children with two Z-scores below the median of the reference population were considered as malnourished and 3 Z-scores below the median of the reference population were considered as suffering from severe malnutrition. Variable of interval scale were described as Mean±SD. Frequencies and percentages were calculated for ordinal and nominal variables. Based on this sample data, 95% confidence limits were calculated using t-test.

Results

Total number of children included in study was 100. Of these, 54 were male and 46 were female. Their ages ranged from 13 months to 59 months. Mean age was 38.10±13.68 months. Out of 100, 79 gave positive cases histories of cough and fever, 42(77.7%) were male and 37(80.4%) were female. Among 93 positive cases, 51(94.4%) were male and 42(91.13%) were female.

Ninety-nine children had normal hair and normal skin only one male child had lustreless hair and scaly skin. Out of 63 children having normal conjunctivae, 32% were male and 31% were female. Among 37 children who were having pale conjunctiva 22(40.7%) were male and 15 (32.6%) were female.All children (n=100) had normal nails. There was no oedema in any children.

According to height for age Z-score, out of 100 children, 80 were normal while 17 were stunted and 3 were severely stunted. Gender-wise, 41(75.9%) male and 39(84.7%) female were normal. Ten (18.5%) male children and 7(15.2%) female children were stunted. Among severely stunted, all 3(5.5%) were male children. According to weight for age Z-score, 79 children were normal, 11 were underweight and 10 were severely underweight. Gender-wise, 42(77.7%) male and 37(80.4%) female were having normal weight. Five (9.2%) male and 6 (13%) female were underweight. Among severely underweight 7 (12.9%) were male and 3 (6.5%) were female. According to weight for height Z-score, 83 children were normal while 13 were wasted and 4 were severely wasted. Gender-wise, 44 (81.4%) male and 39(84.7%) female were normal. Eight male (14.8%) and 5 female (10.8%) were wasted. Among severely wasted 2(3.7%) were male and 2 (4.3%) were females.

Under-Nutrition

There are various risk factors that showed an association with under-nutrition among under-five children.Furthermore, food consumption was found to be lower among girls compared to boys [2]. Poor feeding practices was common during infancy with 46.4% of under-six month's aged children receiving exclusive breastfeeding and 56.7% of those aged 6-9 months receiving complementary food items. The rates of exclusive breast feeding and complementary feeding were higher for mothers who had more antenatal visits and watched television [3]. A study reported that 60% of the caregivers did not know regarding growth monitoring of child. Hence, the

factors related to nutrition and growth monitoring affects the malnutrition status of children [4].

It is known that place of residence, household wealth, birth weight, age of child, awareness regarding diarrheal disease and acute respiratory tract infection control, maternal education, number of under 5 years children < and source of drinking water were strong predictors of child nutritional status in developing countries. In Indian preschool children, the risk of infection was more consistently associated with body mass index (BMI) for age and wasting which indicate current energy deficit as compared to weight for age and height for age [4,5]. Maternal factors like age, weight and anemia also significantly affect child's nutritional status.

Over-Nutrition

There is a paucity of data related to the prevalence and determinants of overweight and obesity among under-five children in India [6]. A study among 4-12 years aged children showed that the mean total calorie intake of the children was not significantly high, but the calories derived from fats was more than the desired 25%, which was especially high in the 4-7 years age group. Lack of physical activity, watching television or video for more than one 1 h daily and a positive family history of obesity contributed significantly to child obesity[7].

Conclusion

Prevalence of under-nutrition among under-five children is relatively high and varied widely depending on the assessment methodology adopted, and there are limited studies on assessment of over-nutrition. The distribution of risk factors and its influence on malnutrition among children in a given set up should be analyzed in planning diverse control measures. Strengthening public health interventions for mild malnutrition cases among the vulnerable groups with a focus on socioeconomic development and research on overweight, obesity and its etiological factors in the country are the prerequisites required to tackle malnutrition among under-five children in India.

References

1. Kumar HN, Mohanan P, Kotian S, Sajjan BS, Kumar SG. Prevalence of overweight and obesity among preschool children in semi urban South India.
2. Ray SK. Action for tackling malnutrition: Growth monitoring or surveillance? Indian J Public Health.
3. Mittal A, Singh J, Ahluwalia SK. Effect of maternal factors on nutritional status of 1-5-year old children in urban slum population. Indian J Community Med. 2007; 32: 264–7.
4. Ramachandran P, Gopalan HS. Undernutrition & risk of infections in preschool children.
5. Ganesh Kumar S, Harsha Kumar HN, Jayaram S, Kotian MS. Determinants of low birth weight: A case control study in a district hospital in Karnataka.
6. Schroeder DG, Brown KH. Nutritional status as a predictor of child survival: Summarizing the association and quantifying its global impact. Bull World Health Organ.
7. Fenn B, Penny ME. Using the new World Health Organisation growth standards: Differences from 3 countries. J Pediatr Gastroenterol Nutr.

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Effect of Different Pre-Processing Methods on the Extruded Products and Its Resultant Effect on Nutritional Properties and Health

Shivani Gupta*, S. Nikhil Gupta, Naveen Gupta*****

Abstract

The study concludes that the buckwheat flour had high antinutritional properties (TPC & TFC) while white sorghum flour had high functional properties (WHC, WAI & WSI). Various processings like puffing, drying and roasting results in decreasing antinutritonal properties while increasing functional properties in all the three flours. It also concluded in the case of Red sorghum flour, different treatments results in decreasing the moisture and ash content.

It has been observed that due to puffing there is increase in functional properties of product of red and white sorghum as compared to flour. In case of buckwheat product due to all the three treatments (puffing, drying and roasting) there is increase in functional properties and decreases in anti-nutritional properties as compare to flour. Roasting plays key role in product development of all the three flours as roasting results in increase in WAI & WHC, but decreases the anti-nutritional properties like TPC and TFC.

In the physical properties, buck wheat product has high bulk density. In the white and red sorghum there is increase in expansion ratio due to roasting and drying respectively.

Keywords: Antinutritonal Properties; Extrusion; Porosity; Proteins; Lahaul and Spiti.

Introduction

India is the one of the leading countries worldwide, blessed with rich and diverse heritage of cultural traditions and wealth of tradition knowledge system of plant species (Pant *et al*; 2009). Himalaya has great wealth of medicinal plants and traditional knowledge (Rawat *et al*; 2010). One of such vegetable plant Buckwheat (*Fagopyrum esculentum, Moench*), an herbaceous plant of the polygonaceae family adapted to high elevations and short growing season where as if we look about Sorghum (*Sorghum bicolor*), it contributes to the food security of many of the world's poorest most food insecure agro –ecological zones (FAO and ICRISAT,1996).

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Area of Cultivation

Sorghum is fifth most important cereal crop grown in the world and important food crop in South Asia, Central America and Africa. Nigeria is the world largest producer of grain sorghum (ICRISAT, 2007). The main producers of Buck wheat are China, Russian6 Federations, Ukraine and Kazakhstan (Li and Zhang, 2001; Bonafaccia *et al*, 2003). Two buckwheat speciesare commonly cultivated: common buckwheat (*F.esculentum*) and tartary buckwheat (*F. tartaricum*)(Krkoskova and Mrazova, 2005).

Physico-Chemical Properties

Sorghum is rich in thiamine, riboflavin, niacin and trace minerals such as iron, phosphorus and potassium. The colour of sorghum varies from white to red to black, and the bran of dark-coloured varieties is rich in compounds called phenolic acids, tannins, anthocyanins and policosanols (USDA,2007), whereas buck wheat is rich in anti oxidant such as tocopherols, reduced glutathione, inositol phosphates and melatonin (Zielinski *et al*. 2006). Among various flavonoids, rutin is reported to be the most abundant one in buckwheat seeds (Kreft *et al*, 1999) and is recognized as the most health protective and has also

been proven to be anti-inflammatory and anti-carcinogenic (Peng *et al*,2008).

Both buck wheat and sorghum are gluten free, thus they provide an important alternative nutritious food for people with celiac disease, (Alvarez-Jubete, Arendt and Gallagher, 2009).

Buck wheat can be added to various food products as a supplement to extend and broaden its consumption, to provide beneficial health effects and to prevent food from oxidizing during processing (Dietrych- Szostak, 1999).

Nutritional Composition

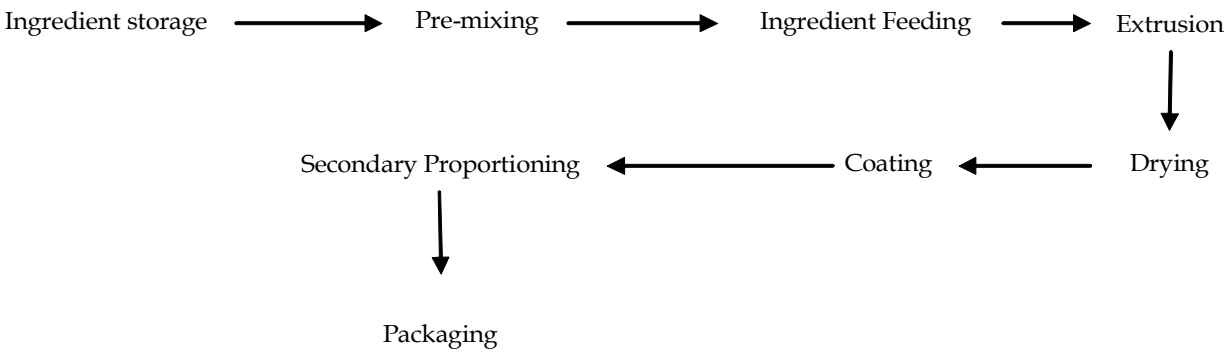
Sorghum is a good source of fibre, mainly the insoluble (86.2%) fibre. The insoluble dietary fibre of sorghum may decrease transit time and prevent gastrointestinal problems, The protein content of sorghum is usually 11-13% but sometimes higher values are reported (David A.V. Dendy, 1995). Prolamins (kafirins) constitute the major protein fractions in sorghum. Sorghum is an important source of B vitamins except B 12, and good source of tocopherols. Sorghum is grown from traditional hybrid seeds and does not contain biotechnology traits, making it non-transgenic or non-GMO, in case of buck wheat the protein content of buckwheat grains has been reported to range from 12% to 18.9%, the starch content of the buck wheat varies from 59% to 70%, fluctuations may occur at the time of variable climatic and cultivation conditions (Qian and Kuhn, 1999). Buckwheat grains contain from 1.5% to 4% of total lipids (Steadman *et al.* 2001).

Extruded Products

Extrusion cooking is used worldwide for the production of expanded snack foods, modified starches, ready to eat cereal foods, pet foods and porridge (Smith, 1996; Pelembe, 2002; Jeff, 2012). This unit operation consists of converting biopolymer-based raw materials into viscoelasticmelts, that is, the transport mechanism through the extruder changes along the screw from solid flow to fluid flow. As a consequence of the pressure built up during fluid flow, high shear stresses are developed, which cause structural transformations in the material. Starch dextrinization (Gomez, 1984) and amylopectin breakdown due to mechanical shear (Davidson, 1984) have been observed during low moisture, high shear single screwextrusion. Starch solubilisation (Mercier, 1975; Sopade, 2010) macromolecular degradation of amylose and amylopectin (Colonna, 1983) and reduction of high molecular weight polysaccharide (Wen, 1990) were reported during twin screw extrusion. The extrusion cooking was carried out using Brabender Single Screw Extruder (Model No. 823500, Germany), having a screw with a compression ratio of 2:1 and L/D ratio of 20:1. The samples were ground to coarse size and were subjected to conditioning by addition of water to obtain desired moisture equilibrium in feed material. The processing conditions like feed moisture, die temperature, screw rpm and feed rate were varied over five levels. The feed moisture was varied from 12% to 16%, die temperature from 150 °C to 190 °C, screw speed from 150 to 210 rpm and feed rate from 50 to 70 g min^{-1}. Finally, the extrudate were dried for a period of 2 h at 50 °C to the desired moisture content of 4% and the effect of these conditions on physical properties of extrudate were determined.

Extrusion Manufacturing Process of Extruded Products

The extrusion-cooking of cereal-based products has



been extensively studied during the last three decades.Product quality can vary considerably depending on the extruder type, screw configuration, feed moisture and temperature profile in the barrel section, screw speed and feed rate (Fletcher, 1985). Various studies have been done on the extrusion of corn, rice, wheat, barley, amaranth, chick pea, and their combinations. But our idea is to explore the utilization of uncommon cereal for the development of extruded snacks as per following ways.

The Objective of this Research is

1. To explore the possibilities of sorghum (red and white) and buckwheat grain for the development of extruded products.
2. To study the effect of extrusion conditions on structural and functional properties of developed extrudates.

Materials and Methods

Materials

The red and white sorghum grains were procured from local market of Himachal Pradesh and buckwheat grains were procured from the market of Lahaul and Spiti area of western Himalayan region. The procured raw material were cleaned and stored for further use. Thesegrains were roasted, dried, puffed and further grind to powder in order to study the effect of processing treatment on the development of extruded snacks.

Methods

Extrusion Process

The extrusion cooking was carried out using single screw extruder (Model No. KE19, Brabender, Germany) having a screw with a compression ratio of 2:1 and L/D ratio of 20:1. The different feed materials from sorghum and buckwheat were ground to coarse size and were subjected to conditioning by addition of water to obtain desired moisture equilibrium in feed material. The processing conditions like feed moisture, die temperature, screw rpm and feed rate were set to optimum. The extruded product were come out at die end and cut into small pieces. The prepared product was dried in hot air oven at 60°C for 15 min. Then packed in airtight bags and place in cool and dry place for further analysis

Analysis of Flour and Extruded Products

The sorghum (red and white) and buckwheat was pre-processed as per flow sheet 1 and 2 were further used for development of extruded snacks. All raw, pre-processed flours and its prepared extruded products were analyzed as per the standards methods.

Determination of Ash

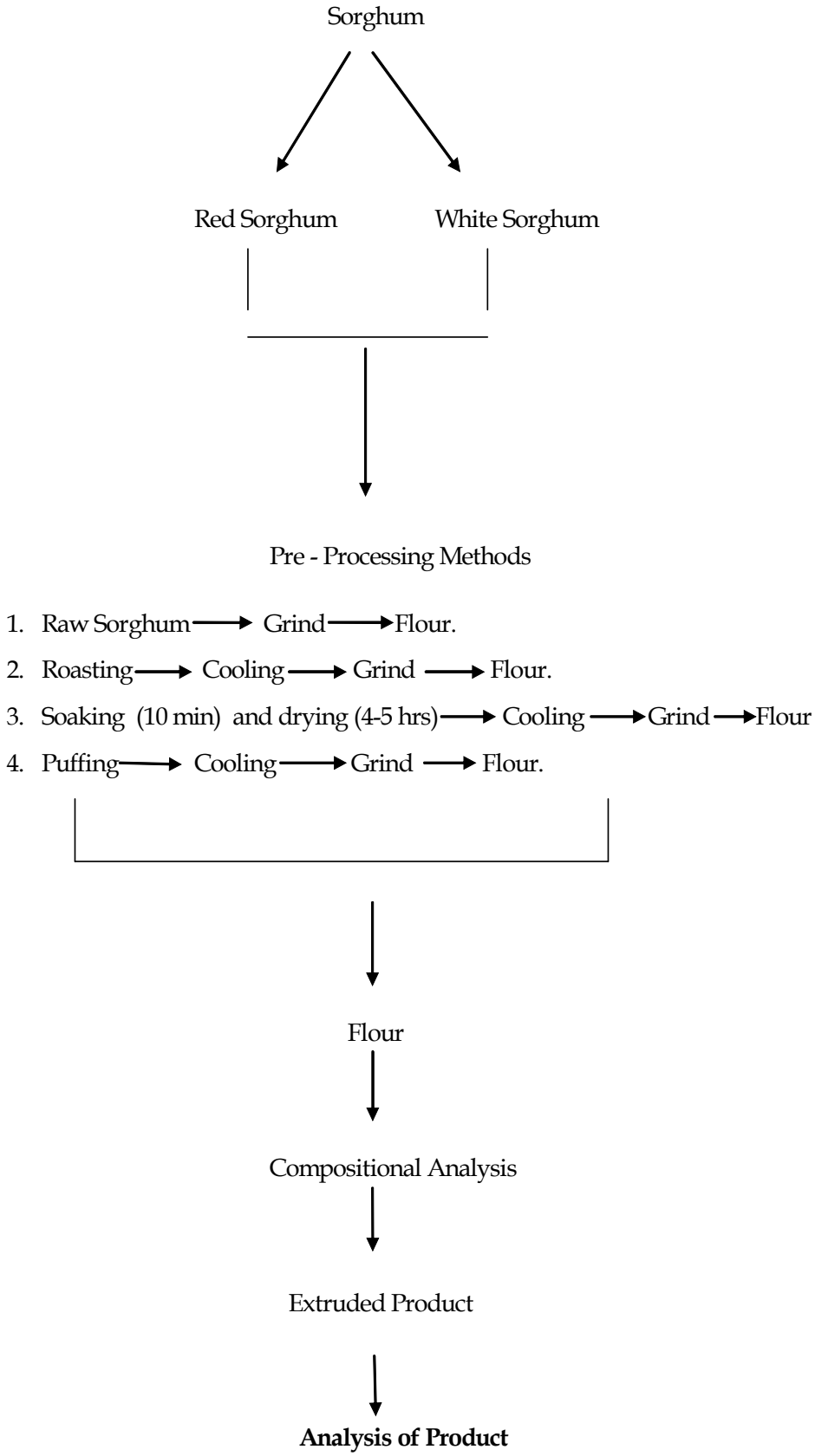
Two porcelain crucibles were washed and dried in an oven to a constant weight at 100°C for 10min. They were allowed to cool in a desiccators, then labelled A and B and weighed. 2.0 g of each sample were weighed into each of the previously weighed porcelain crucibles and reweighed. The crucibles containing the samples were transferred into a furnace, which was set at 550°C for 8 hr to ensure proper ashing. They were then removed and allowed to cool in the desiccators then finally weighed (AOAC.1980).

$$\% \text{ ash} = \frac{\text{weight of ash} * 100}{\text{Weight of sample}}$$

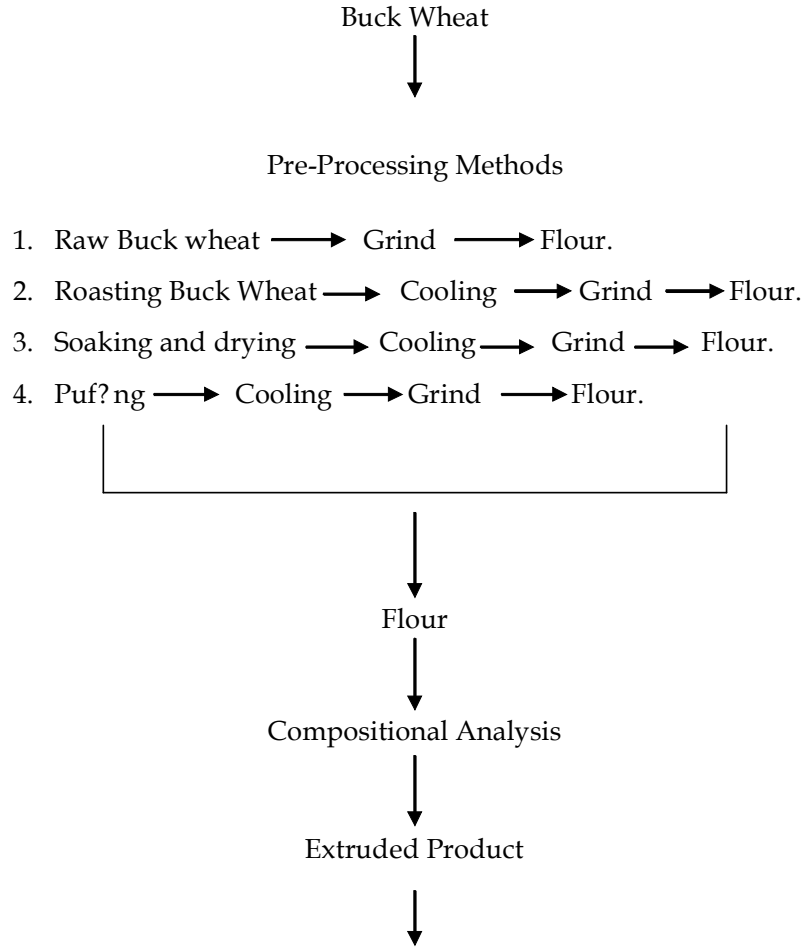
Determination of Moisture

Two petriplates were properly washed and allowed to dry in an air oven at 110°C for 10 min to a constant weight. The petriplates were allowed to cooled in a desiccators for 30 min, then labelled A and B and weighed. 2.0 g of each sample was

Flow sheet 1: Formation of extruded product from sorghum



Flow sheet 2: Formation of extruded product from buckwheat



Analysis of Product

accurately weighed into the previously labelled petriplates and reweighed. The petriplates containing the samples were placed in an oven maintained at 100°C till constant weight came. They were removed and transferred to desiccators to cooled, finally weighed(AOAC, 1980).

$$\% \text{ moisture content} = \frac{(W_1-W_2) * 100}{W_1-W}$$

Where W_1 is weight of sample and petriplates before drying

W_2 is weight of sample and petriplates after drying.

W is weight of empty petriplates.

Determination of Water Absorption Index

WAI can be determined by the method of Anderson (1982), here 2g of sample along with 20 ml of distilled water was taken in pre- weighed centrifuge tubes. Stir it for 5 minutes and further heat at 85°C for 10 minutes. Cool it and centrifuge it at 3500 rpm for 15 minutes. Supernatant was decanted in pre- weighed centrifuge tubes and dried at 100°C for determination of its solid content and sediment was weighed. WAI was calculated as weight of sediment or gel obtained after supernatant removal per unit weight of original solids.

Water Absorption Index = weight of sediment/ weight of dry solids.

Determination of Water Solubility Index

WSI can be determined by the method of Anderson (1982), here 2g of sample along with 20 ml of distilled water was taken in pre- weighed centrifuge tubes. Stir it for 5 minutes and further heat at 85°C for 10 minutes. Cool it and centrifuge it at 3500 rpm for 15 minutes. Supernatant was decanted in pre weighed centrifuge tubes and dried at 100°C for determination

of its solid content and sediment was weighed. WSI can be calculated as weight of dry solids in the supernatant expressed as % of original sample weight on dry basis.

Water Solubility Index = weight of dissolved solids in supernatant/ weight of dry solids *100

Determination of Water Holding Capacity

2g of Buck wheat and sorghum sample were weighed and allowed to rehydration overnight in excess water (20ml) after draining , it was reweighed and WHC was calculated as: Water Holding Capacity = weight of wet extrudates powder- weight of dry extrudate powder/ weight of dry extrudates powder * 100

Determination of Protein by Lowry's Method

Protein content was estimated by using Lowry's Method. The phenolic group Tyrosine and Tryptophan residues in a protein will produce a blue colour complex, with maximum absorption in the region of 660 nm wavelength. With Folin-Ciocalteu reagent which consists of sodium tungstate molybdate and phosphate. Intensity of colour depends on the amount of these aromatic amino acids present and will thus vary for different proteins. Most protein estimation techniques use Bovine Serum Albumin (BSA) universally as a standard protein, because of its low cost, high purity and readily availability. The method is sensitive down to about 10µg/ml and probably most widely used protein assay despite its being only a relative method.

Determination of Bulk Density

Bulk Density was determined by weighing the quantity of 5-cm long pieces required to fill a 100 ml beaker (Hood- Niefer and Tyler 2010). The extrudate pieces are randomly added to container and container was shaken several times during filling. Bulk density was calculated by:

Bulk Density (g/cm^3) = M/V

Where, M is mass (g).V is the volume of the beaker in cm^3.

Determination of Expansion Ratio

For determination of expansion ratio, the cross sectional diameter of the extrudate was measured by using vernier calliper. The expansion ratio was calculated as the cross sectional diameter of the extrudates divided by the diameter of the die opening (Ding *etal*, 2005).

Determination of Porosity

Porosity can be calculated according to Wang *et al* (1999) using the following calculations:

$$\text{Porosity (\%)} = \frac{\text{Particle density- Bulk Density*100}}{\text{Particle Density}}$$

Particle density was calculated according to the method of Gujska and Khan (1990). Individual cylindrical extrudate rods were weighed individually; the diameter and length were measured by using Vernier Calliper:

Particle density (g/cm^3) = $4m/\pi^2L$

Where m and L are rod mass (g) and length (cm) respectively of cooled extrudates with diameter d (cm). The particle density values were calculated as average of twenty measurements for each replicate.

Determination of Colour Measurements

Colour value (L*, a* and b*) analysis was performed using a reflectance colorimeter Minolta, Chroma-Meter C1-200, according to method CIE (1971). L* value is the brightness of the colour in the range of values from 0 (black) to 100 (white); the higher the values, the brighter the colour. The value of a* indicates the redness of sample namely (green) to + (red). The value b* value indicates the yellowness of the sample namely (blue) to + (yellow). Each sample individually measured in triplicate.

Determination of Total Phenolic Content

Total phenolic content of both the sample and the product were determined. Plant polyphenols, a diverse group of phenolic compounds (Flavanols, anthocyanins, phenolic acids, etc.) posses an ideal structural chemistry for free radical scavenging activity. Ant oxidative properties of polyphenol arise from their high reactivity as hydrogen or electron donors from the ability of the poly phenol derived radical to stabilize and delocalize the unpaired electron (chain breaking function) and from their potential to chelate metal ions (termination of the Fenton reaction) (Rice-Evans et al., 1997). (McDonald *et al*, 2001) Folin-Ciocateu reagent method 0.5 ml of extract and 0.1 ml of Folin- Ciocateu reagent (0.5N) are mixed and incubate at room temperature for 15 minutes. Take 2.5 ml of saturated sodium carbonate was added and further incubated for 30 minutes at room temperature and absorbance measured at 760nm.

Determination of Total Flavonoids Content

Total flavonoids content was determined in both sample and product, the antioxidative properties of flavonoids were due to several mechanisms, such as scavenging of free radicals, chelation of metal ions, such as iron and copper and inhibition of enzymes responsible for free radical generation (Benavente-Garcia, 1997). (Chang *et al*, 2003) aluminium chloride method 1 ml of extract 0.5 ml of 1.2% aluminium chloride and 0.5 ml of 120 mM potassium acetate were mixed and incubate for 30 minutes at room temperature, and then absorbance measured at 415nm.

Determination of Water Activity

Water activity of sample was analyzed by Aqualab dew point water activity meter 4TE. Weigh 2.0 g of sample, place sample in small plastic containers and then open the drawer of the water activity meter, insert your sample, close and turn the knob to the read position allow sample to equilibrate read $a_{w.}$

Determination of Fat

Fat content of sample were determined by using Soxhlet method, crude fat content is determined by extracting the fat from the sample using a solvent, then determining the weight of the fat recovered. The sample is contained in a porous thimble that allows the solvent to completely cover the sample. Thimble is contained in an extraction apparatus that enables the solvent and the sample and allow it to dissolve all the fat contained in the sample.

Weigh 5g of sample in a thimble, insert the thimble into a Soxhlet liquid/extract, accurately weigh a clean, dry 250 ml round bottom flask and put about 1150 ml of hexane in the flask. Heat the solvent in the flask until it boils. Adjust the heat source so that solvent drips from the condenser into the sample, chamber at the rate of about 6 drops per second. Continue the extraction for 6 hours, remove the extraction until from the heat source and detach the extractor and condenser. Replace the flask on heat source and evaporate off the solvent. The solvent may be distilled and recovered. Place the flask in an oven at 102°C and dry the solvent until a constant weight is reached (1-2 hours). Cool the flask in desiccators and weigh the flask and container.

$$\% \text{ Crude Fat} = \frac{W_2\text{-}W_1*100}{S}$$

Where weight of empty flask (g) = W_1

Weight of flask and extracted fat = W_2

Weight of sample = S

Table 3.1: Analysis of red sorghum flour

Sample	M	A	WAI	WHC	WSI	TPC	TFC	P	a_w	CI	BD	Fat
Raw	12 ± 0.14	1 ± 0.14	3.63 ± 0.042	272.72 ± 0.07	81.57 ± 0.07	0.693 ± 0.07	1.784 ± 0.014	0.45 ± 0.07	0.588	16.55	0.646	2
Roasted	4 ± 0.14	1 ± 0.14	4.18 ± 0.07	318.18 ± 0.07	98.21 ± 0.14	0.4052 ± 0.056	0.413 ± 0.07	0.158 ± 0.14	0.1976	12.41	0.59	2
Dried	6 ± 0.14	0.5 ±0.07	3.54 ± 0.056	227.27 ± 0.14	98.27 ± 0.14	0.1536 ± 0.052	0.1924 ± 0.14	0.179 ± 0.07	0.2381	13.71	0.56	2
Puff	4 ± 0.14	0.5 ± 0.07	4.63 ± 0.056	372.72 ± 0.14	96.07 ± 0.07	0.1616 ± 0.056	0.399 ± 0.056	0.145 ± 0.07	0.1737	9.78	0.35	2

Table 3.2: Analysis of white sorghum flour

Sample	M	A	WAI	WHC	WSI	TPC	TFC	P	CI	a_w	BD	Fat
Raw	12 ± 0.14	1± 0.14	4.5 ± 0.056	320 ± 0.14	88.88 ± 0.07	0.6631 ± 0.056	1.778 ± 0.07	0.419 ± 0.07	8.87	0.5	0.5434	1.9
Roasted	8 ± 0.14	1 ± 0.14	5 ± 0.042	377.77 ± 0.07	98.07 ± 0.14	0.3096 ± 0.07	0.219 ± 0.07	0.135 ± 0.056	6.97	0.53	0.1993	2.1
Dried	7 ± 0.14	1 ± 0.14	4.8 ± 0.056	350 ± 0.07	94.75 ± 0.14	0.133 ± 0.056	0.1924 ± 0.07	0.159 ± 0.056	10.91	0.6	0.7824	1.9
Puff	4 ± 0.14	1 ± 0.14	4.72 ± 0.042	372.72 ± 0.07	96.08 ± 0.14	0.1936 ± 0.14	0.401 ± 0.07	0.132 ± 0.056	6.76	0.43	0.1581	2.0

Results and Discussions

The present research was undertaken to study the various physico-chemical properties of extruded products prepared from sorghum and buckwheat. The results obtained in the present investigation are presented and discussed under suitable headings.

Physico-Chemical Analysis of Raw Buck wheat and Sorghum

Here M- Moisture. , A- Ash, WAI- Water absorption index, WHC- water holding capacity, WSI- water solubility index, P- protein, CI- colour index, a_{w-}water activity, BD- bulk density, Por- Porosity, ER- expansion ratio.

The moisture content of raw red sorghum flour is

higher (12 ± 0.14) than that of roasted and puff flour (4 ± 0.14). The ash content came out to be same in raw and roasted flours (1 ± 0.14) and same in dried and puff flour (0.5 ± 0.07). The WAI means that how much water had been absorbed by the sample results in higher in case of puff flour (4.63 ± 0.056) and lower in case of dried flour (3.54 ± 0.056). The WHC represents about the how much water had been hold by the flour which came out to be higher in Puff flour (372.72 ± 0.14) and lower in dried flour (227.27 ± 0.14), the TPC and TFC represents the antioxidant activities of the sample where TPC content is high in raw flour (0.693 ± 0.07) and low in dried flour (0.161 ± 0.056) and that of TFC content came out to be higher in raw flour (1.784 ± 0.14) and low in puff flour (0.399 ± 0.056) , the protein content of raw flour (0.45 ± 0.07) is higher than that of puff flour (0.145 ± 0.07), the a_w and colour index of raw flour is higher (a_w- 0.588 and colour index is 16.55) and that of puff flour is lower (a_w – 0.1737 and colour index is 9.78). Bulk density came out to be 0.646 in raw flour and that of 0.35 in puff flour.

Here M- Moisture. , A- Ash, WAI- Water absorption index, WHC- water holding capacity, WSI- water solubility index, P- protein, CI- colour index, a_w- water activity, BD- bulk density, Por- Porosity, ER- expansion ratio.

The moisture content of raw white sorghum flour is higher (12 ± 0.14) than that of puff flour (4 ± 0.14). The ash content came out to be same in all pre-processing flours (1 ± 0.14) The WAI means that how much water had been absorbed by the sample results in higher in case of puff flour (4.72 ± 0.056) and lower in case of raw flour (4.5 ± 0.056). The WHC represents about the how much water had been hold by the flour which came out to be higher in Roasted flour (372.72 ± 0.14) and lower in raw flour (320.27 ± 0.14), the TPC and TFC represents the antioxidant activities of the sample where TPC content is high in raw flour (0.663 ± 0.07) and low in dried flour (0.133 ± 0.056) and that of TFC content came out to be higher in raw flour (1.778 ± 0.14) and low in dried flour (0.1924 ± 0.056) , the protein content of raw flour (0.419 ± 0.07) is higher than that of puff flour (0.139 ± 0.056), the a_w and colour index of dried flour is higher (a_w- 0.7824 and colour index is 10.91) and that of puff flour is lower (a_w– 0.132 and colour index is 6.76). Bulk density came out to be 0.6 in dried flour and that of 0.43 in puff flour.

Table 3.3: Analysis of buckwheat flour

Sample	M	A	WAI	WHC	WSI	TPC	TFC	P	a_w	CI	BD	Fat
Raw	10 ± 0.14	1 ± 0.14	3.6 ± 0.07	280 ± 0.056	95.31 ± 0.14	0.7836 ± 0.056	1.878 ± 0.14	0.632 ± 0.07	0.5096	7.7	0.5	2
Roasted	8 ± 0.14	0.5 ± 0.07	5 ± 0.042	410 ± 0.07	96.22 ± 0.14	0.6096 ± 0.07	0.552 ± 0.07	0.456 ± 0.07	0.1558	3.74	0.64	2.5
Dried	10 ± 0.14	1 ± 0.14	3.36 ± 0.056	254.54 ± 0.056	93.41 ± 0.07	0.1616 ± 0.07	0.8052 ± 0.14	0.237 ± 0.14	0.3408	8.15	0.59	2.5
Puff	4 ± 0.14	0.5 ± 0.07	5.54 ± 0.042	481.81 ± 0.07	97.43 ± 0.07	0.2056 ± 0.056	0.509 ± 0.07	0.137 ± 0.056	0.2796	10.28	0.38	2

Table 3.4: Analysis of buckwheat extruded product

Sample	M	A	WAI	WHC	WSI	TPC	TFC	P	a_w	CI	BD	Por	ER	Fat
Raw	4.02 ± 0.01	1.01 ± 0.02	7.01 ± 0.042	742.35 ± 0.17	99.42 ± 0.07	0.7857 ± 0.056	0.6883 ± 0.14	0.1793 ± 0.07	0.474 2	11.77	0.208	92.53	0.93	5.2
Roasted	4.01 ± 0.07	1.01 ± 0.02	7.18 ± 0.07	759. 94 ± 0.17	99.41 ± 0.14	0.3761 ± 0.14	0.6734 ± 0.14	0.178 ± 0.14	0.128 2	10.36	0.208	94.07	1.46	5
Dried	3.09 ± 0.07	1 ± 0.02	7.23 ± 0.07	701.66 ± 0.17	99.44 ± 0.14	0.4251 ± 0.07	0.5682 ± 0.14	0.1881 ± 0.07	0.303 2	12.49	0.208	94.07	1.43	10
Puff	3.01 ± 0.02	1.01 ± 0.14	7.2 ± 0.07	720.66 ± 0.17	98.73 ± 0.07	0.4163 ± 0.07	0.5182 ± 0.14	0.1774 ± 0.07	0.136 2	12.36	0.208	92.57	0.93	4.5

Here M- Moisture. , A- Ash, WAI- Water absorption index, WHC- water holding capacity, WSI- water solubility index, P- protein, CI- colour index, a_w- water activity, BD- bulk density, Por- Porosity, ER- expansion ratio.

The moisture content of raw and dried Buck Wheat flour are higher (10 ± 0.14) than that of puff flour (4 ± 0.14). The ash content came out to be same in raw and dried flours (1 ± 0.14) and different in roasted and puff flours (0.5 ± 0.14). The WAI means that how much water had been absorbed by the sample results in higher in case of puff flour (5.54 ± 0.056) and lower in case of dried flour (3.36 ± 0.056). The WHC represents about the how much water had been hold by the flour which came out to be higher in Puff flour (481.81 ± 0.07) and lower in raw flour (254.54 ± 0.056),

the TPC and TFC represents the antioxidant activities of the sample where TPC content is high in raw flour (0.7836 ± 0.056) and low in dried flour (0.1616 ± 0.07) and that of TFC content came out to be higher in raw flour (1.878 ± 0.14) and low in puff flour (0.509 ± 0.07), the protein content of raw flour (0.632 ± 0.07) is higher than that of puff flour (0.137 ± 0.056), the a_w of raw flour is higher and colour index of puff flour (a_w- 0.5096 and colour index is 10.28) and a_w of roasted flour is lower and colour index of roasted flour is even lower (a_w – 0.1558 and colour index is 3.74). Bulk density came out to be 0.64 in roasted flour and that of 0.38 in puff flour

Here M- Moisture. , A- Ash, WAI- Water absorption index, WHC- water holding capacity, WSI- water solubility index, P- protein, CI- colour index, a_w- water activity, BD- bulk density, Por- Porosity, ER- expansion ratio.

The moisture content of raw Buck Wheat extruded product is higher (4.01 ± 0.01) than that of puff extruded product (3.01 ± 0.02). The ash content came out to be same in raw, roasted and puff (1.01 ± 0.02) and different in dried extruded product (1 ± 0.02). The WAI means that how much water had been absorbed by the sample results in higher in case of dried extruded product (7.23 ± 0.07) and lower in case of raw extruded (7.01 ± 0.042). The WHC represents about the how much water had been hold by the product which came out to be higher in Roasted extruded product (754.94 ± 0.14) and lower in dried extruded product (701.66 ± 0.17), the TPC and TFC represents the antioxidant activities of the sample where TPC content is high in raw extruded product (0.7857 ± 0.07) and low in puff extruded product (0.4163 ± 0.056) and that of TFC content came out to be higher in raw extruded product (0.6883 ± 0.14) and low in puff extruded product (0.5182 ± 0.14) , the protein content of dried extruded product (0.1881 ± 0.07) is higher than that of puff extruded product (0.1774 ± 0.056) which is lower, the a_w of roasted extruded product is higher and colour index of dried extruded product is higher (a_w- 0.4742 and colour index is 12.49) and that of roasted extruded product is lower (a_w – 0.1282 and colour index is 10.36). Bulk density came out to be 0.208 for all samples. Expansion Ratio is higher in case of roasted extruded product (1.46) and lower in case of dried product (1.43). Porosity came out to be higher in roasted and dried extruded product (94.07) and low in case of raw extruded product (92.57).

Table 3.5: Analysis of red sorghum extruded product

Sample	M	A	WAI	WHC	WSI	TPC	TFC	P	a_w	CI	BD	Por	ER	Fat
Raw	2.7 ± 0.07	1 ± 0.14	5.03 ± 0.042	696.3 ± 0.07	96.42 ± 0.07	0.168 ± 0.07	0.2391 ± 0.07	0.0288 ± 0.07	0.544	9.71	0.178	95.87	1.36	
Roasted	2.62 ± 0.14	0.9 ± 0.02	6.54 ± 0.07	754.45 ± 0.056	88.32 ± 0.07	0.1359 ± 0.14	0.2241 ± 0.14	0.0272 ± 0.14	0.1876	10.77	0.178	99.03	1.23	
Dried	3.4 ± 0.42	1 ± 0.14	6.12 ± 0.056	612.3 ± 0.07	94.12 ± 0.07	0.1691 ± 0.14	0.2031 ± 0.14	0.0239 ± 0.14	0.2272	7.96	0.178	94.06	1.53	
Puff	3.68 ± 0.42	0.9 ± 0.02	6.49 ± 0.042	690.9 ± 0.07	98.22 ± 0.07	0.1483 ± 0.056	0.1939 ± 0.14	0.0179 ± 0.14	0.1673	10.24	0.178	94.08	1.33	

Table 3.6: Analysis of white sorghum extruded product

Sample	M	A	WAI	WHC	WSI	TPC	TFC	P	aw	CI	BD	Por	ER	Fat
Raw	2.26 ± 0.084	1.01 ± 0.02	6.78 ± 0.056	710.88 ± 0.056	97.45 ± 0.14	0.0747 ± 0.056	0.2494 ± 0.056	0.0269 ± 0.14	0.5018	3.95	0.178	91.3	1.36	
Roasted	2.08 ± 0. 07	1 ± 0.14	6.4 ± 0.042	726.16 ± 0.056	95.6 ± 0.14	0.0732 ± 0.14	0.2092 ± 0.07	0.0252 ± 0.14	0.1552	2.88	0.178	94.03	1.43	
Dried	2.48 ± 0.07	1 ± 0.14	6.61 ± 0.042	690.51 ± 0.14	99.32 ± 0.07	0.0899 ± 0.056	0.2465 ± 0.14	0.0216 ± 0.14	0.5315	5.29	0.178	94.08	1	
Puff	2.04 ± 0.42	0.92 ± 0.02	6.85 ± 0.042	725.57 ± 0.056	99.13 ± 0.14	0.0699 ± 0.14	0.1883 ± 0.14	0.018 ± 0.056	0.1417	6.34	0.178	99.04	1.36	

Here M- Moisture. , A- Ash, WAI- Water absorption index, WHC- water holding capacity, WSI- water solubility index, P- protein, CI- colour index, a_w- water activity, BD- bulk density, Por- Porosity, ER- expansion ratio

The moisture content of puff Red Sorghum extruded product is higher (3.68 ± 0.42) than that of roasted extruded product (2.62 ± 0.14). The ash content came out to be same in raw and dried extruded product (1 ± 0.14) and different in roasted and puff extruded product (0.9 ± 0.02). The WAI means that how much water had been absorbed by the sample results in higher in case of roasted extruded product(6.54 ± 0.07) and lower in case of raw extruded (5.03 ± 0.042). The WHC represents about the how much water had been hold by the product which came out to be higher in Roasted extruded product (754.45 ± 0.14) and lower in dried extruded product (612.3 ±

0.07), the TPC and TFC represents the antioxidant activities of the sample where TPC content is high in dried extruded product (0.1691 ± 0.14) and low in roasted extruded product (0.1359 ± 0.14) and that of TFC content came out to be higher in raw extruded product (0.2391 ± 0.07) and low in puff extruded product (0.1939 ± 0.14) , the protein content of raw extruded product (0.0288 ± 0.07) is higher than that of puff extruded product (0.0179 ± 0.14) which is lower, the a_w of raw extruded product is 0(a_w - 0.544) and colour index of roasted extruded product is higher (Colour index is 10.77) and water activity of puff extruded product is (a_w- 0.1673) and that of colour index which is lower in case of dried extruded product (Colour index- 7.96). Bulk density came out to be 0.178 for all samples. Expansion Ratio is higher in case of dried extruded product (1.53) and lower in case of roasted product (1.23). Porosity came out to be higher in roasted extruded product (99.03) and low in case of dried extruded product (94.06).

Here M- Moisture. , A- Ash, WAI- Water absorption index, WHC- water holding capacity, WSI- water solubility index, P- protein, CI- colour index, a_w- water activity, BD- bulk density, Por- Porosity, ER- expansion ratio

The moisture content of dried White Sorghum extruded product is higher (2.48 ± 0.07) than that of puff extruded product (2.04 ± 0.042). The ash content came out to be higher in raw (1.01 ± 0.02) and lower in puff extruded product (0.92 ± 0.02). The WAI means that how much water had been absorbed by the sample results in higher in case of puff extruded product (6.85 ± 0.042) and lower in case of roasted extruded (6.4 ± 0.042). The WHC represents about the how much water had been hold by the product which came out to be higher in Roasted extruded product (726.16 ± 0.056) and lower in dried extruded product (690.51 ± 0.14), the TPC and TFC represents the antioxidant activities of the sample where TPC content is high in dried extruded product (0.0899 ± 0.056) and low in

Fig. 3.1: Figure showing raw extruded product prepared from buck wheat & sorghum

Fig. 3.2: Figure showing roasted extruded product prepared from buck wheat & sorghum

Fig 3.3: Figure showing dried extruded product prepared from buck wheat & sorghum

Fig 3.4: Figure showing puffed extruded product prepared from buck wheat & sorghum

puff extruded product (0.0699 ± 0.014) and that of TFC content came out to be higher in raw extruded product (0.2494 ± 0.056) and low in puff extruded product (0.1883 ± 0.14) , the protein content of raw extruded product (0.0269 ± 0.14) is higher than that of puff extruded product (0.018 ± 0.056) which is lower, the a_w of dried extruded product is higher and colour index of puff extruded product is higher (a_w- 0.5315 and colour index is 6.34) and that of puff extruded product water activity is lower and colour index of raw extruded product is lower (a_w – 0.1552 and colour index is 2.88). Bulk density came out to be 0.178 for all samples. Expansion Ratio is higher in case of roasted extruded product (1.43) and lower in case of dried product (1.00). Porosity came out to be higher in puff extruded product (99.04) and low in case of raw extruded product (91.3).

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References

1. AS; Andersson H; Amado R; Schlemmer H; SerraF. (eds), Bioactive Inositol Phosphates and Phytosterolsin Food. Cost 916. Office for Official Publications of theEuropean Communities, Luxemburg: 69–72., Czech Journal of Food Science. Vol. 26, No. (3): 153–162.
2. Alvarez-Jubete L; Arendt EK; Gallagher E. Nutritive value and chemical composition of pseudo cereals as gluten free ingredients. International Journal of Food Science nutrition. 2009; (60): 240-257.
3. AOAC (Association of Official Analytical Chemists, 1990), Official methods of analysis, volume 2.
4. Bonafaccia G; Marocchini M; Kreft I. Composition and technological properties of the flour and bran from common and tartary buckwheat. Food Chemistry. 2003; (80): 9–15.
5. Chang WS; Lin CC; Chuang HC, Superoxide anion scavenging effect of coumarins. American Journal of Chinese Medicine. 1996; (24): 11-17.
6. Colonna P; Doublier J.L; Melcion J.P; Monredon F; Mercier C. Extrusion cooking and drum drying of wheat starch: I. Physical and macromolecular modifications, Cereal Chemistry 1984; 61(6): 538-543.
7. Colonna P; Mercier C., Macromolecular modifications of manoic starch components by extrusion cooking with and without lipids, Carbohydrate Polymers. 1983; (3): 87-108.
8. Dietrych-Szostak D; Oleszek W. Effect of processing on the flavonoid content in buckwheat (*Fagopyrum esculentum* Moench) grain. Journal of Agricultural and Food Chemistry. 1999; (47): 4383–4387.
9. Davidson VJ; Paton D; Diosady LL; Larocque G. Degradation of wheat starch in a single screw extruder: Characteristics of extruded starch polymers, Journal of Food Science. 1984; 49: 453-458.
10. "FAOSTAT". Food and agriculture organization of the united nations. Retrieved 2010-05-21.
11. Gomez M.H; Aguilera J.M. Changes in the starch fraction during extrusion cooking of corn, Journal of Food Science. 1983; 48: 378-381.
12. Gomez M.H; Aguilera J.M. A physicochemical model for extrusion of corn starch, Journal of Food Science. 1984: (49): 40-49.
13. ICRISAT, "Medium-Term Plan 1994-1998," International Crops Research Institute for the Semi-Arid Tropics, Patancheru, 1992.
14. Kreft I; Plestenjak A; Golob T; Skrabanja V; Rudolf M; Draslar K. (1999a), Functional value of buckwheat

as affected by the content of inositol, phosphate, minerals, dietary fiber and protein. In: Sanberg 161

15. Krkoskova B; Mrazova Z. Prophylactic components of buckwheat. Food Research International. 2005; (38): 561–568.
16. Li, S. Q; Zhang, Q.H. Advances in the development of functional food from buckwheat. Critical Reviews in Food Science Nutrition. 2001; (41): 451-464.
17. Mahasukhonthachat K; Sopade PA; Gidley MJ. Kinetics of starch digestion in sorghum as affected by particle size, Journal of Food Engineering. 2010; 96: 18-28.
18. McDonald S; Prenzler PD; Antolovich M; Robards K. Phenolic content and antioxidant activity of olive extracts. Food Chemistry. 2001; 73: 73-84.
19. Mercier C; Feillet P. Modification of carbohydrate component by extrusion cooking of cereal product, Cereal Chemistry. 1975; 52: 283-297.
20. Mesa-Stonestreet N.J; Sajid A; JeffG. Extrusion-enzyme liquefaction as a method for producing sorghum protein concentrates, Journal of FoodEngineering. 2012; 108(2): 365-375.
21. Pant, S; Samant, S.S. and Arya, S.C. Diversity and indigenous household remedies of the inhabitants surrounding Mornaula reserve forest in west Himalaya, Indian Journal of Traditional Knowledge. 2009; 8(4): 606-610.
22. Pelembe L.A.M; ErasmusC; Taylor J.R.N. Development of a protein-rich composite sorghum-cowpea instant porridge by extrusion cooking process, Lebensm-Wiss.U. Technol. 2002; 35: 120-127.
23. Peng, X; Zheng, Z; Cheng, K-W; Shan, F; Ren, G- X., Chen, F; Wang, M. Inhibitory effect of mung bean extract and its constituents vitexin and isovitexin on the formation of advanced glycation end products. Food Chemistry. 2008; 106: 475-481.
24. Qian J; Kuhn M. Physical properties of buckwheat starches from various origins. Starch/Starke. 1999; 51: 81–85.
25. Rawat, V.S; Rawat, Y.S; Shah, S. Indigenous knowledge and sustainable development in the tones valley of Garhwal Himalaya Journal of Medicinal Plants Research. 2010; 19(4): 2043-2047.
26. Smith AC; Singh N. New applications of extrusion technology, Indian Food Industry, 1996; 15: 14-23.
27. Singh N; Cairns P; Morris V.J; Smith A.C. Physical properties of extruded wheat starch-additive mixtures, Cereal Chemistry. 1998; 75: 325-330.
28. Steadman K.J; Burgoon M.S; Lewis B.A; Edwardson S.E; Obendorf R.L. Buckwheat seed milling fraction: description, macronutrient composition and dietary fibre. Journal of Cereal Science. 2001; 33: 271–278.
29. Wen L.F; Rodis P; Wasserman B.P. Starch fragmentation and protein insolubilization during twin screw extrusion of corn meal, Cereal Chemistry 1990; 67(3): 268-275.
30. Zieliñski H; Koz³owska H. Antioxidant activity and total phenolics in selected cereal grains and their different morphological fractions. Journal of Agricultural and Food Chemistry. 2000; 48: 2008–2016.

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Food Consumption Pattern and Nutritional Status of Marginal and Small Farm Families of U.S. Nagar District of Uttarakhand

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Abstract

With the increase in number of families, the food consumption pattern and nutritional status of 50 marginal and 50 small farm families in U.S. Nagar district of Uttarakhand state were assessed. The results indicated that the per capita availability of cereals per day on marginal and small farms were 402.82 and 413.52 grams respectively, which were lower than the recommended quantity of cereals per day (420 g). Similarly, availability and consumption level of pulses, vegetables and milk were also found to be quite low than the recommended quantities given by ICMR. Iron and carotene were the most deficient nutrients among the subjects of all the age groups in both marginal and small farm families. Thiamine, calcium and vitamin C intake was in safer zone in both types of families. The results of triceps skinfold thickness for females indicated 16.3 percent and 5.5 percent in marginal and small farm families respectively while figures with respect to males was 16.9 and 5.7 percent in marginal and small farms. The mid upper arm circumference (MUAC) results that 3.4 to 22 percent males and 4.8 to 22 percent females were at risk category(<5 percentile). The results of Gomez classification for children upto 5 years revealed that 71.43 and 45.45 percent children respectively on marginal and small farms suffered from various type of malnutrition. According to Water low classification, 65.22 percent and 39.02 percent children of 5-18 years on marginal and small farms were suffering from various degree of malnutrition. The overall results indicated that, from the point of view of food security and nutritional status, the subjects from both the small farm families as well as marginal families were unsecured.

Keywords: Food Security; Malnutrition; Per Capita Availability.

Introduction

Nutritional status is definitely influenced by the food and nutrition security of individuals. Food and nutrition security leading to a healthy population have been the endeavour of the Indian government. Attainment of food security is the biggest challenge for the country from the very beginning of new millennium. Food security refers to adequate availability of basic food items, particularly food grains, in the country as a whole and also availability of adequate purchasing power to meet the food requirements at the household level. According to the report of the International Food Policy Research Institute (1992), Washington, food security is basically defined as access by all people, at all times, to the food needed for a healthy life. Accelerated agricultural development based on increase in productivity and income would meet both these elements of food security. The rapidly increasing population of our country, majority of which belongs to rural areas and the increasing demand for food makes large population to be absorbed as a labour force in agriculture. Due to increasing population, law of inheritance and partition of families, the number of marginal and small farmers is increasing. The low productivity in Indian agriculture is generally attributed to marginal (having cultivated land upto one hectare) and small size (possessing cultivated land from one to two hectare) of land holdings, which in turn causes low level of income and consequently affects the level of consumption and nutrition.

In view of the above facts, the present study was planned to study the food and nutrition security of small and marginal farm families in rural area of U.S. Nagar district in the state of Uttarakhand, so that

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essential steps can be formulated to improve upon the condition of such families.

Materials and Methods

Selection of the Study Area

The present study was conducted in six villages of Rudrapur block of Udham Singh Nagar district of Uttarakhand state. The selected villages were Shantipuri, Anandpur, Gangapur, Ganeshpur, Phulsunga and Narayanpur. A sample size of 100 farmers i.e. 50 marginal and 50 small was selected.

Required information related to family ecology, food habits and anthropometric measurements was collected.

Dietary Method

For measuring the dietary adequacy, the per capita availability of various food items was computed. 24 hours dietary recall method was used to collect information on food consumption of subjects of selected farm families. The selected farm families were asked about frequency of certain food items or food groups consumed during a specified time period i.e. daily, twice a week, weekly, and monthly.

Anthropometric Measurements

The anthropometric measurements including height, weight triceps skinfold thickness and Mid Upper Arm Circumference (MUAC), were determined by the method given by Jelliffee (1966).

Interpretation of Anthropometric Measurements

1. The interpretation of anthropometric measurements was done by Gomez classification for children between 0-5 years.
2. Waterlow classification for children between 5-18 years and BMI (Body Mass Index) classification for adults.

Results and Discussion

The results obtained on family type, farm income, food habits, educational status, food consumption pattern, dietary adequacy, average food intake and nutritional status of small and marginal families are being described here.

Table 1: General profile of selected marginal and small farmers

Sl. No.	Particulars	Marginal Farmers		Small farmers		Marginal + Small farmers	
		No.	%	No.	%	No.	%
1.	**Family Type**						
	Nuclear	27	54	24	48	51	51
	Joint	23	46	26	52	49	49
2.	**Food habits**						
	Vegetarian	28	56	19	38	47	47
	Non-vegetarian	22	44	31	62	53	53
3.	**Educational status**						
	Illiterate	22	10.18	36	11.15	64	10.70
	Primary	54	19.61	51	15.79	105	17.56
	Secondary	36	13.09	48	14.86	84	14.05
	High School	57	20.73	53	16.40	110	18.39
	Intermediate	41	14.91	57	17.65	98	16.39
	Graduation	34	12.36	48	14.86	82	13.71
	Above graduation	25	9.09	30	9.29	55	9.20

Family Type

General family profile (Table 1) showed that the percentage of nuclear families (51%) was higher than the joint families (49%) in the study area.

Farm Income

The average farm income of marginal and small farm families were Rs. 36192 and Rs. 58303 respectively, whereas annual per capita income on small was Rs. 15563 and that for marginal farm it was Rs. 14383 as shown in Table 2 and Table 3.

Family Size

Average family size for marginal farm families (5.26) was smaller than that for the small farm families (6.65). Similarly the average size of land holdings for marginal farm families was lower (0.736 ha) than that of the small farm families (1.528 ha) as is clear from Table 2 and 3.

Table 2: Size of family and per capita income on marginal farms

Size of farms (ha.)	Average size of family (no.)	Farm Income (Rs.)	Non farm income (Rs.)	Total Income (Rs.)	Annual per capita income (Rs.)	Per capita/day income (Rs.)
0.40	4.88	21463 (40.41)	31650 (59.59)	53113 (100.00)	10884	29.82
0.60	5.40	34655 (47.05)	39000 (52.95)	73655 (100.00)	13640	37.37
0.80	4.75	42107 (45.56)	50310 (54.44)	92417 (100.00)	19663	53.87
1.00	6.00	46543 (58.13)	33530 (41.87)	80073 (100.00)	13346	36.56
overall (0.736)	5.26	36192 (48.38)	38623 (51.62)	74815 (100.00)	14383	39.41

Note: Figures in parenthesis show the percent contribution of farm and non farm income to total income respectively on different size and overall size of marginal farms.

Table 3: Size of familyand per capita income on small farms

Size of farms (ha.)	Average size of family (no.)	Farm Income (Rs.)	Non farm income (Rs.)	Total Income (Rs.)	Annual per capita income (Rs.)	Per capita/day income (Rs.)
1.2	7.43	40830 (57.30)	30429 (42.70)	71259 (100.00)	9591	26.28
1.4	5.08	51976 (54.53)	43333 (45.47)	95309 (100.00)	18762	51.40
1.6	6.40	61967 (58.38)	44183 (41.62)	106150 (100.00)	16586	45.44
1.8	6.33	63657 (88.34)	8400 (11.66)	72057 (100.00)	11383	31.19
2.0	8.00	73085 (42.51)	98850 (57.49)	171935 (100.00)	21492	58.88
overall (1.528)	6.65	58303 (56.42)	45039 (43.58)	103342 (100.00)	15563	42.64

Note: Figures in parenthesis show the percent contribution of farm and non farm income to total income respectively on different size and overall size of small farms

Food Habits

On aggregate basis a higher percentage (53%) of families was found to be non-vegetarian in comparison to vegetarian families (47%). The percentage of non vegetarian families (62%) was higher on small farms as compared to marginal farms (44%) as depicted in Table-1.

Educational Status

Illiteracy was still prevailing on both the marginal and small farm families and about 10.18 and 11.15 percent subjects were found illiterate on both the marginal and small farms respectively. The literacy percentage on marginal and small farms were 89.82 and 88.85 percent respectively (Table 1). The percent of population having graduation and above graduation on marginal and small farms were 21.45 and 24.15 percent. In other words, the literacy percentage in the study area was higher than the all India average (64.84 percent).

Food Consumption Pattern

The consumption frequency of various types of food materials like cereals, pulses, GLVS, roots and

Table 4: Consumption frequency of food among selected marginal and small farm families (percent)

Food	Family (N=50)	Daily (%)	Twice/ week (%)	Weekly	Frequently (%)	Monthly
Marginal Farm Families						
Cereals	50	100	-	-	-	-
Pulses	50	60	10	-	30	-
Green Leafy Vegetables	50	-	8	10	6	76
Roots and Tubers	50	100	-	-	-	-
Nuts and Oilseeds	50	100	-	-	-	-
Spices and Condiments	50	100	-	-	-	-
Meat, fish & poultry products	23	-	-	8	2	36
Milk and milk products	50	84	-	4	12	-
Small Farm Families						
Cereals	50	100	-	-	-	-
Pulses	50	75	5	-	20	-
Green Leafy Vegetables	50	2.0	12	4	8	74
Roots and Tubers	50	100	-	-	-	-
Nuts and Oilseeds	50	100	-	-	-	-
Spices and Condiments	50	100	-	-	-	-
Meat, fish & poultry products	32	-	4	6	4	50
Milk and milk products	50	74	6	-	20	-

tubers, nuts and oil seeds, spices and condiments, meat, fish and poultry products etc. by families of selected marginal and small farms have been given in Table 4.

It is evident from the results that cereals constituted the basic food materials and were consumed daily by both the categories of families. The pulses which are considered as the rich source of protein, were not available for daily consumption. Only 60 percent families of marginal and 75 percent of small farms were in a position to consume pulses daily. However 10 percent families on marginal and 5 percent on small farms were in a position to consume pulses only twice in a week.

The consumption of GLV was not found on marginal farms. Only 2 percent small farm families indicated the inclusion of green leafy vegetables in their daily diet. Results indicate that 8 percent families of marginal farms and 12 percent families of small farms consume GLVs twice in a week in their diet. Similarly weekly consumption of GLVs was observed by 10 and 4 percent families of marginal and small farms respectively. Six percent marginal and 8 percent small farm families told that they used to consume GLVS frequently and 76 and 74 percent marginal and small farm families respectively consumed GLVS once in a month.

The consumption of roots and tubers, nuts and oils, spices and condiments was made daily by all the families of both the categories.

Among the selected marginal and small farm families, the number of families consuming meat, fish and poultry products were 23 and 32 respectively. About 8, 2 and 36 percent families of marginal farm used to consume non vegetarian foods weekly, frequently and monthly respectively whereas by small families as weekly, frequently and monthly were 6,4 and 50 percent respectively. The daily milk consumption was indicated by 84 and 74 percent of the marginal and small farm families respectively. However, 12% marginal and 20% small farm families consumed milk frequently.

The overall analysis of various types of food intake by marginal and small farm families indicated that except cereals, the consumption frequency of the other food materials was not to the desired level.

Per Capita Per Day Availability of Food Items

The results pertaining to per capita per day availability (g) of various food materials on various size of marginal and small farms are depicted in Tables 5 & 6. The per capita per day availability of various food items revealed that the availability of cereals on small (413.52 g) and marginal farms (402.82 g) was near to recommended quantities (420 g), but the availability of other three food items i.e. pulses, vegetables and milk were far below the requirements. The availability of pulses on marginal farms (27.06 g/day/capita) shows that it was even less than 50% of the recommended quantity (60 g/day/capita) and for small farms as 29.62 g/day/capita. The main reasons for low availability of pulses was that these were considered as more risky crops and hence farmers were not allocating area under pulse crops. Moreover, lands were also not suitable for successful cultivation of these crops and purchases were low due to their high costs.

Regarding the availability of vegetables by both marginal and small farm families, it was observed that the vegetables produced on the farm were not sufficient to meet the recommended requirements. The practice of growing vegetables was not common by the sample farmers and hence did not meet the recommended requirements. Due to lack of budget,

Table 5: Per capita per day availability (g) of important food materials on various size of marginal farms

Size of farms (ha.)	No. of farmers	Cereals	Pulses	Vegetables	Milk
0.40	8	398.75	25.13	64.38	106.88
0.60	12	396.58	26.17	77.50	128.33
0.80	18	403.78	27.06	82.08	128.33
1.0	12	410.33	29.25	88.02	139.00
overall (0.736) availability as percentage	50	402.82	27.06	80.50	127.46
of recommended quantity		95.91	45.10	20.13	42.49

Table 6: Per capita per day availability (g) of important food materials on various size of small farms

Size of farms (ha.)	No. of farmers	Cereals	Pulses	Vegetables	Milk
1.20	14	408.36	29.36	141.57	90.36
1.40	12	419.17	29.75	183.33	189.58
1.60	10	413.60	27.90	157.00	198.50
1.80	6	412.00	28.50	153.50	120.00
2.00	8	415.13	32.88	185.00	210.62
overall (1.528) availability as percentage	50	413.52	29.62	163.06	158.60
of recommended quantity		98.46	49.37	40.77	52.87

additional purchases of vegetables was not made on majority of sample farms. Milk consumption was better than pulses and vegetables availability due to large number of milch cattles reared by the people.

Dietary Adequacy

Nutrient adequacy for the subjects is given in Table 7. It was observed that the subjects of the both marginal and small farms were most deficient in iron and carotene i.e. 55.7% and 74.2% subjects of marginal families were found having adequacy <50 % for iron and carotene respectively and in small farm 47.1% subjects had iron adequacy <50% and 69.3% had carotene adequacy <50%. Only calcium, thiamine and vitamin C were taken adequately by subjects of both type of families. However protein adequacy was experienced by 58.9 and 62.8 percent of subjects of marginal and small farm families respectively. Energy, riboflavin and niacin were marginally adequate for maximum number of subjects.

Table 7: Percent adequacy of various nutrients among marginal and small farm families

Nutrients (%)	Marginal farm family (n=275)				Small farm family (n=323)			
	< 50%	50-75	75-100	>100% RDA	<50%	50-75	75-100	>100% RDA
Energy	8.7	38.9	36.7	15.7	5.9	23.2	43.9	27.0
Protein	2.2	17.8	21.1	58.9	1.9	9.6	25.7	62.8
Calcium	4.7	9.8	17.1	68.4	1.9	4.6	7.7	85.8
Iron	55.7	32.0	8.7	3.6	47.1	38.7	7.4	6.8
Carotene	74.2	1.8	2.2	21.8	69.3	4.0	5.6	21.1
Thiamine	3.6	9.1	17.1	70.2	1.9	2.8	11.1	84.2
Riboflavin	13.5	37.5	23.2	25.8	3.7	18.0	24.1	54.2
Niacin	7.6	26.2	34.2	32.0	4.3	12.1	32.2	51.4
Vitamin C	3.3	6.5	7.6	82.6	2.5	2.8	3.1	91.4

Table 8: Average food intake by the subjects of marginal farm families (gram/capita/day)

Nutrients (%)	*Marginal farm family (n=275)*				*Small farm family (n=323)*			
	< 50%	*50-75*	*75-100*	*>100% RDA*	*<50%*	*50-75*	*75-100*	*>100% RDA*
Energy	*8.7*	*38.9*	*36.7*	*15.7*	*5.9*	*23.2*	*43.9*	*27.0*
Protein	*2.2*	*17.8*	*21.1*	*58.9*	*1.9*	*9.6*	*25.7*	*62.8*
Calcium	*4.7*	*9.8*	*17.1*	*68.4*	*1.9*	*4.6*	*7.7*	*85.8*
Iron	*55.7*	*32.0*	*8.7*	*3.6*	*47.1*	*38.7*	*7.4*	*6.8*
Carotene	*74.2*	*1.8*	*2.2*	*21.8*	*69.3*	*4.0*	*5.6*	*21.1*
Thiamine	*3.6*	*9.1*	*17.1*	*70.2*	*1.9*	*2.8*	*11.1*	*84.2*
Riboflavin	*13.5*	*37.5*	*23.2*	*25.8*	*3.7*	*18.0*	*24.1*	*54.2*
Niacin	*7.6*	*26.2*	*34.2*	*32.0*	*4.3*	*12.1*	*32.2*	*51.4*
Vitamin C	*3.3*	*6.5*	*7.6*	*82.6*	*2.5*	*2.8*	*3.1*	*91.4*

Table 9: Average food intake by the subjects of small farm families (gram/ capita/day)

Age (years) and sex	Cereals (g)	Pulses (g)	Vegetables (g)	Fruits (g)	Milk (ml)	Meat (g)	Fat and oil (g)	Sugar/ Jiggery (g)
1-3	64	15	55	8	325	-	5	12
4-6	79	18	65	11	323	-	7	13
7-9	103	26	70	19	315	-	9	12
10-12 (male)	240	27	75	12	236	-	18	20
10-12 (female)	235	25	85	14	226	-	17	18
13-15 (male)	281	29	75	17	215	-	19	21
13-15 (female)	253	28	82	15	189	-	17	17
16-18 (male)	291	30	80	15	165	-	22	21
16-18 (female)	276	32	45	16	137	-	18	24
18-60 (male)	412	30	100	17	75	-	24	21
18-60 (female)	405	28	85	15	80	-	19	22
> 60 (male)	400	27	75	17	80	-	15	17
> 60 (female)	392	25	70	12	40	-	13	15

Average Food Intake by Marginal and Small Farm Families

Consumption of cereals by children of all age groups on both type of families, was less than the recommended quantity. However, the consumption

of cereals was higher than the recommended quantities for adults. The level of pulse and vegetable consumption for all subjects was quite lower than the recommended quantities. Milk consumption by children was higher as compared to adults. Consumption of fruits was very low among subjects of all age groups. Similarly, consumption of fats and sugar were also found to be lower than the recommended levels.

In a nut shell, except cereals, the consumption level of all other food materials was lower than the recommended quantities in both groups of families as shown in Table 8 and 9.

Nutritional Status

Nutritional Status of Adults (18 years and above) of Small & Marginal Families (according to BMI classification) It was found that in the total sample size of 93 males and 99 females in marginal farm families about 36.12 percent adults were suffering from malnutrition (CED I+CED II+ CED III), 21.67 percent subjects possessed low weight but were normal, 92.14 percent were found to be normal whereas 38.74 percent were falling in obese grade I and 11.76 percent in obese grade II (Table 10). Whereas in small farm families about 31.92 percent family members were suffering from malnutrition (CED I+II+III). About 89.54 percent adults were having normal and 20.07 percent low weight but normal nutritional status. The problem of grade I obese (51.23 percent) was observed to be more acute as compared to grade II obese (12.76 percent) as shown in Table 10.

Table 10: Nutritional status of adult males and females (18 years and above) of small and marginal farm families (according to BMI classification)

BMI	Small farm families					Marginal farm families				
	Male	(%)	Female	(%)	Affected aggregate %	Male	(%)	Fe-male	(%)	Affected aggregate %
<16	4	3.70	2	1.80	5.51	2	2.15	8	8.08	10.23
16-17	2	1.85	4	3.60	10.97	2	2.15	4	4.04	6.19
17-18.5	5	4.63	12	10.81	15.44	8	8.60	11	11.11	19.70
18.5-20	10	9.26	12	10.81	20.07	7	7.53	14	14.14	21.67
20-25	50	46.30	48	43.24	89.54	50	53.76	38	38.39	92.14
25-30	31	28.70	25	22.52	51.23	21	22.58	16	16.16	38.74
>30	6	5.56	8	7.21	12.76	3	3.23	8	8.08	11.76

A comparison of nutritional status of adults of marginal and small farm families indicated that all types of malnutrition on marginal farms were in severe form as compared to small farm families. This may be attributed to availability of inadequate food materials on both male and females members of marginal farms.

Nutritional Status of Children (0-5 yrs) on Marginal and Small Farms (based on Gomez Classification)

In all, 14 children in marginal farm families and 22 on small farms, between 0-5 years of age were studied for assessing their nutritional status. Out of these, only 28.57 percent children on marginal farms and 54.55 percent children on small farms were found normal and remaining percentage of children on both the categories of farms were suffering from different degrees of malnutrition (Table 11). The nutritional status of 21.43 percent children on marginal farms and 36.36 percent on small farms was moderate. On marginal farms, the nutritional status of about 42.86 percent children was observed to be mild while the percentage of such children was quite low (9.09 percent) on small farms. The case of severe deficient nutritional status was observed only in children of marginal farm families and not observed on small farms. It was found that overall nutritional status of children on small farms was comparatively better than the children of marginal farm families.

Table 11: Nutritional status of children (0-5 years) in small and marginal farm families (according to Gomez Classification)

Nutritional status	Small farm families		Marginal farm families	
	No. of children (n=22)	Percentage	No. of children (n=14)	Percentage
Normal	12	54.55	4	28.57
Moderate	8	36.36	3	21.43
Mild	2	9.09	6	42.86
Severe	-	-	1	7.14
Total	**22**	**100.00**	**14**	**100.00**

Nutritional Status of Children (5-18 yrs) on Marginal and Small Farms (based on Waterlow Classification)

The nutritional status of 69 children of marginal farms and 82 children of small farms in the age group of 5-18 yrs was studied as shown in Table 12.

Based on Waterlow classification about 34.78 percent children on marginal farms and 69.98 percent children of small farm families in the age group 5-18

years were identified as normal from nutrition point of view. On the other hand, more percentage of children (13.41 percent) in small farms were suffering from severe nutritional deficiency as compared to children in marginal farms (5.80 percent) as depicted in Table 12.

A comparison of nutritional status of children of marginal and small farms indicated that the degree of malnutrition among children of marginal farms was more pronounced as compared to small farms. Thus children on small farms were relatively better fed compared to marginal farms.

Table 12: Nutritional status of children (5-18 years) in small and marginal farm families (according to Waterlow Classification)

Nutritional status	Small farm families		Marginal farm families	
	No. of children (n=82)	Percentage	No. of children (n=69)	Percentage
Normal	50	69.98	24	34.78
Stunted	5	6.10	20	28.99
Wasted	16	19.51	21	30.43
Stunted & wasted	11	13.41	4	5.80
Total	82	100.00	69	100.00

Triceps Skinfold Thickness (TSK)

The triceps skinfold thickness (TSK) measurement revealed that higher percentage of males and females (16.9 and 16.3 percent respectively), of marginal farm families were falling in the risk category (<5 percentile) as compared to only 5.7 percent males and 5.5 percent females on small farms which indicated that status of small farms was relatively satisfactory as compared to marginal farms.

Mid Upper Arm Circumference (MUAC)

However, results for mid upper arm circumference measurement, revealed that 22 percent each of males and females of marginal farms were falling in the risk category i.e. <5 percentile. About 3.4 percent males and 4.8 percent females of small farm families were at risk of malnutrition which was quite lower as compared to males and females of marginal farms. Only 0.8 percent of females and no male was found in the range of >95 percentile.

Summary and Conclusion

Overall results of the study revealed that the food consumption pattern of both types of farm families was not satisfactory except cereals. The consumption level of all other food categories was lower than the recommended quantities. Results for nutritional status of marginal and small farm families revealed that the nutritional status of adults as well as children of small farm families was better than that of marginal farm families.

References

1. Gibson, R.S. Principles of Nutritional Assessment. New York. Oxford University Press. 1990; 639-649.
2. Gomez, F.; Ramos, G.R.; Frank, S..; Gravioto, J.; Chavez, R.; J. Mortality in second and third degree malnutrition. J. Trop. Pediatr. 1956; 2: 77-83.
3. Gopalan, C.; Rama Sastri, B.V. and Balasubramanian, S.C. Nutritive Value of Indian Foods. National Institute of Nutrition, ICMR, Jamai Osmania, Hyderabad. 1999; 156.
4. James, W.P.T.; Feuro-Luizzi and Waterlow, J.C. 1988. Definition of chronic energy deficiency in adults. Eur. Clin. Nutri. 1998; 42(12): 968-981.
5. Jelliffe, D.B. 1996. The Assessment of Nutritional Status of the Community. Geneva. World Health Organization.
6. Swaminathan, M. 1990. Essentials of Food and Nutrition. Vol. I. The Bangalore Printing and Publishing Co. Ltd, Bangalore. 1990; 927.
7. Waterlow, J.C. Classification and definition of protein calorie malnutrition. Br. Mid. J. 1972; 3: 566-563.

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Economic Analysis of Pumpkin and Papaya as Fruit Leathers and their Utilization as Protective Cover against Cancer in the Medical Science

Shivani Gupta*, S. Nikhil Gupta, Naveen Gupta***, Salil Jaggi******

Abstract

The present project entitled "Utilization of Pumpkin & Papaya for preparation of Fruit Leather" was undertaken in the School of Bioengineering & Food Technology, Shoolini University, Solan in 2014. Papaya & Pumpkin were undertaken in regard to physico-chemical analysis, effect of processing treatment on organoleptic characteristics of fruit leather. Papaya fruit contained 88.5% moisture, TSS 9°Brix, Titrable acidity 0.10% citric acid, colour pale yellow, %edible portion 80%, ascorbic acid 185.81mg/100g and total sugars 12.97g/100g. Pumpkin contained 83% moisture, TSS 10°Brix, Titrable acidity 0.38% citric acid, colour yellow, %edible portion 75%, ascorbic acid 14mg/100g and total sugars 9g/100g. Papaya leather made from different TSS of pulp had constant moisture content of 11%, ash content decreased from 6.9% in control sample to 0.9% in leather made from pulp of 25°Brix TSS, ascorbic acid content decreased from 60mg/100g in control sample to 40mg/100g in sample C and total sugar increased from 13g/100g in control sample to 20g/100g in sample C.

Pumpkin leather made from different TSS of pulp had constant moisture content of 10%, ash content decreased from 15% in control sample to 5% in leather made from pulp of 25°Brix TSS, ascorbic acid content decreased from 10mg/100g in control sample to 7.5mg/100g in sample C and total sugar increased from 11g/100g in control sample to 12.5g/100g in sample C. On the basis of sensory analysis of papaya leather, sample B i.e. leather made from pulp of TSS 20°Brix showed maximum overall acceptability. On the basis of sensory analysis of pumpkin leather, sample C i.e. leather made from pulp of TSS 25°Brix showed maximum overall acceptability.

Economic analysis for both type of Papaya and Pumpkin fruit leathers were performed. The results revealed that total cost for manufacturing 1kg of papaya leather was Rs. 140 and 1kg of pumpkin leather was Rs. 88.

Keywords: Pumpkin; Papaya; Fruit Leather.

Introduction

Papaya and Pumpkin are the fruits of commercial importance because of their nutritive and medicinal values. Papaya(*Carica papaya L*) belongs to the family of Caricaceaewhere as Pumpkin (*Cucurbitamoschata*) belongs to the family of Cucurbitaceae. There are three common types of pumpkin worldwide, namely *Curcurbitapepo*, *Curcurbita maxima* and *C. moschata* (Lee *et al.,*2003), whereas papaya comprised of six genera and 35 species (Ming *et al.,* 1975).

Cultivation

Papaya cultivation had its origin in South Mexico and Costa Rica. Total annual world production is estimated at 6 million tonnes of fruits. India leads the world in papaya production with an annual output of about 3 million tonnes. Other leading producers are Brazil, Mexico, Nigeria, Indonesia, China, Peru, Thailand and Philippines, Asia has been the leading papaya producing region, accounting for 52.55 percent of the global production

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between 2008 and 2010, followed by South America (23.09%), Africa (13.16%), Central America (9.56%), the Caribbean (1.38%), North America (0.14%), and Oceania (0.13%) (FAOSTAT, 2012). Pumpkins originated in America. Fragments of stems, seeds, and fruits have been identified and recovered from cliff dweller ruins in the southwestern United States. Some pumpkin varieties may have originated in Mexico and Central America, while others probably developed in Peru, Colombia, and Ecuador (Geisler, 2010).

Physico-Chemical Properties

Agriculture, food-processing, pharmaceutical as well as feed industry have all taken growing interest in pumpkin fruit and pumpkin-derived products in the past few years because of the nutritional and health protective value of the proteins and oil from the seeds as well as the polysaccharides from the fruit (Sojak*etal.*,2010). Pumpkin is a good source of carotene, pectin, mineral salts, vitamins and other substances that are beneficial to health (Jun *et al.*,2006). Traditionally, the pulp is used to relieve dyspepsia, stomach disorders and intestinal inflammation (Sentu & Debjani, 2007) and papaya contain high content of vitamin C and provitamin A, which has a protective effect against cancer. It is recommended for low hypo caloric diets for its low calorie status. For all these reasons, the acceptance of papaya as fruit is rising upward worldwide (Lobo *et al.*,1998). Papaya fruit is also a potential source of proteolytic enzymes like papain and chymopapain. As it contains proteolytic enzymes, it is used conveniently as digestive protein, meat tenderizer, digestive medicine, etc. in different manufacturing industries like pharmaceutical, brewing and tanning industries (Nakasone *et al.*,1998). Pumpkin fruit is an excellent source of vitamin A which the body needs for proper growth,healthy eyes and protection against diseases. It is rich in vitamin C, vitamin E, lycopene and dietary fibre (Pratt & Matthews,2003).

Fruit Leather

The origin of fruit leathers may go back to the PersianEmpire. They are known as "Pestil" in Turkey, "Bastegh" or "Pastegh" in Armenia, "Qamar al deen" in Lebanon, Syria and other Arab countries and "Fruit roll" or "Fruit leather" in the United States. The last denomination is possibly more usual in the scientific literature (Maskan*et al.,* 2002), (Chan *et al.,* 1978).

Fruit leather is made by drying thin layers of pureed fruit in the oven or dehydrator. Sometimes called fruit rolls or taffies, fruit leathers make delicious, wholesome and nutritious high-energy snacks for people on the go. They are relatively light in weight, easy to prepare and a good way to use left-over canned fruit and slightly over-ripe fresh fruit. Fruit leathers can be eaten as is, or made into a beverage by combining 5 parts water with 1 part leather in a food blender. They also can be used in pie fillings, in cooking and as a dessert topping. Nutritional food values become concentrated in dried fruit, and so do calories. Since moisture is gone, the residue is concentrated. So it becomes necessary to analyse changes in physical and chemical properties. Fruit leathers are dehydrated fruit-based products that are eaten as candy or snacks, and presented as flexible stripes or sheets. They receive this name because of the final product aspect (it is shiny and has the texture of leather).

Due to its novel and attractive structure, and for being products that do not require refrigeration, they constitute a practical way to incorporate fruit solids,especially for children and adolescents. Fruit leathers allow left over ripe fruits to be preserved. Moreover, fruit pulp left from making jellies, during prolonged time in reduced volumes may also be converted into leathers.

In recent times, increased attention has been focused on under utilized indigenous crops, for example thepumpkin, and their promotion would help maximize the available resources, eradicate the dearth in foodsupply and be useful in food industries in the formulation of value added products thus cater for the dailyneeds of the citizens nutritionally. Despite the pumpkin being regarded as a 'poor mans' food and as anorphaned crop, it represents a cheap but quality nutrition for large parts of the population in both rural andurban areas (Chweya and Eyzaguirre, 1999).

Papaya and pumpkin are fruits having large amount of moisture content so they have a shelf life of few days only. These fruits should be preserved because of their so much nutritional and functional benefits. Fruit leather manufacturing is a step in this direction. So keeping in view the shelf life, nutritional and functional aspects, following objectives had been chosen for the present research work.

- Development of fruit leather from papaya and pumpkin
- Analysis of physico-chemical properties of fruit leather from papaya and pumpkin

Materials and Methods

The details of the materials used and methods adopted during present investigation are presented in this chapter.

Materials Required

Pumpkin and Papaya

The well matured and fully ripened pumpkin and papaya were purchased from local market of Solan. The colour of both was yellow and they were checked for defects before purchasing.

Sugar

Granulated sugar was purchased from local market of Solan and was grinded before use.

Potassium Metabisulphite

Preservative used was of CDH(Central Drug House).

Packaging Material

White glass bottles were purchased from local market of Solan having capacity of 250gms.

Methods

Determination of Weight of Fruits

The weight was taken in gram with the help of an electric balance.The percentage of edible portion of fruit was calculated by using the formula: % of edible portion= (weight of edible parts ÷ weight of whole fruit)* 100

Determination of Titrable Acidity

Titrable acidity is an indication of the level of sourness of fruits (Rangana, *etal.,* 1979).Titrable acidity was analyzed using the titration method, fruit pulp (5g) was homogenized with 10mL of distilled water using homogeniser, and the mixture was filtered through sieve.Five mL of the filtrate with one to two drops of phenolphthalein (1%) as indicator was titrated using 0.1N NaOH to an endpoint pink. The results were expressed as percentage of citric acid per 100 g fresh weight.

$$\text{Formula: \% citric acid} = \frac{N*V*\text{Eq. wt.}*100}{W*1000}$$

Where N is normality of base

V is titre value

Eq. wt. is equivalent weight of acid

W is weight of sample

Determination of Ascorbic Acid

Ascorbic acid was determined using the Dye Method (Ranganna, 1979). Fruit pulp tissues (10 g) from papaya and pumpkin were homogenized with 90 mL of 3% metaphosphoricacid(HPO_3) using a homogeniser, the mixture was filtered through sieve. Five mLof aliquot was titrated with a standard dye solution (2, 6-dichlorophenol-indophenol) to a pink colour that persisted for 15 seconds. The ascorbic acid content(Vitamin C) was expressed as (mg/100g) of fresh fruits.

$$\text{Formula: mg of ascorbic acid per 100g} = \frac{\text{titre}*\text{dye factor}*\text{volume made up}*100}{\text{Aliquot of extract}*\text{Wt. of sample}}$$

Determination of Total Sugars

The Phenol - Sulphuric Acid method is an example of a colorimetric method that is widely used to determine the total concentration of carbohydrates present in foods(Ranganna, 1979). A clear aqueous solution of the carbohydrates to be analyzed was placed in a test-tube, and then phenol and sulphuric acid were added. The solution turned to yellow-orange colour as a result of the interaction between the carbohydrates and the phenol. The absorbance at 420 nm was proportional to the carbohydrate concentration initially in the sample. The sulphuric acid causes all non-reducing sugars to be converted to reducing sugars, so that this method determines the total sugars present. This method is non-stoichemetric and so it is necessary to prepare a calibration curve using a series of standards of known carbohydrate concentration.

Determination of Ash Content

Two porcelain crucibles were washed and dried in an oven to a constant weight at 100^{o}C for 10min. They were allowed to cool in a desiccators, then labelled A and B and weighed. 2.0 g of each sample were weighed into each of the previously weighed porcelain crucibles and reweighed. The crucibles

containing the samples were transferred into a furnace, which was set at 550°C for 8 hr to ensure proper ashing. They were then removed and allowed to cool in the desiccators then finally weighed (AOAC,1980).

$$\text{Formula: \% ash} = \frac{\text{weight of ash} * 100}{\text{Weight of sample}}$$

Determination of Moisture Content

Two petriplates were properly washed and allowed to dry in an air oven at 110°C for 10 min to a constant weight. The petriplates were allowed to cooled in a desiccators for 30 min, then labelled A and B and weighed. 2.0 g of each sample was accurately weighed into the previously labelled petriplates and reweighed. The petriplates containing the samples were placed in an oven maintained at 100°C till constant weight came. They were removed and transferred to desiccators to cooled, finally weighed(AOAC, 1980).

$$\text{Formula: \% moisture content} = \frac{(W_1 - W_2) * 100}{W_1 - W}$$

Where W_1 is weight of sample and petriplate before drying

W_2 is weight of sample and petriplate after drying

W is weight of empty petriplate

Method for Sensory Evaluation

The Organoleptic evaluation of fruit leather with respect to colour, flavour, texture, taste, appearance and overall acceptability were carried using departmental semi-trained panel members. The panel members were requested to evaluate the product on 9 Point Hedonic Scale (Ranganna, 1979).

Comments –

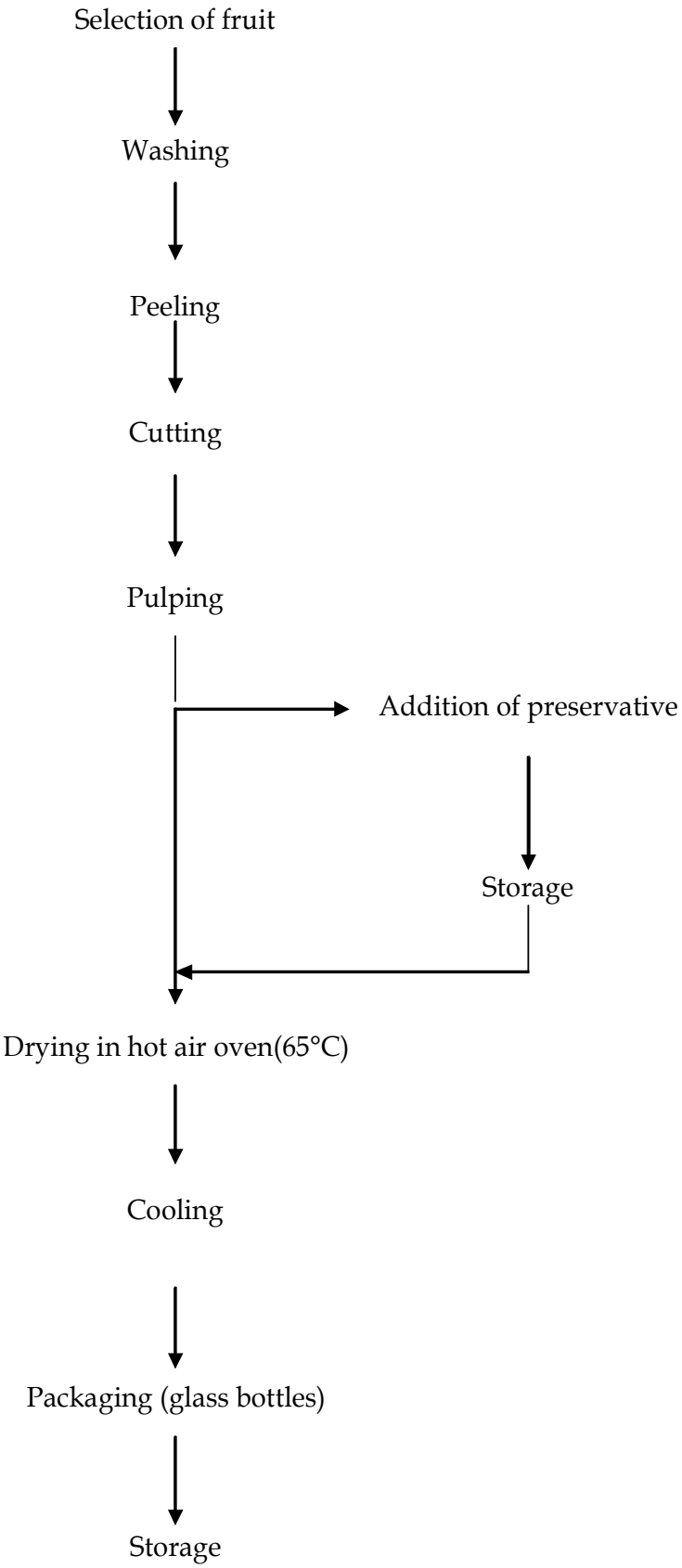
Table 3.1: Performa for sensory evaluation

Sample	Colour	Texture	Flavour	Sugar Acid Blend	Appearance	Overall acceptability

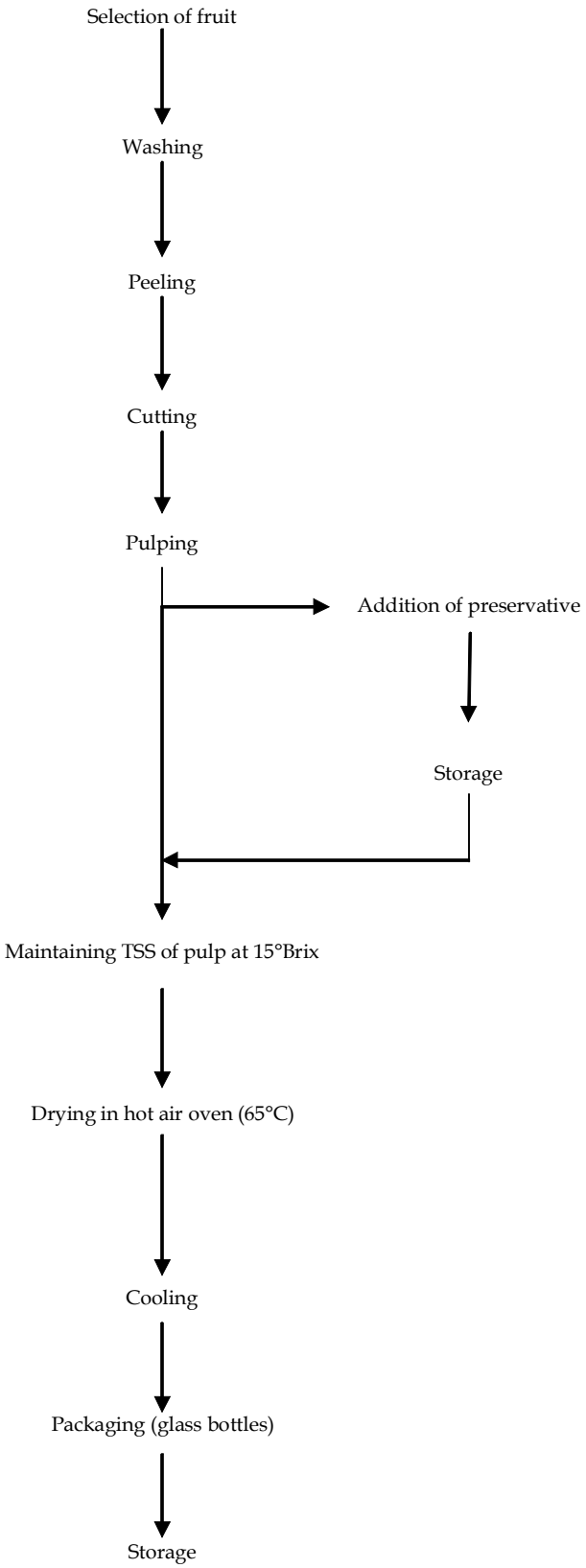
Name of evaluator	**Signature**
Hedonic scale	
Score	**Specifications**
9	Like extremely
8	Like very much
7	Like moderately
6	Like slightly
5	Neither like nor dislike
4	Dislike slightly
3	Dislike moderately
2	Dislike very much
1	Dislike extremely

Preparation of Fruit Leather

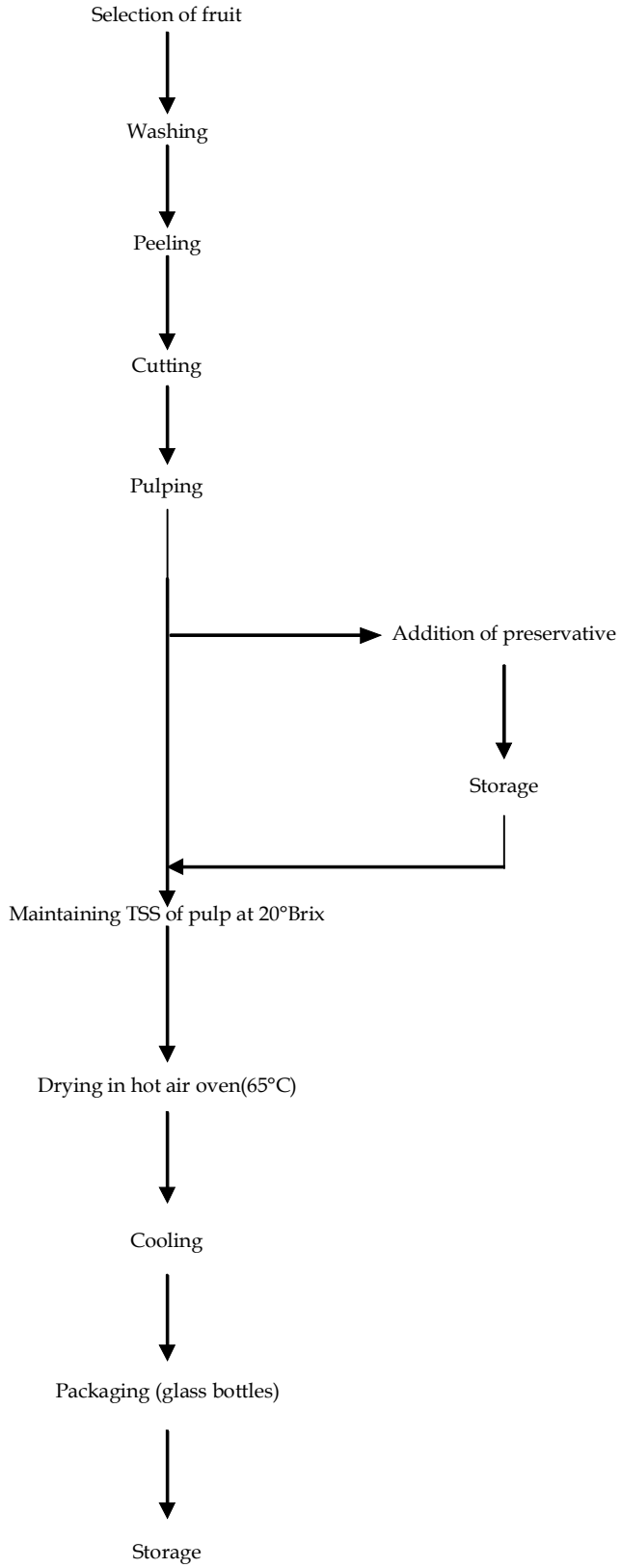
Standard Method (Flow sheet)



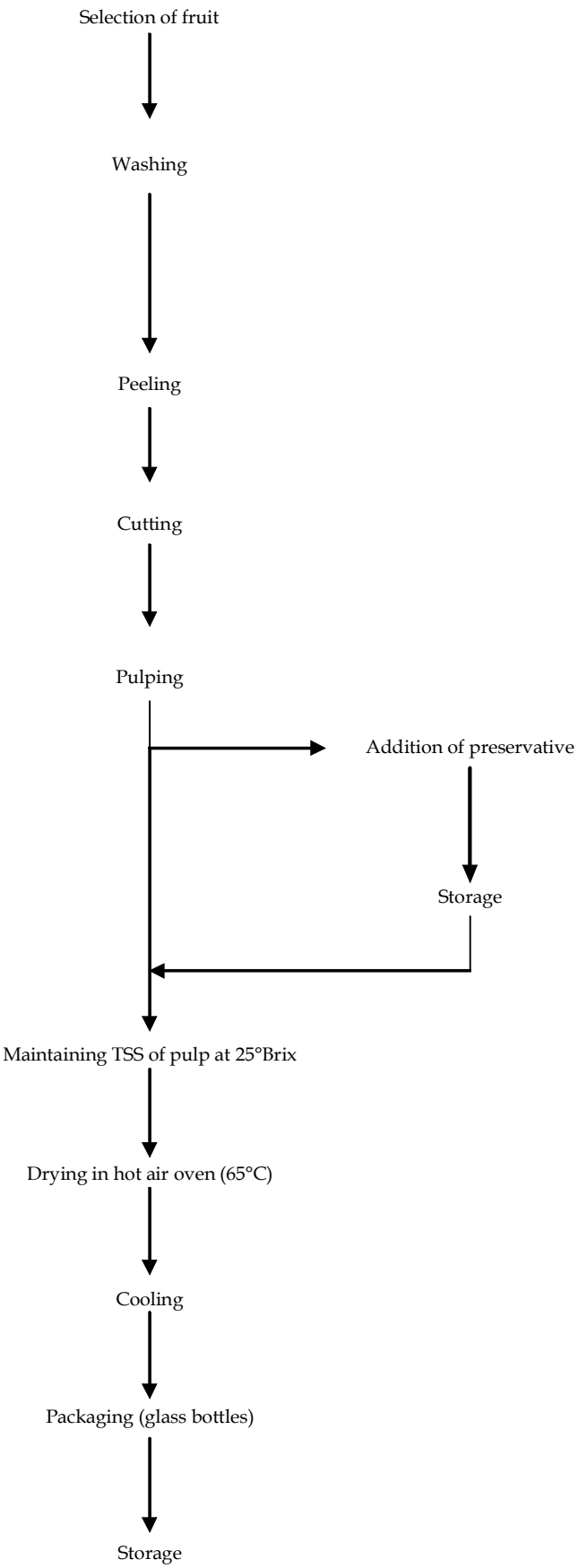
Method A (flow sheet)



Method B (flow sheet)



Method C(flow sheet)



Results and Discussion

The present research was undertaken to study thevarious physico-chemical properties of fruit leather prepared from pumpkin and papaya. The results obtained in the present investigation are presented and are discussed under suitable headings.

Physico-Chemical Analysis of Raw Papaya and Pumpkin

Table 4.1 shows the physico-chemical properties of raw pumpkin and papaya. Fruits have been incorporated in the class of perishable foods because of containing high amount of moisture content (Anonymous, 1979). Papaya and Pumpkin were also not found different from this as their moisture content 88.75% and 83% respectively was also higher in proportion. The moisture content also increases as the fruit ripens and its juiciness proves its higher amount of moisture. Such high moisture papaya fruits had also been reported by Akaniwor & Arachie, (2002) in Nigeria and Zaman*et al.,* (2006) in India. There was not much variation in the TSS, edible portion and colour of both fruits as pumpkin had slightly higher TSS and Papaya had slightly higher amount of edible portion.

The Titrable acidity of Papaya and Pumpkin was estimated as 0.10% and 0.38% citric acid. Early season fruits have higher amount of Titrable acidity than late season ripened fruit. Such a decrease in acidity during ripening of papaya had been reported by Bron and Jocomino, (2006). Ascorbic acid, also known as Vitamin C, content in both fruits was significantly varied. Papaya had much higher amount of ascorbic acid than Pumpkin. According to Cho, (2004), papaya contains 313% of daily requirement while pumpkin serves only 8% of the daily requirement of Vitamin C for our body. The values of ascorbic acid mentioned in Table 4.1 also had match with Oathman, (2009) and Rao, (2013). The total sugar content of papaya and Pumpkin was analysed as 12.97 and 9g/100g pulp. According to Oathman, (2009), the total sugar content increases with the ripening of fruit as the pectin content converts in to sugars.

Physico-Chemical Analysis of Papaya and Pumpkin Leather

The fruit leather samples containing different concentration of sugar (Control, 15%, 20%, and 25%) were prepared from pumpkin and papaya by following the methodology mentioned in material and method section. Control sample contain only natural sugar present in fruit and no sugar was added from outside. All the samples were dried in hot air oven at 65°C.Physico-chemical properties are important qualitative indexes of any fruit for fresh consumption (Zaman*et al.*, 2006).

Various physico-chemical properties of Pumpkin and Papaya leathers have been given in Table 4.2. There was not significant variation in the moisture content of all samples of leathers prepared from Pumpkin and Papaya. The moisture content of Papaya leather ranged between 11.06 - 11.85% and 12.04 - 12.55% in Pumpkin leather. It has been reported by Prabhanjan, *et al*., (1995) that the higher temperatures provide a larger water vapor pressure deficit (the difference between the saturated water vapor pressure and partial pressure of water vapor in air at a given temperature), which is one of the driving forces for the outward moisture diffusion process (drying). According to Che Man *et al*., (1997), when higher temperatures and longer drying times are used, leather with lower moisture content is obtained.

According to Pathak*et al*., (1991), when heated air is used as drying medium, the primary factor influencing the rate of drying is temperature. During preliminary investigations, it was observed that leathers dried at temperatures above 60°C burnt the product. Studies have proved that prolonged exposure during hot air drying can lead to burning of the material which happens nearly at zero moisture content (Fasina*et al.*,1998). Similarly, higher temperatures and short time or distance can also result in burning of product. The latter is the reason for the observed burns during the experiment and shown in Figure 4.1.

The ash content of Papaya and Pumpkin leather ranged from 2.7-4.7% and 8.25–15.22% respectively (Table 4.2) and the reason for this variation is the addition of sugar. Bansal*et al* (2013) reported in his research that sugar content lowers the ash content. This implies that temperature had no effect on the ash content of leathers. The ash content is a measure of the total amount of minerals present within a food. High mineral contents are sometimes used to retard the growth of certain microorganisms and can have beneficial effects on the physicochemical properties of foods.

Drying caused loss of ascorbic acid (Tables 4.2) and it was ranged in between 40–60mg/100g sample in Papaya leather and 7.5–10mg/100g sample in Pumpkin leather. The research conducted by Guang-yuan and Bo, (2000) had shown that furaldehyde and 5-(hydroxymethyl)furaldehyde (5-HMF) are the two

main compounds responsible for degradation of ascorbic acid. Their presence has been proposed as an index of browning (Kanner*et al.*, 1981). The oxidation and polymerization of phenolic compounds does not only lead to colour browning but also the formation of new colour pigments. The individual decrease of ascorbic acid in Papaya and Pumpkin leather was may be due to the increase of sugar content because temperature used for drying was the same.

Non-enzymatic browning reactions such as Maillard could possibly explain the browning that took place during drying. The Maillard reaction is the action of amino acids and proteins on sugars. Water activity levels <0.8 and associated moisture levels attained <25% could favour non enzymatic

Table 4.1: Physico-chemical analysis of raw papaya and pumpkin

Parameters	Papaya	Pumpkin
Moisture Content	88.75%	83%
TSS	9°Brix	10°Brix
Titrable Acidity	0.10% citric acid	0.38% citric acid
Colour	Pale yellow	Yellow
% Edible portion	80%	75%
Ash content	0.48%	2.1%
Ascorbic Acid	185.8mg/100g of pulp	18mg/100g of pulp
Total Sugars	12.97g/100g	9g/100g

Table 4.2: Physico-chemical analysis of papaya and pumpkin leather

Leather Type	Papaya Leather				Pumpkin Leather	
Parameters	Control Sample	15%	20%	25%	Control Sample	25%
Moisture	11.22%	11.85%	11.06%	11.55%	12.55%	12.04%
Ash	4.7%	3.6%	3.1%	2.7%	15.22%	8.25%
Ascorbic acid	60mg /100g	50mg /100g	45mg /100g	40mg /100g	10mg /100g	7.5mg /100g
Total Sugars	13g /100g	16g /100g	18g /100g	20g /100g	11g /100g	12.5g /100g

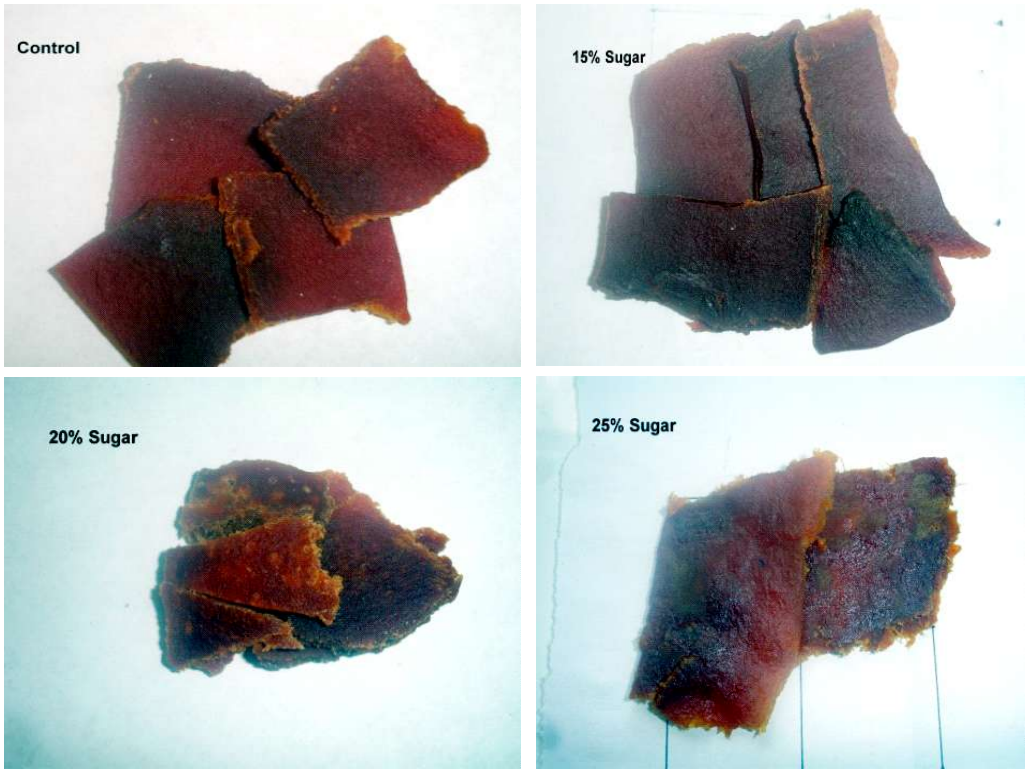


Fig. 4.1: Samples of papaya fruit leather prepared by different blends of sugar

Fig. 4.2: Samples of pumpkin fruit leather prepared by different blends of sugar

browning (Sumaya-Martinez *et al*., 2005). Nonetheless these reactions occur mainly at temperatures greater than 95°C (Sumaya-Martinez *et al*., 2005). Since the temperature of drying (50°C) was lower than 95°C, other factors as vitamin C and polyphenols oxidation could have resulted in browning.

Total sugar content showed the increasing trend in both Papaya and Pumpkin leather (Table 4.2) and this was ranged in between 13-20 g/100g and 10-12.5 g/100g in Papaya and Pumpkin leather, respectively. The reason was the addition of sucrose from outside which also enhanced the taste and flavour of the final product.

Research conducted by McClements, (1999) has shown that the physico-chemical properties of foods ultimately determine their perceived quality and behaviour during storage and consumption. The values obtained indicate that leathers produced by hot air oven drying are similar to those reported in literature. Overall, the values obtained indicate that the leathers are of good quality in terms of vitamin C content, color (purplish) and Moisture content.

Sensory Evaluation of Papaya Leather and Pumpkin Leather

The leatherprepared by various methods was served to semi – trained panel members to get the good quality product. Table 4.3 is clearly indicating that the leatherprepared by standard method and leather prepared by method A were showing similar sensory attributes of panel members. The leather prepared by method C had shown slightly less overall acceptability than standard method. Leather prepared by method B showed maximum overall acceptability.

Color is one of the quality parameters of fruit leathers because of its aesthetic appeal to consumers. The color of the fruit leather was not significantly affected. On average, the color of the Papaya fruit leather with 20% sugar content was liked very much by all respondents. In Pumpkin fruit leather 25% sugar content containing sample was liked the most.

Higher values were recorded for mouth feel compared to all the other parameters. This indicates that panelists disliked the mouthfeel slightly and could be attributed to the fact that panelists were not used to the chewy nature of the leathers. This is because about 40% of the panelists commented that it got stuck to their molars and this could have affected the values for mouthfeel. For leathers with no Sugar and 15% sugar, no significant differences existed between them. However, they differed from both leathers with 20% and 25% sugar. This indicates that mouthfeel as perceived by panelists was affected by the percentage of sugar and acceptability increased with increased amount of sugar. From literature low sugar content leather is harder and has more chewiness, whereas increased sugar content makes texture more viscous and therefore less chewiness

Table 4.3: Sensory evaluation of papaya leather

Sample	Colour	Mouth feel	Taste	Smell	Appearance	Overall Acceptability
Control Sample	8.0	7.0	7.0	7.0	7.0	7.0
Sample A	8.0	8.0	7.5	7.0	7.5	7.0
Sample B	8.5	9.0	8.5	9.0	8.5	8.0
Sample C	7.0	7.0	8.0	7.5	8.0	6.0

Table 4.4: Sensory evaluation of pumpkin leather

Sample	Colour	Mouth feel	Taste	Smell	Appearance	Overall Acceptability
Control Sample	7.0	7.0	6.0	6.0	7.0	6.0
Sample C	8.0	8.0	8.0	7.0	7.0	7.0

(Jain and Nema, 2007). The highest mean score indicates slightly hard texture whilst lower rating shows soft texture.

The taste recorded high average values from 8.5 to 6 (like very much-like slightly). It is evident from Table 4.3 and 4.4 that consumer preference increased with increasing sugar content.

The smell (flavor) of foods is a very essential component of sensory evaluation. From the sensory analysis result, the smell of the leathers was not affected significantly by the amount of sugar added. Papaya only and 15% sugar had no significant difference but differed slightly from 20% and 25% sugar. Significant difference in smell of Pumpkin fruit leather sample was noticed because of the difference in sugar amount i.e. control sample and 25% sugar sample. Therefore, based on the panelists' preference, incorporating sugar affected the flavor but did not follow any trend.

The overall acceptability of Papaya and Pumpkin fruit leather was not significantly affected. This shows that 20% sugar can be used in leather production without consumers detecting any change when it is compared with leather made from Papaya only. Similarly 25% sugar can be beneficial to add in preparation of Pumpkin leather.

Economic Analysis of Papaya Leather

Development costs, while generally a small percentage of total cost, can have significant effects on technology choice and lead to substantial cost savings. A thorough economic analysis of the product and the required development effort is necessary in order to define the remainder of the development project (Adler *et al.,* 1995). Various types of cost calculated during the manufacturing of both papaya and pumpkin fruit leather has been mentioned in Table 4.5 and 4.6

Cost A:

Cost of Papaya fruit = Rs 30 per Kg.

Total quantity of fruit purchased = 2.5 Kg

Total cost of fruit = 2.5*30 = Rs. 75

Cost B:

Cost of Sugar = Rs. 36 per kg

Quantity of sugar purchased = 500g

Cost of sugar purchased = 36*0.5 = Rs. 18

Cost C:

Processing cost is generally taken as 10% of the Raw material cost.

The total cost of raw material was sum of Cost A and Cost B.

Cost A+ Cost B = Rs. 93

So 10% of this was Rs. 9.3

Cost D:

This cost included Packaging Cost. The glass container was used to store the fruit leather. The cost of one glass container was Rs. 20.

Total Cost of the Papaya fruit leather was calculated as sum of all costs.

Total cost = Cost A + Cost B + Cost C + Cost D

Total Cost = 75+18+9.3+20

= 122.3

The quantity of papaya fruit leather prepared was 875g. So the cost of 875g papaya fruit leather was Rs. 122.3. From this, the cost of one kg of papaya fruit leather was calculated and it was estimated as Rs. 139.77 ~ 140.

Table 4.5: Economic analysis of papaya leather

Sr.No	Component	Quantity	Cost (Rs)
1.	Papaya Fruit	2500gms	75
2.	Papaya Pulp	2000gms	-
3.	Sugar	500gms	18
4.	Total Raw Material Cost		93
5.	Packaging Cost	4	80
6.	Processing Cost		9.3
7.	Final Cost of leather	875gms	122.3
8.	Production Cost per kg of leather		139.77

Cost A:

Cost of Papaya fruit = Rs 30 per Kg.

Total quantity of fruit purchased = 4.0 Kg

Total cost of fruit = 4.0*30 = Rs. 120

Cost B:

Cost of Sugar = Rs. 36 per kg

Quantity of sugar purchased = 500g

Cost of sugar purchased = 36*0.5 = Rs. 18

Cost C:

Processing cost is generally taken as 10% of the Raw material cost.

The total cost of raw material was sum of Cost A and Cost B.

Cost A+ Cost B = Rs. 138

So 10% of this was Rs. 13.8

Cost D:

This cost included Packaging Cost. The glass container was used to store the fruit leather. The cost of one glass container was Rs. 20.

Total Cost of the Papaya fruit leather was calculated as sum of all costs.

Total cost = Cost A + Cost B + Cost C + Cost D

Total Cost = 120+18+13.8+20

= 171.8

Table 4.6: Economic analysis of pumpkin leather

Sr. No	Component	Quantity	Cost (Rs)
1.	Pumpkin	4000gms	120
2.	Pumpkin Pulp	3000gms	-
3.	Sugar	500gms	18
4.	Total Raw Material Cost		138
5.	Packaging Cost	2	40
6.	Processing Cost		13.8
7.	Final Cost of leather	1950gms	191.8
8.	Production Cost per kg of leather		98.35

The quantity of papaya fruit leather prepared was 875g. So the cost of 1950g papaya fruit leather was Rs. 171.8. From this, the cost of one kg of papaya fruit leather was calculated and it was estimated as Rs. 88.10 ~ 88.

References

1. Abalone, R., Cassinera, A., Gastón, A. and Lara, M.A. Thin layer drying of amaranth seeds, *Journal of Biosciences and Engineering. 2006;* 93(2), 179–188.
2. Anonymous.(1979). Post-harvest food conservation Report on the INSA-US-NAS JointWorkshop, New Delhi India.
3. AOAC (1995).*Official methods of analysis* (16th Ed.). Washington, DC: Association ofOfficial Analytical Chemists.
4. Ashaye, O.A., Babalola, S.O., Babalola, A.O., Aina, J.O., and Fasoyiro S.B. Chemical and organoleptic characterization of pawpaw and guava leathers.*World Journal of Agricultural.Science.* 2005; 1(1): 50-51.
5. Azeredo H. M. C., Brito E. S., Moreira G. E. G., Farias V. L. & Bruno L. M. Effect ofDrying and Storage Time on the Physico-Chemical Properties of Mango Leathers. *International Journal of Food Science and Technology*. 2006; 41(6): 635-638.
6. Babalola.S.O.,Ashaye, O. A., Babalola, A. O. and Aina, J. O. Effect of cold temperature storage on the quality attributes of pawpaw and guava leathers. *African Journal of Biotechnology*. 2002; 1(2): 61–63.
7. Bains M. S., Ramaswamy H. S. & Lo K.V. Tray Drying of Apple Puree.*JournalofFood Engineering. 1989;* 9(3): 195-201.
8. Barbosa-Cánovas, G.V. and Vega-Mercado, H. Dehydration of foods. *Chapman& Hall, New York*; 2006; 53-59.
9. Belitz, H.D., Grosch, W., Schieberle P. *Journal of Food Chemistry.* Berlin, SpringerVerlag. 2009; 886–890.
10. Bron I.U. and Jocomino A.P. Ripening and quality of "Golden" papaya fruit harvested atdifferent maturity stages. *Journal of Plant Physiology.* 2006; 18(3): 389-396.
11. Cazzonelli, C. I. and Pogson, B. J. Source to sink: Regulation of carotenoid biosynthesis in plants. *Trends in Plant Science.* 2010; 15: 266–274.
12. Chan H. T. andCavaletto C. G. Dehydration and Storage Stability of Papaya Leather.*Journal of Food Science*. 1978; 43(6): 1723-1725.
13. Che Man, IrwandiY.B.,YusofJ., SelamatS. andSugisawa, H. Effect of different dryers and drying conditions on acceptability and physicochemical characteristics of durian leather.*Journal of Food Process.* 1997; 21(5): 425–441.
14. Chinenye, N.M. (2009).Effect of drying temperature and air velocity on the drying rate and drying

constant of cocoa bean.*CIGR ejournal*.11.

15. Cho E, Sedden J.M, Rosner B, Willet W.C., Hankinson S.E. Prospective study of intake of fruits, Vegetables, vitamins and Carotenoids and risk of age related maculopathy. *Arch Ophthalmol*. 2004; 122: 883-892.
16. Chweya, J. AandEyzagirre P. B. (1999).The biodiversity of traditional Leafy Vegetables, *International Plant Genetic Resource Institute, Rome, Italy.*
17. Delahaut K.A.,Newenhouse A.C. (2006).Growing pumpkin & other vine crops is winsconsin: Aguide for fresh market growers (A3688), University Of Wisconsin extension publications 22.
18. Doymaz, I. Drying kinetics of white mulberry. *Journal of Food Engineering*. 2004; 61: 341-346.
19. Drouzas A. E., TsamiE.andSaravacos G. D. Microwave/Vacuum Drying of Model Fruit Gels. *Journal of Food Engineering*. 1999; 39(2): 117-122.
20. Ekanayake, S. and Bandara L. Development of banana fruit leather.*Annals of the Sri Lanka Department of Agriculture*. 2002; 4: 353-358.
21. Fasina, O.O., Tyler, R.T., and Pickaw, M.D. Modeling the infrared radiative heating of agricultural crops.*DryingTechnology*. 1998; 16(9 and 10): 2065-2082.
22. FAOSTAT (Food and Agriculture Organization of the United Nation) (2012).
23. FAOSTAT (Food and Agriculture Organization of the United Nation) (2013).
24. Fiorentini C., Leiva Diaz E.andGiner S. A. A Mass-Transfer Model for the Drying of an Innovative Tomato Gel.*Food Science and Technology International*. 2008; 14(1): 39-46.
25. Gonzalez-Aguilar, G. A., M. A. Martinez-Tellez, G. I., Olivas, E. Alvarez-Parrilla and L. A. de la Rosa, Bioactive compounds in fruits: Health benefits and effects of storage conditions *Postharvest Stewart Review*. 2008; 4: 1-10.
26. Goyal, R. K.,Kingsly, A. R. P., Manikantanl, M. R. and Ilyas, S. M. Thin-layer drying kinetics of raw mango slices.*Journal of Biosystem Engineering*. 2006; 95(1): 43–49.
27. Guangyuan Zhao, Bo Li. Determination of iron in Milk Powdermicrowave digestion and Flame Atomicabsorption Spectrophotometry. CCTA (*Colorado Conservation Tillage Association*). 2008; 3: 1629-1636.
28. Gujral H. S. and Khanna G. Effect of Skim Milk Powder, Soy Protein Concentrate and Sucrose on the Dehydration Behaviour, Texture, Color and Acceptability of Mango Leather.*Journal of Food Engineering*. 2002; 55(4): 343-348.
29. Harsimrat, K. and Dhawan, S. S. Preparation of guava fruit bar.*Poster abstrct*.IFCON. 1998; 04: 533.
30. Hu, F., Plant-based foods and prevention of cardiovascular disease.*Journal of Food Engineering. 2003; 99*: 142-150.
31. Huang X. and Hsieh F. H. Physical Properties, Sensory Attributes and Consumer Preference of Pear Fruit Leather.*Journal of Food Science*. 2005; 70(3): 177-186.
32. Imaga, N.O.A., Gbenle, G.O., Okochi, V.I., Akanbi, S.O., Edeoghon, S.O., Oigbochie, V., Kehinde, M.O., Bamiro, S.B. Antisickling property of *Carica papaya* leaf extract. *African.Journal of Biochemical*. 2009; 3: 102-106.
33. Irwandi I. andChe Man Y. B. Durian Leather: Development, Properties and Storage Stability. *Journal of Food Quality*. 1996; 19(6): 479-489.
34. Jain, P. K. and Nema, P. K. (2007). Processing of pulp of various cultivars of guava (*psidiumguajava*l.) for leather production. *ejournal*.9 Manuscript FP 07 001.
35. Jaturonglumlert S. and Kiatsiriroat T. Heat and Mass Transfer in Combined Convective and Far-Infrared Drying of Fruit Leather.*Journal of Food Engineering*. 2010; 100(2): 254-260.
36. Kanner, J., Harel, S., Fishbein, Y., and Shalom, P. Furfural accumulation in stored orange juice concentrates. *Journal of Agricultural Food Chemistry*. 1981; 29: 948-951.
37. Kajuna, S.T.A.R., Silayo, V.C.K., Mkenda A. and Makungu1 P.J.J. Thin layer drying of diced cassava roots. *African.Journal of Science Technology*. 2001; 2(2): 94-100.
38. Kumar, P.D.G., Hebbar, H.U. and Ramesh, M.N. Suitabilityof thin layer models for infrared–hot air-drying ofonion slices. LWT - Food Science and Technology. 2006; 39: 700-705.
39. Lahsasni, S., Kouhila, M., Mahrouz, M. and Jaouhari J.T. Drying kinetics of prickly pear fruit (Opuntiaficusindica).*Journal of Food Engineering*. 2004; 61: 173-179.
40. Lazos ES. Nutritional, Fatty acids and oil characteristics of pumpkin and melon seeds. *Journal of Food Science*. 1986; 51; 1382-1383.
41. LeivaDíaz E., Giannuzzi L. andGiner S. A. Apple Pectic Gel Produced by Dehydration. Food and Bioprocess Technology. 2009; 2(2): 194-207.
42. Leong, L. P., andShui, G. (2002).An investigation of antioxidant capacity of fruits in Singapore markets. *Journal of AgriculturalFoodChemistry*. 2002; 76(1): 69-75.
43. Leung, A.y., and S. Foster.(1996) *Encyclopedia of common ingredients used in fruit drug and cosmetics*, New York.
44. Lobo, M. G. and Cano, M. P. (1998).Preservation of hermaphrodite and female papaya fruits(Carica papaya L., cv. Sunrise, Solo group) by freezing: Physical, physico-chemical and sensorial aspects. Department of Plant Science and Technology, InstitudodelFrio. Consejo Superior de Investigaciones Cientfficas (CSIC), Ciudad Universitaria, E-28040 Madrid, Spain, 1-7.

45. Malik, S. K., Chaudhury, R., Dhariwal, O. P. and Bhandari, D. C. (2010).Genetic resources of tropical underutilized fruits in India. New Delhi: NBPGR.

46. Marfo, E.K., Oke, O.L., Afolabi, O.A. Chemical composition of papaya (*Caricapapaya*) seeds.*Journal of AgriculturalFood Chemistry*. 1986; 22: 259-266.

47. McClements. D.J. Principles and instrumentation of ultrasonic analysis.*Seminars in Food Analysis*. 1999; 4: 73-93.

48. Michael.,O.D, George L.G.and Jayson K. H. (2008).Pumpkin Production "Agricultural Alternatives (2000). Penn.State College of agriculture Sciences.

49. Mohammadi, A., Rafiee, S., Keyhani, A. and Emam-Djomeh, Z. Estimation of Thin layer drying characteristics of kiwifruit (cv. Hayward) with Use of Page's Model.*American-Eurasian Journal of Agricultural& Environmental Science*. 2008; 3(5): 802-805.

50. Modi and Reddy. Quality and decay of mango fruit wrapped in heat-shrinkable film.Horticulure Science. 1967; 18(6): 957-958

51. Moyls A. L. Drying of Apple Purees.*Journal of Food Science*. 1981; 46(3): 939-942.

52. Muhamad, Ida Idayu., MdZaki, N.A., Salleh, Liza Md, Khairuddin, N. Drying characteristics of papaya (Carica papaya L.) during microwave vacuum treatment.*World Engineering Congress, Penang, Malaysia*. 2007; 1-7.

53. NASS(National Agricultural Statistics Service) (2012).

54. NASS(National Agricultural Statistics Service) (2013).

55. Nakasone, H.Y., Paull, R.E. (1998).Tropical fruits. CAB International, Wallingford.

56. Ndukwu, M.C. Effect of drying temperature and drying air velocity on the drying rate and drying constant of cocoa bean.AgriculturalEngineering Institute CIGR*ejournal*.,Manuscript. 2009; 1091: 11.

57. Okeniyi, J.A.O., Ogunlesi, T.A., Oyelami, O.A., Adeyemi, L.A. Effectiveness ofdriedCarica papaya against Human intestinal parasitosis: A pilot study.*Journal of Medical.Federation*. 2007; 10: 194-196.

58. Okilya, S., Mukisa I. M., and Kaaya, A.N. (2010).Effect of solar drying on the quality and acceptability of jackfruit leather.*Journal of Environmental and Agricultural Food chemistry*. 2010; 9(1): 101-111.

59. Okos, M.R., Narsimhan, G., Singh, R.K. and Weitnauer, A.C. Food dehydration: In *handbook of Food Engineering*, (D.R. Heldman and D. B. Lund Eds.), 1992; 563-620.

60. Olagunju, J.A., Adeneye, A.A., Fagbohunka, B.S., Bisuga, N.A., Ketiku, A.O., Benebo, A.S.,Olufowobi, O.M., Adeoye, A.G., Alimi, M.A., Adeleke, A.G. Nephroprotectiveactivities of the aqueous seed extract of *Carica papaya* Linn. In carbon tetrachloride inducedrenal injured Wistar rats: a dose- and time-dependent study. *Journal of Biology and Medicine*. 2009; 1: 11-19.

61. Othman O.C. Heavy metals in green vegetables and soils from vegetable gardens inDares Salaam, Tanzania *Tanz. Journal of Science and Technology*. 2001; 27: 37-48.

62. Pathak, P.K., Agrawal, Y.C. and Singh B.P.N. Thin layer drying model for rapeseed. *TRANS. ASAE*. 1991; 34(6): 2505-2508.

63. Pathak D, Pathak K, Sigla AK. Flavonoids as medicinal agents: recent advances. Fitoterapia. 1991; 62: 371-388.

64. Prabhanjan, D.G., Ramaswamy, H.S., and Raghavan, G.S.V. Microwave-assisted convective air drying of thin layer carrots. *Journal of Food Engineering*. 1995; 25: 283-293.

65. Pratt S.G.,Mattews K. Superfoods RX: Fourteen Foods that will change your life,Harper Collins, New York. 2003; 352

66. Quintero Ruiz N. A. &Giner S. A. (2010). GelesPécticosDeshidratados de Manzana (*malusdomestica*Borkh. L, cv Granny Smith): Seguimiento de los Parámetros de Calidad Durante el.

67. Ranganna, S. (1979).Manual of Analysis of Fruits and Vegetables products. Tata McGraw-Hill Publishing Company Ltd., New Delhi. 2-95 and 634.

68. Rodriguez-Amaya, D. B. (1999).A guide to carotenoid analysis in foods.Washington:International Life Sciences Institute (ILSI) Press.

69. Rozek A., Garcia-Perez J. V., Lopez F., Guell C., Ferrando M. (2010).Infusion of grapephenolics into fruits and vegetables by osmotic treatment: Phenolic stability during airdrying.

70. Salunkhe, D.K. and B.B. Desai.(1984). Postharvest biotechnology of fruits.Vol. 2. CRC Press, Boca Raton FL

71. SentuS ,Debjani G. Effect of ripe fruit pulp extract of cucurbitapepolinn, In Aspirininduced gastric& duodenal ulcer in rats, S.N.Pradhancentre for neurosciences university ofCalcutta, Kolkata India. 2007; 639-645.

72. Sumaya-Martinez, M.T., Thomas, S., Linard, B., Binet, A. and Guerard, F. Effect of Maillard Reaction Conditions on Browning and Antiradical Activity of Sugar-tuna Stomach Hydrolysate Model System.*Food Research Institute*. 2005; 38(8-9): 1045-1050.

73. Taheri-Garavanda, A., Rafieea, S., and Keyhania., A. (2011).Mathematical modeling of thin layer drying kinetics of tomato.*Journal of Engineering, Applied Science and Technology*.

74. Temple, N.J. Antioxidants and disease.*Journal of Nutrition and Research*. 2000; 20(3): 449-459.

75. Torley P. J., De Boer J., BhandariB.R., Kasapis S., Shrinivas P. and Jianget B. Application of the Synthetic Polymer Approach to the Glass Transition of Fruit Leathers.*Journal of Food Engineering*. 2008; 86(2): 243-250.

76. Vijayanand P., Yadav A. R., Balasubramanyan N. and Narasimham P. (2000).Storage Stabilityof Guava Fruit Bar Prepared Using a New Process. Lebensmittel-Wissenschaft und-Technologie. 2000; 33(2): 132-137.

77. Villegas, V.N. (1997).Edible fruits and nuts - *Carica papaya*, WageningenUniversity.The Netherlands.

78. Yarnell E, Abascal K, Hooper C. Clinical Botanical Medicine. New York: Mary Ann Liebert, 2003; 293-306.

79. Zaman W, Biswas S.K., Helali MOH, Ibrahim M and Hassan P. Physicochemical composition of four papaya varieties grown at Rajshahi.*Journal of Biological Science*. 2006; 14: 83-86.

Review Article

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Vegetables as Functional Foods

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Abstract

The adequate nutrition is essential for good health and physical and cognitive development of human body. It requires a diverse diet including staple foods, vegetables, fruits, animal-source foods. Over 60% of the world's under nourished people live in Asia, and a quarter in Africa. Surprisingly, nearly 60-80% of the Indian population is deficient in Vitamin D. Dietary calcium intake among Indians remains significantly low, mainly in those who have vitamin D deficiency, as its absorption is dependent on adequate levels of vitamin D. The most common B12 deficiency was not thought to be prevalent in India but recent studies have shown 47-49% prevalence. Adequate levels of vitamin B12 are required for conversion of inactive folate to its active form. Naturally, those without adequate levels of B12 are likely to suffer from folic acid deficiency. Vitamin A deficiency still remains a major public health nutritional problem in rural pre-school children of India. It also makes children more susceptible to iron deficiency because of its crucial role in mobilising iron from the site where it is stored. More than 75% of toddlers in India suffer from iron-deficiency anemia and about 52 % of young girls are severely anemic. Deficiency of zinc is common in pregnant and lactating women, forming a predominant cause of death in children from rural areas.

India faces the human and economic threat posed by non communicable diseases (NCDs). Cardiovascular diseases, cancers, chronic respiratory diseases, diabetes, and other NCDs are estimated to account for 60% of all deaths in India, making them the leading cause of death – ahead of injuries and communicable, maternal, prenatal, and nutritional conditions. At present, almost every third person in the society is under stress and having chronic disorders like diabetes, arthritis, allergy, cardiovascular disease, fatigue and even cancer. The growing incidence of NCDs causes great individual hardship and places enormous burden on society, untenable in the long run for any country or economy. Recently, there is decline in the physical and mental capabilities along with the social values. The modern synthetic diet, formulated to appeal to our inherent attraction to sugar, salt, fats, and calories at the expense of nutrition, leaves us over-fed and under-nourished. A considerable portion of chronic human diseases, including diabetes and heart disease, appear to be related largely to a diet that is inadequate in the essential vitamins, minerals, phytonutrients, and other constituents found in natural, unprocessed foods. The vegetables are rich in vitamin and mineral content, flavonoid, isoflavone, and carotenoid which are essential to maintain health and fight disease.

Vegetable are an immense store of active chemical compounds and considered as the cheapest and most easily available sources of these essential nutrients.

Keyword: Vitamins; Minerals; Phytonutrients; Flavonoid; Isoflavone; carotenoid.

Vegetables as Functional Foods

The concept of nutraceuticals is not entirely new, although it has evolved considerably over the years. In the early 1900s, food manufacturers in the United States began adding iodine to salt in an effort to prevent goiter (an enlargement of the thyroid gland), representing one of the first attempts at creating a functional component through fortification. A nutraceutical is a food with a medical-health benefit, including the prevention and treatment of disease. Such foods also commonly are referred to as functional foods, signifying they and/or their components may provide a health benefit beyond basic nutrition. While all foods are functional in that they provide nutrients, nutraceuticals contain health-promoting ingredients or natural components that

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have a potential health benefit for the body.Among these foods vegetables (leaves, shoots, buds, flowers, roots, tubers etc) are rich sources of essential vitamins, minerals and phytochemicals (Figure 1) having functional properties.

Fruits, vegetables, and other plant-based foods are rich in bioactive phytochemicals that may provide desirable health benefits beyond basic nutrition to reduce the risk of the development of chronic diseases and also have been hypothesized to reduce the risk of major chronic diseases (Liu, 2004). The intake of green and leafy vegetables lowers the risk of chronic diseases, cardiovascular diseases, anemia, cancer, oxidative stress, diabetes, weight gain etc (Anu *et al.*, 2014).

Numerous nutraceuticals currently are on the market. The Table 2 represents available nutraceuticals / active principles and their potential human health benefits.

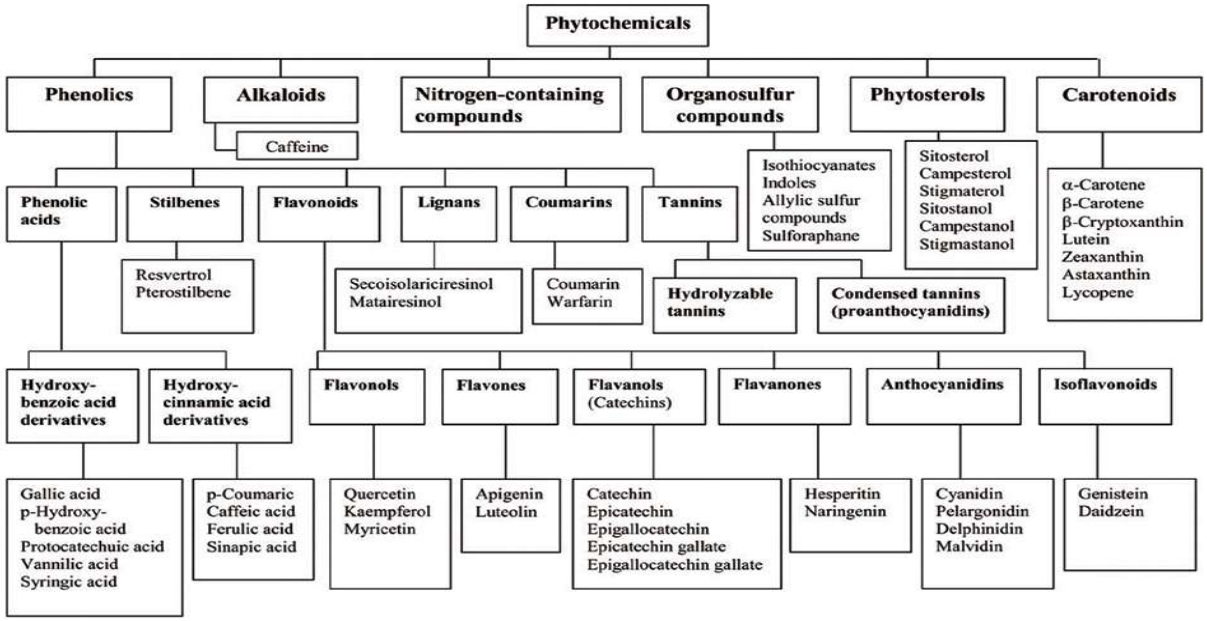

Fig. 1: List of various phytochemicals (Liu, 2004)
(Source: Mahima *et al.,* 2013)

Vegetables : Phytonutrients and Natural Antioxidants

Steinmetz and Potter (1991a) identified more than a dozen classes of these biologically active plant chemicals, now known as phytochemicals. Some of dark green leafy vegetables like arugula, broccoli, spinach, kale and cabbage; dandelion greens; swiss chard and watercress etc., provide a variety of nutrients like vitamin A and B complex, vitamin E, major minerals (calcium and phosphorous) and trace minerals (manganese and potassium) etc. Root vegetables like beets are rich in vitamin B complex, Vitamin C, manganese, magnesium, iron, copper and phosphorus. A close relative of Indian drumstick (*Moringa oleifera)* has highly nutritious leaves, edible flowers, edible pods, antibiotic properties in seeds and the bark is used as a hot condiment with one of the highest calcium levels and highest Vitamin C levels. Young plantain leaves, consumed raw in salad in Asia, are rich source in vitamin B1 and riboflavin.

Vegetables can provide phytonutrients as well as nutritional components, such as vitamins, minerals and fiber (Mattoo *et al*., 2007; Orech *et al*., 2007; Murphy *et al*., 2012; Bumgarner *et al*., 2012) and amazing source of antioxidants (Kiefer *et al*., 2004; Odukoya *et al*., 2007; Thompson *et al*., 2010) and vitamins (β-carotene, vitamins C and E (Esfahani *et al*., 2011; Mahima *et al*., 2011). Vegetables like carrots, pumpkins, acorn squash, butternut squash, Hubbard squash and sweet potatoes, also known as orange vegetables, are a rich source of carotenoids, which act as antioxidants. Due to presence of antioxidants, higher intake of green leafy vegetables and cruciferous vegetables reduces homocysteine and markers of oxidative stress (Singh *et al*., 2009; Esfahani *et al*., 2011) leading to lower risk of bladder cancer (Michaud *et al*., 1999), non-Hodgkin's lymphoma (NHL) and particularly follicular lymphoma (Thompson *et al*., 2010; Chiu *et al*., 2011). Increased consumption of vegetables has also been found to improve the Pneumovax II vaccination antibody response in older people, leading to improved immunity (Gibson *et al*., 2012). The antioxidants are

Table 2: Vegetables their scientific name, active principle and health benefits

Vegetable	Scientific name	Family name	Active principles	Beneficial health effects
Ladies finger	*Abelmoschus esculentus*	*Malvaceae*	Mucilage	Have blood sugar stabilizing property by regulating sugar absorption from intestine. Have anti ulcer property. Have hypoglycaemic effect. Lower cholesterol in blood and prevent cancer as it blinds to bile acids.
Tamarind	*Tamarindus indica*	*Leguminosae*	Cardiac glycosides, tartaric acid	Have anti microbial effect, anti-inflammatory properties, hypolipomi c and antioxidant activities
Coconut	*Cocas nucifera*	Areaceae	Phytohormones, peroxidase, RNApolymerases	Coconut juice has estrogenic effect. Have both anti bacterial and anti viral properties, antidote effect, antithrombotic effect.
Egg plant	*Solanum melongena*	Solanaceae	Rich source of iron, calcium, potassium, phosphorus, vitamin B complex	Lowers blood cholesterol level
Drum stick	*Moringa oleifera*	Morigaceae	Its leaves are particularly rich in potassium, calcium, phos-phorous, iron, vitamins A & D	Can be used for diabetes, hypertension, or HIV/AIDS
Cabbage	*Brassica oleracea*	Brassicaceae	Beta carotene	Have anticancer, antioxidant, antiasthmatic, analgesis properties. Improve digestion, circulation and remove constipation
Broccoli	*Brassica deracea*	Brassicaceae	Quercetin, sulphoraphane, polyphenols, glucosinolates	Potent anticancer, artery protecting, immune-modulating infection-fighting, antioxidant properties;promote reproductive potential;relive constipation;decrease cholesterol
Cucumber	*Cucumis sativus*	Cucurbitaceae		Have cooling effect, helpful in fevers, acidosis constipation, high blood pressure, rheumatism, obesity
Radish	*Raphanus sativus*	Brassicaceae	Raphanin	Anti-microbial, antiviral and secretolytic property; helpful in uterine involution,bronchitis, hyperlipidemia
Beet	*Beta vulgaris*	Amranthaceae	Betacyanin	Beneficial effect in tuberculosis, constipation, poor appetite, obesity, gout, pimples and tumors, hepatic disorders
Chilli	*Capsicum*	Solanaceae	Capsaicinoids, Lignan	Antioxidant and anti-inflammatory properties; helps in uterine involution
Tomato	*Solanum lycopersicum*	Solanaceae	Lycopene, Betacarotene	Potent antioxidant, helpful in prevention of arterial diseases and cancer

also helpful in combating the oxidative stress induced by the environmental pollutants such as heavy metals and pesticides (Singh *et al*., 2007; Kumar *et al*., 2012).

Out of more than 600 carotenoids present in plants, only few like alphacarotene, betacarotene, lycopene, zeaxanthine, lutein and betacryptoxanthine are utilized by human beings. The high level of α-carotene, β-carotene, lutein, zeaxanthin, lycopene and total carotenoids in blood circulation is helpful in reduced risk of breast cancer in women (Eliassen *et al*., 2012). Phytoene and phytofluene, precursors of higher unsaturated carotenoids are responsible for photoprotective effects (Stahl and Sies, 2012). Green leafy vegetables are rich in iron content required for synthesis of haemoglobin, hence suggested in iron deficiency anaemia. Various minerals including the trace minerals are also co-enzymes in certain biochemical reactions in the body (Mahima *et al*., 2012), which adds to the importance of leafy vegetables in metabolic reactions.

The fiber content of vegetables provides a bulk in the diet. This helps to reduce the intake of starchy foods, enhances gastrointestinal function, prevents constipation and may thus reduce the incidence of metabolic diseases like maturity onset, diabetes mellitus and hypercholesterolemia. The fibre cleanses the gut by removing the various carcinogens from the body and prevents the absorption of excess cholesterol. It also prevents the intake of excess starchy food and therefore protect against metabolic disorders (hypercholesterolemia and diabetes mellitus). Fibre from the seed coat and the cell walls

of the cotyledon of peas is beneficial for gastrointestinal function and health (Dahl *et al*., 2012) and also phytochemicals like polyphenolics and saponins present in coloured seed coat of peas have potent antioxidant and anticarcinogenic properties. Polyphenols play critical role in prevention of various diseases including cardiovascular, neurodegenerative disorders, diabetes mellitus, osteoporosis and even cancer (Hafidh *et al*., 2009; Mudgal *et al*., 2010), hepatic damage (Salawu and Akindahunsi, 2006), inhibit angiogenesis (Sahib *et al*., 2010) and obesity (El-Shebini *et al*., 2007). Green and yellow vegetables decrease the risk of chronic disease and inhibit the development of atherosclerosis (Wolfenden *et al*., 2012). Therefore, it may lead to a reduction in the risk of coronary heart disease (Samman *et al*., 2003; Adams *et al*., 2006; Esfahani *et al*., 2011), diabetes (Imai *et al*., 2012), stroke, markers of inflammation and oxidative stress (Holt *et al*., 2009) viz., serum homocysteine and markers of protein, lipid and DNA oxidation (Esfahani *et al*., 2011). Such consumptions could also mitigate contaminant exposure and/or their adverse health effects (Gagne *et al*., 2013).

Major mineral components of the leaves include calcium (1.22-4.13 mg 100 g^{-1}), potassium (0.08-6.10 mg 100 g^{-1}), sodium (0.03-6.84 mg 100 g^{-1}) and iron (0.01-0.12 mg 100 g^{-1}). Calcium is a major component giving strong bones, muscle contraction and relaxation, synaptic transmission, blood clotting and absorption of Vitamin especially B_{12}. The relatively high content of calcium in *Gryllotalpa africana* (4.13 mg 100 g^{-1}), *T. triangulare* (7.44 mg 100 g^{-1}), potassium and magnesium are known to decrease blood pressure. Potassium plays a crucial role in skeletal muscle contraction and transmission of nerve impulses. Therefore, the persons having the soft bone are usually advised to have the vegetables rich in calcium and potassium.

Phytoconstituents of vegetables are also very effective stimulants for the nervous system of the body. The bitter leaf contains an alkaloid, vernomine, which is capable of reducing headaches associated with hypertension (Ayitey-Smith, 1989). Broccoli is as excellent source of sulphoraphane, which has a powerful anticancerous effect. Spinach retards central nervous system and cognitive behavioral deficits. *Ocimum* species are rich in alkaloids that are useful in cold, cough, chronic catarrh and migraine. The medicinal importance of tannins, saponins and inulins which are components of traditional herbal preparations are highly useful in managing various common ailments. Lesser medication and more natural foods need to be have a priority place in our life but to get maximum health benefits sufficient knowledge and understanding a necessity.

Diets rich in vegetables and fruit have been linked with lower rates of cancer and coronary heart disease (Craig, 1997; Beecher, 1993; Potter, 1997; Steinmetz and Potter, 1996). Plant-based phenols, flavonoids, isoflavones, terpenes, glucosinolates, and other compounds that are present in the everyday diet are reported to have antioxidant and anticarcinogenic properties and a wide spectrum of tumor-blocking activities (Craig, 1997; Potter, 1997; Rhodes, 1996; Zhang *et al*., 1992). The search for the mechanisms of chemoprotection has focused on the biological activity of compounds found in cruciferous and green leafy vegetables, citrus fruit, green tea, and red wine (Rhodes, 1996; Chung *et al*., 1998; Verhoeven *et al*., 1997). Plant flavonoids may protect against LDL oxidation through a reduction of free radicals, chelation of metal ions, or protection or regeneration of á-tocopherol (Hertog *et al*., 1992 Bravo,1998; Wattenberg, 1993).

Glucosinolates and isothiocyanates are also regarded as dietary protectors against cancer (Zhang *et al*., 1992). Isothiocyanates inhibit the activation of carcinogens by cytochrome P-450 (phase 1) enzymes and promote detoxification of activator carcinogens by inducing phase 2 enzymes. Phase 2 enzymes inactivate carcinogens by neutralizing their toxic properties and speeding their elimination from the body (Fahey *et al*., 1997). Some phase 2 enzymes function as inhibitors of cytochrome P-450 (Zhang *et al*., 1992).

Lutein is a yellow-to-orange pigment or phytochemical found mostly in plants. It works as an antioxidant to reduce the damage done by free radicals. Lutein is a carotenoid and is related to vitamin A. Other carotenoids include beta carotene, alpha carotene and zeaxanthin. Orange and yellow vegetables, including carrots, spinach, pumpkins, winter squash, cantaloupes, and red peppers, are rich sources of β-carotene. Dark green leafy vegetables, including spinach, kale, turnip greens, broccoli, Brussels sprouts, and collards, are rich sources of lutein and zeaxanthin. Tomatoes, is the most common source of lycopene. It has been estimated that 85% of lycopene intake in the United States is from processed tomato products such as ketchup, tomato paste, and tomato soup. The most abundant carotenoids in potatoes are lutein and zeaxanthin, followed by β-carotene and β-cryptoxanthin (Andre, 2007).

Dietary glutathione occurs in moderate amounts in some fruits and vegetables, whereas it is absent or found only in small amounts in grains and dairy

products (Jones *et al.,* 1992). Dietary glutathione content of fresh asparagus is 28.3 mg/100 g and fresh avocado 27.7 mg/100 g (Jones *et al.,* 1992). Glutathione may protect cells from carcinogenic processes through functioning as an antioxidant (Jones *et al.,* 1989; Mannervik *et al.,* 1989), binding with mutagenic chemical compounds (Wattenberg, 1985; Frei *et al.,*1989) directly or indirectly acting to maintain functional levels of other antioxidants such as vitamins C and E and beta-carotene (Frei *et al.,* 1989; Frei *et al*., 1988), involvement in the DNA synthesis and repair (Oleinick *et al.*, 1988; Fuchs,1989) and enhancing the immune response (Buhl *et al.,* 1989).

Antioxidants

Several epidemiological studies have indicated that a high intake of plant products is associated with a reduced risk of a number of chronic diseases, such as atherosclerosis and cancer (Gosslau and Chen, 2004; Gundgaard *et al.*, 2003; Hashimoto *et al.*, 2002; Kris-Etherton *et al.*, 2002; Law and Morris, 1998; Temple, 2000). These beneficial effects have been partly attributed to the compounds which possess antioxidant activity. The major antioxidants of vegetables are vitamins C and E, carotenoids, and phenolic compounds, especially flavonoids. These antioxidants scavenge radicals and inhibit the chain initiation or break the chain propagation (the second defense line). Vitamin E and carotenoids also contribute to the first defense line against oxidative stress, because they quench singlet oxygen (Krinsky, 2001; Shi *et al.*, 2001). Flavonoids as well as vitamin C showed a protective activity to α-tocopherol in human LDL, and they can also regenerate vitamin E, from the α-chromanoxy radical (Davey *et al.*, 2000; Zhu and Huang, 2000).

Nutrient antioxidants may act together to reduce reactive oxygen spieces level more effectively than single dietary antioxidants, because they can function as synergists (Eberhardt *et al.*, 2000; Rossetto *et al.*, 2002; Trombino *et al.*, 2004). In addition, a mixture containing both water-soluble and lipid-soluble antioxidants is capable of quenching free radicals in both aqueous and lipid phases (Chen and Tappel, 1996). For example, with the liposome oxidation method, the activity of combination of quercetin or catechins plus α-tocopherol was significantly higher than the sum of the individual activities (Murakami *et al.*, 2003). Combinations of α-tocopherol or vitamin C plus phenolic compounds also provided synergistic effects in human erythrocyte membrane ghosts and phosphatidylcholine liposome systems (Liao and Yin, 2000).

Water-Soluble Antioxidants

Vitamin C

Vitamin C, which includes ascorbic acid and its oxidation product—dehydroascorbic acid, has many biological activities in human body. Block *et al.* (2004) have found that vitamin C can reduce levels of C-reactive protein (CRP), a marker of inflammation and possibly a predictor of heart disease. More than 85% of vitamin C in human diets is supplied by fruits and vegetables (Davey *et al.*, 2000 ; Lee and Kader, 2000). Biological function of L-ascorbic acid can be defined as an enzyme cofactor, a radical scavenger, and as a donor/acceptor in electron transport at the plasma membrane. Ascorbic acid is able to scavenge the superoxide and hydroxyl radicals, as well as regenerate α-tocopherol (Davey *et al.*, 2000). The content of vitamin C among Brassica vegetables varies significantly between and within their subspecies. Vitamin C levels varied over a 4-fold in broccoli and cauliflower, 2.5-fold in brussels sprouts and white cabbage, and twice in kale. The cause of reported variations in vitamin C content might be related to the differences in genotype (Kurilich *et al.*, 1999; Vallejo *et al.*, 2002).

Dehydroascorbic acid (DHA)—oxidation product of ascorbic acid is unstable at physiological pH and it is spontaneously and enzymatically converted to 2, 3-diketogulonic acid (Davey *et al.*, 2000). According to Gokmen *et al.* (2000), DHA was the dominant form of vitamin C in cabbage, with 4-fold higher level than ascorbic acid. In contrast to this report, Vanderslice *et al.* (1990) observed that the contribution of DHA to the total vitamin C contents was 14% or 8% in cauliflower and broccoli, respectively. Vallejo *et al.* (2003) reported the contribution of DHA to the total vitamin C contents was 11.3% in broccoli.

Potatoes are good sources of vitamin C (ascorbic acid). Andre *et al.* (2007) reported that the vitamin C content in potatoes ranged from 22 to 69 mg per 100 g dry weight depending on cultivars. One medium-size baked potato (173 g, fresh weight) provides 16.6 mg of vitamin C (USDA, 2012), which could meet 27.7% of daily value. Vitamin C is an essential nutrient and plays an important function in collagen synthesis to prevent scurvy, a vitamin C deficiency disease. Vitamin C is also an excellent antioxidant to scavenge free radicals and to prevent oxidative stress.

Lipid-Soluble Antioxidants

Carotenoids

Carotenoids are classified into hydrocarbons (carotenes) and their oxygenated derivatives

(xanthophylls), with a 40-carbon skeleton of isoprene units (Liu, 2004). It is estimated that >600 distinct carotenoids have been isolated and identified with yellow, orange, and red colors and are present widely in fruits, vegetables, whole grains, and other plants. In terms of health benefits, carotenoids have received considerable attention because of their unique physiological functions as provitamins and antioxidant effects, especially in scavenging singlet oxygen.

Carotenoids (carotens and xanthophylls) are yellow, orange, and red pigments present in many fruits and vegetables. Several of them are precursors of vitamin A (i.e. β-carotene, γ-carotene, and β-cryptoxanthin), and due to conjugated double bonds they are both radical scavengers and quenchers of singlet oxygen. Lower serum β-carotene levels have been linked to higher rates of cancer and cardiovascular diseases, as well as to increased risk of myocardial infarction among smokers (Rice-Evans *et al*..1997).

Carotenoids are especially powerful in scavenging singlet oxygen generated from light induced lipid oxidation or radiation. Astaxanthin, zeaxanthin, and lutein are excellent in scavenging free radicals because of the unique end functional groups.

Vitamin E

In addition to carotenoids, vitamin E also belongs to a group of lipid-soluble antioxidants. The biological activity of vitamin E exhibit tocopherols and tocotrienols, especially α-tocopherol. The predominant reaction responsible for tocopherol antioxidant activity is hydrogen atom donation, where a tocopheroxyl radical is formed (Lampi *et al.*, 2002). Vitamin E shows protective effects against the coronary heart disease due to inhibition of LDL oxidation (Stampfer and Rimm, 1995). Although vegetables in addition to fats, oils and cereal grains, constitute the major source of vitamin E in our diet, there are only few data of tocopherol content in vegetables. Piironen *et al.* (1986) reported that α-tocopherol was predominant tocopherol in all brassica vegetables, except in cauliflower, containing predominantly γ-tocopherol. In contrast, Kurilich *et al*. (1999) reported lower concentration of γ-tocopherol than α-tocopherol in cauliflower. In general, the best sources of lipid-soluble antioxidants are kale and broccoli. Brussels sprouts have moderate levels of the above-mentioned compounds, while cauliflower and cabbage are characterized by their relatively low amounts.

Lycopene

Lycopene is a carotenoid that is present in tomatoes, processed tomato products and other fruits. It is one of the most potent antioxidants among dietary carotenoids. Dietary intake of tomatoes and tomato products containing lycopene has been shown to be associated with a decreased risk of chronic diseases, such as cancer and cardiovascular disease. Serum and tissue lycopene levels have been found to be inversely related to the incidence of several types of cancer, including breast cancer and prostate cancer. Although the antioxidant properties of lycopene are thought to be primarily responsible for its beneficial effects, evidence is accumulating to suggest that other mechanisms may also be involved. Along with genetic factors and age, lifestyle and diet are also considered important risk factors. About 50% of all cancers have been attributed to diet (Williams *et al.*, 1999).

Oxidative stress induced by reactive oxygen species is one of the main foci of recent research related to cancer and cardiovascular disease. Reactive oxygen species are highly reactive oxidant molecules that are generated endogenously through regular metabolic activity, lifestyle activity and diet. They react with cellular components, causing oxidative damage to such critical cellular biomolecules as lipids, proteins and DNA. There is strong evidence that this damage may play a significant role in the causation of several chronic diseases (Ames *et al*.,1995).

The antioxidants such as vitamin E, vitamin C, polyphenols and carotenoids are available from food. Current dietary guidelines to combat chronic diseases, including cancer and coronary artery disease, recommend increased intake of plant foods, including fruits and vegetables, which are rich sources of antioxidants. The role of dietary antioxidants, including vitamin C, vitamin E, carotenoids and polyphenols, in disease prevention has received much attention in recent years (Halliwell *et al*., 1995). These antioxidants appear to have a wide range of anticancer and antiatherogenic properties. These observations may explain the epidemiological data indicating that diets rich in fruits and vegetables are associated with a reduced risk of numerous chronic diseases (Gaziano *et al.*, 1999).

Dietary antioxidant thought to be important in the defence against oxidation is lycopene, of which tomatoes are an important dietary source (Rao and Agarwal,1999). Lycopene is a natural pigment synthesized by plants and microorganisms but not by animals. It is a carotenoid, an acyclic isomer of ß-carotene. Lycopene is a highly unsaturated hydrocarbon containing 11 conjugated and 2 unconjugated double bonds. Lycopene from natural plant sources exists predominantly in an all-*trans* configuration, the most thermodynamically stable

form. In human plasma, lycopene is present as an isomeric mixture, with 50% as *cis* isomers (Nguyen and Schwartz,1999).

Lycopene is one of the most potent antioxidants, with a singlet-oxygen-quenching ability twice as high as that of ß-carotene and 10 times higher than that of á-tocopherol (DiMascio *et al.*,1989). It is the most predominant carotenoid in human plasma. Its level is affected by several biological and lifestyle factors. Owing to their lipophilic nature, lycopene and other carotenoids are found to concentrate in low-density and very-low-density lipoprotein fractions of the serum. Lycopene is also found to concentrate in the adrenal gland, testes, liver and prostate gland, where it is the most prominent carotenoid. Tissue-specific lycopene distribution may be important in the role of this antioxidant. However, unlike other carotenoids, lycopene levels in serum or tissues do not correlate well with overall intake of fruits and vegetables (Michaud *et al.,* 1998).

The biological activities of carotenoids such as ß-carotene are related in general to their ability to form vitamin A within the body. Since lycopene lacks the ß-ionone ring structure, it cannot form vitamin A (Stahl and Sies, 1996). Its biological effects in humans have therefore been attributed to mechanisms other than vitamin A. Two major hypotheses have been proposed to explain the anticarcinogenic and antiatherogenic activities of lycopene: nonoxidative and oxidative mechanisms. Lycopene also has been shown to act as a hypocholesterolemic agent by inhibiting HMG-CoA (3-hydroxy-3-methylglutaryl-coenzyme A) reductase (Fuhramn *et al*., 1997).

Lycopene has been hypothesized to prevent carcinogenesis and atherogenesis by protecting critical cellular biomolecules, including lipids, lipoproteins, proteins and DNA. In healthy human subjects, lycopene- or tomato-free diets resulted in loss of lycopene and increased lipid oxidation, whereas dietary supplementation with lycopene for 1 week increased serum lycopene levels and reduced endogenous levels of oxidation of lipids, proteins, lipoproteins and DNA. Patients with prostate cancer were found to have low levels of lycopene and high levels of oxidation of serum lipids and proteins (Rao and Agrawal, 1999).

Red fruits and vegetables, including tomatoes, watermelons, pink grapefruits, apricots and pink guavas, contain lycopene. Processed tomato products, such as juice, ketchup, paste, sauce and soup, all are good dietary sources of lycopene. In a recent study in our laboratory, the average daily dietary intake of lycopene, assessed by means of a food-frequency questionnaire, was estimated to be 25 mg/d with processed tomato products, accounting for 50% of the total daily intake (Rao *et al*., 1998).

Although comparative bioavailability values for lycopene from different tomato products are unknown, lycopene from processed tomato products appears to be more bioavailable than that from raw tomatoes (Gartner *et al.*, 1997). The release of lycopene from the food matrix due to processing, the presence of dietary lipids and heat-induced isomerization from all-*trans* to a *cis* conformation enhance lycopene bioavailability. The bioavailability of lycopene is also affected by the dosage and the presence of other carotenoids, such as ß-carotene. The bioavailability of lycopene was significantly higher when it was ingested along with ß-carotene than when ingested alone.

Phenolic Compounds

There are several thousand different flavonoids present in plants, and many of them have antioxidant activities. Such phenolic compounds have already been implicated as playing a role in the protection that fruits and vegetables have against chronic diseases (Nijveldt *et al.,* 2001). Phenolics are a group of compounds with ≥1 aromatic rings possessing ≥1 hydroxyl groups. Phenolics are generally are classified as subgroups of phenolic acids, flavonoids, stilbenes, coumarins, and tannins (Liu, 2004). Phenolic acids can be divided into 2 major subgroups: hydroxybenzoic acid and hydroxycinnamic acid derivatives. Hydroxybenzoic acid derivatives in plant foods include *p*-hydroxybenzoic, gallic acids, syringic, protocatechuic, and vanillic acids (Liu, 2004). They are usually present in the bound form in foods as components of complex structures such as lignins and hydrolyzable tannins or attached to cell walls and proteins. They can also be found as derivatives of sugar and organic acids in fruits, vegetables, and whole grains. Hydroxycinnamic acid derivatives in plant foods include *p*-coumaric, ferulic, caffeic, and sinapic acids. They are primarily present in the bound form, connected to cell wall structural components such as cellulose, lignin, and proteins through ester bonds (Liu, 2004).

Phenolic compounds are a large group of the secondary metabolites categorized into classes depending on their structure and subcategorized within each class according to the number and position of hydroxyl group and the presence of other substituents. The most widespread and diverse group of the polyphenols are the flavonoids which are built upon C_6–C_3–C_6 flavone skeleton. In addition, other

phenolic compounds such as benzoic acid or cinnamic acid derivatives have been identified in fruits and vegetables (Aherne and O'Brien, 2002). Phenolic compounds, especially flavonoids, possess different biological activities, but the most important are antioxidant activity, capillary protective effect, and inhibitory effect elicited in various stages of tumor (Cook and Samman, 1996; Czeczot, 2000; Hollman *et al.*,1996; Kuntz *et al.*,1999). Phenolics are able to scavenge reactive oxygen spieces due to their electron donating properties. Their antioxidant effectiveness depends on the stability in different systems, as well as number and location of hydroxyl groups. In many in vitro studies, phenolic compounds demonstrated higher antioxidant activity than antioxidant vitamins and carotenoids.

Flavonoids

Flavonoids are a major group of phenolic compounds that commonly have a generic structure consisting of 2 aromatic rings (A and B rings) connected by 3 carbons that are usually in an oxygenated heterocycle ring, or C ring (Liu, 2004). Fruits, vegetables, and other plant foods are rich sources of flavonoids, which have been linked to reducing the risk of major chronic diseases, such as heart disease, cancer, stroke, diabetes, Alzheimer's disease, cataracts, and age-related function decline (Liu, 2004). More than 5000 individual flavonoids have been isolated and identified. Structural differences in the heterocycle C ring categorize them as flavonols (quercetin, kaempferol, and myricetin), flavones (luteolin and apigenin), flavonols (catechin, epicatechin, epigallocatechin, epicatechin gallate, and epigallocatechin gallate), flavonones (naringenin), anthocyanidins (cyanidin and malvidin), and isoflavonoids (genistein and daidzein). These are common flavonoids in the diet. Dietary flavonoids are most commonly found in nature as conjugates in glycosylated or esterified forms, but can be present as aglycones, especially in cooked or processed plant foods. Many different glycosylated forms can be found in nature because >80 different sugars have been reported bound to flavonoids in plant foods (Hollman 2000). Anthocyanidins provide unique colors in some fruits, vegetables, and whole grains.

Thiols

Thiols comprises of sulfur-containing phytonutrients present in garlic and cruciferous vegetables (cabbage, turnips and members of the mustard family). Allylic Sulfides subclasses is abundantly found in garlic, onions, leeks, shallots and chives (Hofgen *et al.*, 2001) and are released when the plants are cut or smashed. These possess antimutagenic and anticarcinogenic properties as well as immune enhancing and cardiovascular protective properties (Vazquez-Preeto and Miatello, 2010).

Phytochemicals and Bitterness

Although present in very small amounts, antioxidant phytochemicals impart a perceptible bitter taste to foods. As documented below, some of these compounds are so aversive to the consumer (Drewnowski, 1996; Matsuura, 1989; Van Doorn, 1998) that they are selectively bred out of plants and routinely removed from processed foods (Rouseff, 1990; Roy, 1990). Indeed, the low amounts of bitter plant compounds in the current diet largely reflect the achievements of the agricultural and food industries (Roy, 1990). The debittering of plant foods has long been a major sensory concern for food science (Fenwick, 1990).

Cruciferous vegetables (broccoli, cauliflower, kale, turnips, collards, brussels sprouts, cabbage, kohlrabi, rutabaga, chinese cabbage, and bok choy) contain stable glucosinolates in the amounts of 0.5–1 g/g (Carlson *et al.*, 1987; Fenwick, 1990). Glucosinolates are natural pesticides, being toxic to insects (Fenwick, 1990). The major glucosinolates in cabbage and brussels sprouts—sinigrin, progoitrin, and glucobrassicin—are toxic to rats (Fenwick, 1990). Three-day-old broccoli sprouts contained higher concentrations of sulforaphane than did the mature plant (Fahey, 1997).

Diets high in vegetables and fruit have been associated with reduced cancer risk (Steinmetz and Potter, 1996). Many studies focused on the chemoprotective role of phytochemicals. Chemoprotective agents generally belong in 1 of 3 categories: those that block metabolic activation of carcinogens, those that prevent the formation of carcinogens from precursors, and those that suppress neoplasia in cells previously exposed to carcinogens (Wattenberg, 1993; Sharma *et al.*, 1994). Phytonutrients and their metabolites elicit a variety of biological activities, acting as antioxidants, phytoestrogens, or enzyme inducers (Dragsted *et al.*, 1993). Among the most promising compounds under study are bitter phenols and polyphenols, flavonoids, isoflavones, and glucosinolates.

Tomatoes

Tomatoes have received significant attention because of interest in lycopene, the primary carotenoid found in this fruit (Gerster, 1997), and its role in cancer

risk reduction (Weisburger, 1998).The men, those who consumed tomato products had less than one-half the risk of developing advanced prostate cancer (Giovannucci *et al*., 1995). Interestingly, lycopene is the most abundant carotenoid in the prostate gland (Clinton *et al*., 1996). Other cancers whose risk have been inversely associated with serum or tissue levels of lycopene include breast, digestive tract, cervix, bladder, and skin (Clinton, 1998) and possibly lung (Li *et al*., 1997). Proposed mechanisms by which lycopene could influence cancer risk are related to its antioxidant function. Lycopene is the most efficient quencher of singlet oxygen in biological systems (Di Mascio *et al*., 1989). The antioxidant function of lycopene may also explain the recent observation in a multi-center European study that adipose tissue levels of carotenoids were inversely associated with risk for myocardial infarction (Kohlmeier *et al*., 1997).

Garlic

Garlic is likely the herb most widely quoted in the literature for medicinal properties (Nagourney, 1998). Thus, it's not surprising that garlic has ranked as the second best selling herb in the United States for the past two years (Anon., 1998). The purported health benefits of garlic are numerous, including cancer chemopreventive, antibiotic, anti-hypertensive, and cholesterol-lowering properties (Srivastava *et al*., 1995).

The characteristic flavor and pungency of garlic are due to an abundance of oil-and water-soluble, sulfur-containing elements, which are also likely responsible for the various medicinal effects ascribed to this plant. The intact garlic bulb contains an odorless amino acid, alliin, which is converted enzymatically by allinase into allicin when the garlic cloves are crushed (Block, 1992). Allicin then spontaneously decomposes to form numerous sulfur-containing compounds, some of which have been investigated for their chemopreventive activity. Considerable variation in the quantity of organosulfur compounds available in fresh and commercially available garlic products has been demonstrated (Lawson *et al*., 1991). Several epidemiologic studies show that the garlic may be effective in reducing human cancer risk (Dorant *et al*., 1993). The investigation conducted in China showed a strong inverse relationship between stomach cancer risk and in-creasing allium intake (You *et al*., 1988). More recently, in study postmenopausal women, garlic consumption was associated with nearly a 50% reduction in colon cancer risk (Steinmetz *et al*., 1994). A more recent review of 20 epidemiological studies (Ernst, 1997) suggests that allium vegetables, including onions, may confer a protective effect on cancers of the gastrointestinal tract. Garlic has also been advocated for the prevention of CVD, possibly through antihypertensive properties. According to Silagy and Neil (1994a), however, there is still insufficient evidence to recommend it as a routine clinical therapy for the treatment of hypertensive subjects. The cardioprotective effects are more likely due to its cholesterol-lowering effect. In a meta-analysis, Warshafsky *et al.* (1993) showed that an average of 900 mg garlic/day could decrease total serum cholesterol levels by approximately 9%. Silagy and Neil (1994b) reported that 800 mg garlic/day reduced total cholesterol levels by 12%. It was reported that 12 weeks of garlic treatment was ineffective in lowering cholesterol levels in subjects with hypercholesterolemia (Isaacsohn *et al*., 1998). It is currently unclear which component in garlic is responsible for its cholesterol-lowering effect.

Broccoli and other Cruciferous Vegetables

Epidemiological evidence has associated the frequent consumption of cruciferous vegetables with decreased cancer risk. Verhoeven *et al.* (1996) demonstrated an inverse association between consumption of total brassica vegetables like cabbage, broccoli, cauliflower, and brussels sprouts and cancer risk. Verhoeven *et al.* (1997) attributed the anticarcinogenic properties of cruciferous vegetables to their relatively high content of glucosinolates. Glucosinolates are a group of glycosides stored within cell vacuoles of all cruciferous vegetables. Myrosinase, an enzyme found in plant cells, catalyzes these compounds to a variety of hydrolysis products, including isothiocyanates and indoles. Indole-3 carbinol (I3C) is currently under investigation for its cancer chemopreventive properties, particularly of the mammary gland. Although a wide variety of naturally occurring and synthetic isothiocyanates have been shown to prevent cancer in animals (Hecht, 1995), attention has been focused on a particular isothiocyanate isolated from broccoli, known as sulforaphane. Sulforaphane has been shown to be the principal inducer of a particular type of Phase II enzyme, quinone reductase. Fahey *et al.* (1997) recently demonstrated that 3-day-old broccoli sprouts contained 10-100 times higher levels of glucoraphanin (the glucosinolate of sulforaphane) than did corresponding mature plants. However, in view of the importance of an overall dietary pattern in cancer risk reduction, the clinical implications of a single phytochemical in isolation has been questioned (Nestle, 1998).

These vegetables possess both antioxidant and anticarcinogenic vegetables (Cohen *et al.*, 2000; Verhoeven *et al*., 1997). In addition to antioxidant vitamins, carotenoids, and polyphenols, Brassica vegetables provide a large group of glucosinolates, which according to Plumb *et al.* (1996) possess rather low antioxidant activity, but the products of their hydrolysis can protect against cancer (Keum *et al*., 2004; Paolini, 1998).

Broccoli is a source of flavonol and hydroxycinnamoyl derivatives. Price e*t al.* (1998) identified the main flavonol glycosides present in broccoli florets as quercetin and kaempferol 3-*O*-sophoroside. Three minor glucosides of these aglycones were also detected, namely isoquercitrin, kaempferol 3-*O*-glucoside and kaempferol diglucoside. The predominant hydroxycinnamoyl acids were identified as 1-sinapoyl-2-feruloylgentiobiose, 1,2-diferuloylgentiobiose, 1,2,2′ -trisinapoylgentiobiose, and neochlorogenic acid (Vallejo *et al*., 2003). In addition, 1,2′ -disinapoyl-2-feruloylgentiobiose and 1,2-disinapoylgentiobiose, 1-sinapoyl-2,2-diferuloyl gentiobiose, isomeric form of 1,2,2′ -trisinapoylgentiobiose, and chlorogenic acids were found in broccoli (Price *et al*., 1997; Vallejo *et al*., 2003). Total amounts of feruloylsinapoyl esters of gentiobiose and caffeic acid derivatives in 14 cultivars of broccoli varied from 0 to 8.25 mg/100 g, and from 0 to 3.82 mg/100 g, respectively.

Nielsen *et al.* (1993) showed that cabbage contains a mixture of more than 20 compounds of which seven have been identified as 3-*O*-sophoroside-7-*O*-glucosides of kaempferol and quercetin with and without further acylation with hydroxycinnamic acids. In addition, unmodified kaempferol tetraglucosides or their derivatives acylated with either sinapic, ferulic or caffeic acid were found in cabbage leaves (Nielsen *et al*., 1998). Red pigmentation of red cabbage is caused by anthocyanins, which belong to flavonoids. Red cabbage contains more than 15 different anthocyanins which are acylglycosides of cyanidin (Dyrby *et al*., 2001; Mazza and Miniati, 1993). Total anthocyanins content in red cabbage was 25 mg/100 g (Wang *et al*., 1997) or 44.4–51.2 mg/100 g for anthocyanidins released after acid hydrolysis (Franke *et al*., 2004).

Phenolics in vegetables exist in both free and conjugated forms. After hydrolysis, HPLC analysis showed that quercetin was the predominant flavonol aglycone in brassica vegetables Its level in Mauritian brassica vegetables varied from 3.9 mg/100 g in cauliflower to 39.0 mg/100 g in Chinese cabbage (Bahorun *et al*., 2004). However, Chu *et al.* (2000) reported much lower contents of quercetin for brassica vegetables cultivated in Taiwan: 0.004 mg/100 g for white cabbage and 0.024 mg/100 g for Chinese cabbage. Kaempferol and myricetin derivatives were also present in Brassica vegetables, but myricetin was not present in broccoli, white cabbage, purple cabbage, and cauliflower. According to Bahorun *et al.* (2004), apigenin and luteolin were flavones detected in the hydrolysed extracts of different Brassica vegetables except for broccoli. Among four Taiwan Brassica vegetables studied by Chu *et al.* (2000), the levels of flavone were higher than those of flavonol in all tested vegetables. Apigenin was the predominant flavone aglycone in these vegetables except Chinese cabbage, where luteolin content was nearly 4-fold higher than apigenin content.

Phenolic compounds in our diet may reduce the risk of chronic diseases such as cancer, heart disease, and diabetes. Fruits and vegetables are good sources of dietary phenolics. Among the common vegetables consumed in the United States, spinach had the highest phenolic content, followed by red pepper, beets, broccoli, Brussels sprouts, eggplant, asparagus, and green pepper, in order of phenolic content (Song *et al*., 2010; Chu *et al*., 2002). The rest of the vegetables in order of phenolic content were yellow onion, cauliflower, cabbage, radish, chili pepper, mushroom, sweet potato, carrot, sweet corn, potato, squash, white onion, green pea, tomato, green bean, celery, lettuce, romaine lettuce, and cucumber.

Bottle Gourd

Phytochemical screening on *L. siceraria* fruit flavonoids, cucurbitacins, saponins, polyphenolics, triterpenoids (Chen *et al.* 2008). Various extracts of fruit of *Lagenaria siceraria* were found to have anti-inflammatory, analgesic, hepatoprotective, anti-hyperlipidemic, diuretic and antibacterial activities (Gangwal *et al.* 2009).

Apart from above the bottle gourd also contents 1.6% choline on a dry weight basis; a precursor to acetylcholine, a chemical used to transfer nerve impulses and hence, it is believed to have neurological effects (Thomas, 2008). Bottle gourd contains cucurbitacins, polyphenols and two sterols namely; campesterol and sitosterol (Ghule *et al.* 2007). Bottle gourd is well known for their immunomodulatory, hepatoprotective, antioxidant, anti-stress, adaptogenic, analgesic, anti-inflammatory, cardio protective, cardio tonic, antihyperlipidemic, diuretic, aphrodisiac, alternative purgative, antidote to certain poisons and cooling properties (Ahmad *et al.* 2011; Deshpande *et al.* 2008; Mohale *et al.* 2008).

Beetroot

Beetroot predominately contains pigments called betalains, a class of betalamic acid derivatives which are composed of betacyanins and betaxanthins (Pitalua *et al*., 2010). The betalain and phenolic composition of red beetroot has been studied in detail by Kujala *et al.* (2000) and Kujala *et al.* (2002). Beetroots are rich in valuable active compounds such as carotenoids (Dias *et al.,* 2009), glycine betaine (de Zwart *et al*., 2003), saponins (Atamanova *et al*., 2005), betacyanines (Patkai *et al.* 1997), folates (Jastrebova *et al*., 2003), betanin, polyphenols and flavonoids (Vali *et al*., 2007). The beetroot ingestion can be considered a factor in cancer prevention (Kapadia *et al*.1996).

Beetroot is one of the most potent vegetables with respect to antioxidant activity (Zitnanova *et al*., 2006; Georgiev *et al*., 2010). Betacyanins are a group of compounds exhibiting antioxidant and radical-scavenging activities (Pedreno and Escribano, 2000). They also inhibit cervical ovarian and bladder cancer cells in vitro (Zou *et al*., 2005).).

Dietary Phytochemicals in the Prevention NCDs

Population-based studies (Hertog *et al*., 1992 and Hertog *et al*., 1993) showed that the risk of coronary heart disease was reduced at higher estimated intakes of flavonoids (apigenin, kaempferol, luteolin, myricetin, and quercetin). Data on diet and colon cancer (Trock *et al*., 1990) also show a significant decline in risk with higher consumption of vegetables, green leafy vegetables, and cabbage. There is a general consensus that a diet higher in plant foods than is the current norm is associated with improved health and reduced disease risk. However, the most potent plant products are also likely to be the most bitter and therefore the most aversive to the consumer.

Risk of Cancer

The diet, which is rich in vegetables and fruits, including tomatoes, has been suggested to be responsible for the lower cancer rates. Dietary intake of tomatoes and tomato products has been found to be associated with a lower risk of a variety of cancers in several epidemiological studies. A high intake of tomatoes was linked to protective effects against digestive tract cancers in a case-control study http://www.cmaj.ca/content/163/6/739. and a 50% reduction in rates of death from cancers at all sites in an elderly US population. In recent studies serum and tissue levels of lycopene were shown to be inversely associated with the risk of breast cancer and prostate cancer; no significant association with other important carotenoids, including ß-carotene, was observed (Gann *et al*., 1999). Overwhelming evidence from epidemiological, in vivo, in vitro, and clinical trial data indicates that diets high in fruits and vegetables can reduce the risk of chronic disease, particularly cancer (Block, 1992).

It is estimated that one third of all cancer deaths in the United States could be prevented through the dietary modification (Willett, 2002; Doll, 1981; Anand *et al*., 2008). Increasing bioactive compounds and antioxidant defenses through dietary phytochemicals, present in fruits, vegetables, whole grains, and other plant foods, may prevent, reduce, or delay the oxidation of DNA and affect cellular signal transduction pathways controlling cell proliferation and apoptosis (Liu, 2004). The high consumption of fruits and vegetables to reduce the risk of the development of cancer.

Most of the workers have investigated the effects of tomato or tomato product (lycopene) supplementation on oxidative damage to lipids, proteins and DNA. A preliminary report has indicated that tomato extract supplementation in the form of oleoresin capsules lowers the levels of prostate-specific antigen in patients with prostate cancer (Kucuk *et al*., 1999).

Risk of Cardiovascular Disease

Antioxidant nutrients are believed to slow the progression of atherosclerosis because of their ability to inhibit damaging oxidative processes. Several controlled clinical trials and epidemiological studies have provided evidence for the protective effect of vitamin E, which has been ascribed to its antioxidant properties. The studies indicated that consuming tomatoes and tomato products containing lycopene reduced the risk of cardiovascular disease (Kohlmeier *et al*., 1997).

Many epidemiological studies have examined the role of phytochemicals and increased dietary intake of fruits and vegetables in the prevention of cardiovascular disease (CVD). Consumption of flavonoids in humans was significantly inversely correlated with mortality from coronary heart disease (CHD) and with the incidence of myocardial infarction (Hertog *et al*., 1993). Dietary flavonoid intake was also inversely associated with CHD mortality (Hertog *et al*., 1995). The total intake of flavonoids (quercetin, myricetin, kaempferol, luteolin, and ficetin) was inversely associated with the LDL cholesterol and plasma total cholesterol concentrations (Arai *et al*., 2000). As a single phytochemical, intake of quercetin was inversely correlated with LDL cholesterol and total cholesterol plasma levels. Intake of fruits and vegetables was inversely correlated with

the incidence of stroke, stroke mortality, CVD mortality, CHD mortality, and all-cause mortality (Bazzano *et al*., 2002).

References

1. Adams MR, Golden DL, Chen H, Register TC, Gugger ET. A diet rich in green and yellow vegetables inhibits atherosclerosis in mice. J. Nutr. 2006; 136: 1886-1889.
2. Ahmad I, Irshad M and Rizvi MMA. Nutritional and medicinal potential of Lagenaria siceraria. International Journal of Vegetable Science. 2011; 17(2): 157-170.
3. Ames BN, Gold LS, Willet WC. The causes and prevention of cancer. Proc. Natl. Acad. Sci. USA. 1995; 92: 5258-5265.
4. Anand P, Kunnumakkara AB, Sundaram C, Harikumar KB, Tharakan ST, Lai OS, Sung B, Aggarwal BB. Cancer is a preventable disease that requires major lifestyle changes. *Pharm Res.* 2008; 25: 2097–116.
5. Andre CM, Ghislain M, Bertin P, Oufir M, Herrera Mdel R, Hoffmann L, Hausman JF, Larondelle Y, Evers D Andean potato cultivars (Solanum tuberosum L.) as a source of antioxidant and mineral micronutrients. *J Agric Food Chem.* 2007; 55: 366–78.
6. Anonymous. U.S. topselling herbs and supplements. Nutraceuticals Intl. 1998; 3(2): 9.
7. Anu RM, Amit KV, Amit K, Ruchi T, Sanjay K, Sandip C, Kuldeep D. Phytonutrients and Nutraceuticals in Vegetables and Their Multi-dimensional Medicinal and Health Benefits for Humans and Their Companion Animals: A Review. Journal of Biological Sciences. 2014; 14: 1-19.
8. Arai Y, Watanabe S, Kimira M, Shimoi K, Mochizuki R, Kinae N. Dietary intakes of flavonols, flavones and isoflavones by Japanese women and the inverse correlation between quercetin intake and plasma LDL cholesterol concentration. *J Nutr.* 2000; 130: 2243–50.
9. Atamanova A, Brezhneva TA, Slivkin AI, Nikolaevskii VA, Selemenev VF and Mironenko NV. Isolation of saponins from table beetroot and primary evaluation of their pharmacological activity. Pharma Chem Journal. 2005, 39(12) :650–652.
10. Ayitey-Smith E. Prospects and Scope: Plant Medicine in Health Care. Ghana University Press, Ghana, 1989; pp: 29.
11. Aherne SA, O'Brien NM. Dietary flavonols: chemistry, food content, and metabolism. Nutrition. 2002; 18: 75–81.
12. Bahorun T, Luximon-Ramma Crozier A, Aruoma OI. Total phenol, flavonoid, proanthocyanidin and vitamin C levels and antioxidant activities of Mauritian vegetables. J. Sci. Food Agril. 2004; 84: 1553–1561.
13. Bazzano LA, He J, Ogden LG, Loria CM, Vupputuri S, Myers L, Whelton PK. Fruit and vegetable intake and risk of cardiovascular disease in US adults: the first National Health and Nutrition Examination Survey Epidemiologic Follow-up Study. *Am J Clin Nutr.* 2002; 76: 93–9.
14. Block E. The organosulfur chemistry of the genus *Allium* - Implications for organic sulfur chemistry. Angew. Chem. Intl. Edn. Engl. 1992; 31: 1135-1178.
15. Block G, Jensen C, Dietrich M, Norkus EP, Hudes M, Packer L. Plasma C-reactive protein concentrations in active and passive smokers: influence of antioxidant supplementation. American College of Nutrition. 2004; 23:1 41–147.
16. Bravo, L. Polyphenols: Chemistry, Dietary Sources, Metabolism, and Nutritional Significance. Nutr. Rev. 1998; 56: 317-333.
17. Buhl R, Holroyd KJ, Mastrangeli A, Cantin AM, Jaffe HA. Systemic glutathione deficiency in symptom-free HIV-seropositive individuals. Lancet. 1989; 1294-1298.
18. Bumgarner NR, Scheerens JC, Kleinhenz MD. Nutritional yield: A proposed index for fresh food improvement illustrated with leafy vegetable data. Plant Foods Hum. Nutr. 2012; 67: 215-222.
19. Chen CH, Chen HW, Chang CY. Friedooleanane-Type Triterpenoids from *Lagenaria siceraria* and Their Cytotoxic Activity, Chem. Pharm. Bull. 2008; 56(3): 385-388.
20. Chen H, Tappel A. Protection by multiple antioxidants against lipid peroxidation in rat liver homogenate.Lipids. 1996; 31: 47–50.
21. Chiu BC, Kwon S, Evens AM, Surawicz T, Smith SM, Weisenburger DD. Dietary intake of fruit and vegetables and risk of non-Hodgkin lymphoma. Cancer Causes Control. 2011; 22: 1183-1195.
22. Carlson DG, Daxenbichler ME, VanEtten CH, Kwolek WF, Williams PH. Glucosinolates in crucifer vegetables: broccoli, Brussels sprouts, cauliflower, collards, kale, mustard greens, and kohlrabi.J. Am. Soc. Hort. Sci. 1987; 112: 173–8.
23. Chu Y H, Chang CL, Hsu HF. Flavonoid content of several vegetables and their antioxidant activity. J. Sci. Food Agril. 2000; 80: 561–566.
24. Chu Y-F, Sun J, Wu X, Liu RH. Antioxidant and antiproliferative activities of vegetables. *J Agric Food Chem.* 2002; 50: 6910–6.
25. Chung KT, Wong TY, Wei CI, Huang YW, Lin Y. Tannins and human health: a review. Crit. Rev. Food. Sci. Nutr. 1998; 36: 421–464.
26. Clinton SK, Emenhiser C, Schwartz SJ, Bostwick DG, Williams AW, Moore BJ, Erdman JJW. Cis-trans lycopene isomers, carotenoids and retional in the human prostate. Cancer Epidemiol. Biomarkers Prev. 1996; 5: 823-833.
27. Clinton SK. Lycopene: chemistry, biology, and implications for human health and disease. Nutr. Rev. 1998; 56: 35-51.

28. Cohen J, Kristal R, Stanford J. Fruit and vegetable intakes and prostate cancer risk. J. National Cancer Institute. 2000; 9: 61–68.

29. Cook NC, Samman S. Flavonoids—Chemistry, metabolism, cardioprotective effects, and dietary sources. Nutritional Biochemistry. 1996; 7: 66–76.

30. Craig WJ. Phytochemicals: guardians of our health. J. Am. Diet. Assoc. (Suppl):S. 1997; 199–204.

31. Czeczot H. Biological activities of flavonoids – a review. Polish J. Food Nutrition. 2000; 950(4): 3–13.

32. De Zwart FJ, Slow S, Payne RJ, Lever M, George PM, Gerrard JA and Chambers ST. Glycine betaine and glycine betaine analogues in common foods. *Food Chemistry*. 2003, 83: 197–204.

33. Dahl WJ, Foster LM, Tyler RT. Review of the health benefits of peas (*Pisum sativum* L.). Br. J. Nutr. 2012; 108: S3-S10.

34. Davey MW, van Montagu M, Inze D, Sanmartin M, Kanellis A, Smirnoff N. Plant l-ascorbic acid: chemistry, function, metabolism, bioavailability, and effects of processing. *J.* Sci. Food Agril. 2000; 80: 825–860.

35. Deshpande JR, Choudhri AA, Mishra MR, Meghre VS, Wadodkar SG and Dorle AK. Beneficial effects of *Lagenaria siceraria* (Mol.) *standley* fruit epicarp in animal models. Indian Journal of Experimental Biology. 2008; 46(4): 234-242.

36. Dias MG, Camoes MFGFC and Oliveira L. Carotenoids in traditional Portuguese fruits and vegetables. Food Chemistry. 2009; 113: 808–815.

37. Di Mascio P, Kaiser S, Sies H. Arch. Biochem. Biophys. Lycopene as the most efficient biological carotenoid singlet oxygen quencher. 1989; 274: 532-538.

38. Doll R, Peto R. Avoidable risks of cancer in the United States. *J Natl Cancer Inst.* 1981*;* 66*:* 1191–308.

39. Dorant E, van den Brandt PA, Goldbohm RA, Hermus RJJ, Sturmans F. Garlic and its significance for the prevention of cancer in humans: a critical view. Br. J. Cancer. 1993; 67: 424-429.

40. Dragsted LO, Strube H, Larsen JC. Cancer-protective factors in fruits and vegetables: biochemical and biological background. Pharmacol Toxicol. 1993; 72: 116–35.

41. Drewnowski A. J. Am. Coll. Nutr. Genetic Taste Markers and Preferences for Vegetables and Fruit of Female Breast Care Patients. 1996; 15: 1147–1153.

42. Dyrby M, Westergaard N, Stapelfeldt H. Light and heat sensitivity of red cabbage extract in soft drink model systems.Food Chemistry. 2001; 72: 431–437.

43. Eberhardt MV, Lee CY, Liu RH. Antioxidant activity of fresh apples. Nature. 2000; 405: 903–904.

44. Eliassen AH, Hendrickson SJ, Brinton LA, Buring JE, Campos H. Circulating carotenoids and risk of breast cancer: pooled analysis of eight prospective studies. J. Natl. Cancer Inst. 2012; 104: 1905-1916.

45. El-Shebini SM, Tapozada ST, Hanna LM, Ghattas LA, Mohamed HI. Effects of high vegetables consumption on inflammatory and immune functions in human obesity. J. Medical Sci. 2007; 7: 1268-1275.

46. Ernst E. Can allium vegetables prevent cancer? Phytomed. 1997; 4: 79-83.

47. Esfahani A, Wong JMW, Truan J, Villa CR, Mirrahimi A, Srichaikul K, Kendall CWC, Health effects of mixed fruit and vegetable concentrates: A systematic review of the clinical interventions. J. Am. Coll. Nutr. 2011; 30: 285-294.

48. Fahey JW, Zhang Y, Talalay P. Broccoli sprouts: an exceptionally rich source of inducers of enzymes that protect against chemical carcinogens. Proc Natl Acad Sci U S A. 1997; 94: 10367–72.

49. Fenwick GR, Curl CL, Griffiths NM, Heaney RK, Price KR. Bitter principles in food plants. In: Rouseff RL, ed. Bitterness in foods and beverages; developments in food science 25. Amsterdam: Elsevier. 1990; 205–250.

50. Franke AA, Custer LJ, Arakaki C, Murphy SP. Vitamin C and flavonoid levels of fruits and vegetables consumed in Hawaii Journal of Food Composition and Analysis. 2004; 17: 1–35.

51. Frei B, England L. Ames BN. Ascorbate is an outstanding antioxidant in human blood plasma. Proc Natl. Acad. Sci. USA. 1989; 86: 6377-6381.

52. Frei B, Stocker R. Ames BN. Antioxidant defenses and lipid peroxidation in human blood plasma. Proc. Natl. Acad. Sci. USA. 1988; 85: 9748-9752.

53. Fuchs JA. Glutaredoxin. In: Glutathione. Biochemical and Medical Aspects. Dolphin, D., Avramovic, O. and Poulson, R. (eds). New York, Wiley, pt B. 1989; pp551-570.

54. Fuhramn B, Elis A, and Aviram M. Hypocholesterolemic effect of lycopene and ß-carotene is related to suppression of cholesterol synthesis and augmentation of LDL receptor activity in macrophage. Biochem Biophys Res Commun. 1997; 233: 658-62.

55. Gagne D, Lauziere J, Blanchet R, Vezina C, Vaissiere E, Ayotte P, O'Brien HT. Consumption of tomato products is associated with lower blood mercury levels in Inuit preschool children. Food Chemical Toxicol. 2013; 51: 404-410.

56. Gangwal A, Parmar SK and Sheth NR. Isolation and immunomodulatory activity of phytocenstituents of *Lagenaria siceraria*. Pharm Communique (Suppl). 2009; 2(2): 46-50.

57. Gann P, Ma J, Giovannucci E, Willett W, Sacks FM, Hennekens CH Lower prostate cancer risk in men with elevated plasma lycopene levels: results of a prospective analysis. Cancer Res. 1999; 59: 1225-1230.

58. Gartner C, Stahl W, Sies and H. Lycopene is more bioavailable from tomato paste than from fresh tomatoes. Am J Clin Nutr. 1997; 66: 116-122.

59. Gaziano JM, Manson JE, Branch LG, Colditz GA, Willett WC, Buring JE. A prospective study of consumption of carotenoids in fruits and vegetables

and decreased cardiovascular mortality in the elderly. Ann Epidemiol. 1999; 5: 255-260.

60. Georgiev VG, Weber J, Kneschke EM, Nedyalkov DP, Bley T and Pavlov AI. Antioxidant activity and phenolic content of betalain extracts from intact plants and hairy root cultures of the red beetroot *Beta vulgaris cv. detroit dark red*, Plant Foods for Human Nutrition.2010; 65: 105–111.
61. Gerster H. The potential role of lycopene for human health. J. Am. Coll. Nutr. 1997; 16: 109-126.
62. Ghule BV, Ghante MH, Yeole PG, Saoji AN. Diuretic activity of *Lagenaria siceraria* fruit extracts in rats. Indian Journal of Pharmceutical Sciences. 2007; 69(6): 817-819.
63. Gibson A, Edgar JD, Neville CE, Gilchrist SE, McKinley MC. Effect of fruit and vegetable consumption on immune function in older people: A randomized controlled trial. Am. J. Clin. Nutr. 2012; 96: 1429-1436.
64. Giovannucci E, Ascherio A, Rimm EB, Stampfer MJ, Colditz GA, Willett WC. Intake of carotenoids and retinol in relation to risk of prostate cancer. J. Natl. Cancer Inst. 1995; 87: 1767-1776.
65. Gokmen V, Kahraman N, Demir N, Acar J. Enzymatically validated liquid chromatographic method for the determination of ascorbic and dehydroascorbic acids in fruit and vegetables J Chromatography. 2000; 881: 309–316.
66. Gosslau A, Chen KY. Nutraceuticals, apoptosis, and disease prevention. Nutrition. 2004; 20: 95–102.
67. Gundgaard J, Nielsen JN, Olsen J, Sorensen J. Increased intake of fruit and vegetables: Estimation of impact in terms of life expectancy and healthcare costs. Public Health Nutrition. 2003; 6: 25–30.
68. Hafidh RR, Abas F, Abdulamir AS, Jahanshiri F, Abu Bakar F, Sekawi Z. A review: Cancer research of natural products in Asia. Int. J. Cancer Res. 2009; 5: 69-82.
69. Halliwell B, Aeschbach R, Löliger J, Aruoma OI. The characterization of antioxidants. Food Chemistry and Toxicology. 1995; 33: 601-617.
70. Hashimoto K, Kawamata S, Usui N, Tanaka A, Uda Y. In vitro induction of the anticarcinogenic marker enzyme, quinone reduktase, in human hepatoma cells by food extracts. Cancer Letters. 2002; 180: 1–5.
71. Hecht SS. Chemoprevention by isothiocyanates. J. Cell. Biochem. Suppl. 1995; 22: 195-209.
72. Hertog MGL, Kromhout D, Aravanis C, Blackburn H, Buzina R, Fidanza F, Giampaoli S, Jansen A, Menotti A, Nedeljkovic S. Flavonoid intake and long-term risk of coronary heart disease and cancer in the Seven Countries Study. *Arch Intern Med.* 1995; 155*:* 381–6.
73. Hertog MGL, Hollman PCH, Katan MB. Content of potentially anticarcinogenic flavonoids of 28 vegetables and 9 fruits commonly consumed in The Netherlands. J Agric Food Chem. 1992; 40:2379–2383.
74. Hertog MGL, Hollman PCH, van de Putte B. Content of potentially anticarcinogenic flavonoids of tea infusions, wines and fruits juices. J Agric Food Chem. 1993; 41: 1242–1246.
75. Hofgen R, Kreft O, Willmitzer L, Hesse H. Manipulation of thiol contents in plants. Amino Acids, 2001; 20: 291-299.
76. Hollman PCH, Arts ICW. Flavonols, flavones and flavonols - nature, occurrence and dietary burden. *J Sci Food Agric.* 2000*;* 80*:* 1081–1093.
77. Hollman PCH, Hertog MGL, Katan MB. Analysis and health effects of flavonoids. Food Chemistry. 1996; 57 (1) :43–46.
78. Holt EM, Steffen LM, Moran A, Basu S, Steinberger J. Fruit and vegetable consumption and its relation to markers of inflammation and oxidative stress in adolescents. J. Am. Diet Assoc. 2009; 109: 414-421.
79. Imai S, Fukui M, Ozasa N, Ozeki T, Kurokawa M, Komatsu T, Kajiyama S. Eating vegetables before carbohydrates improves postprandial glucose excursions. Diabetic Med., 2012; 30: 370-372.
80. Isaacsohn JL, Moser M, Stein EA, Dudley K, Davey JA, Liskov E, Black HR. Garlic powder and plasma lipids and lipoproteins: A multicenter, randomized, placebo-controlled trial. Arch. Int. Med. 1998; 158: 1189-1194.
81. Jastrebova J, Witthoft C, Grahn A, Svensson U and Jagerstad M. HPLC determination of folates in raw and processed beetroots. Food Chemistry. 2003; 80; 579–588.
82. Jones DP, Coates RJ, Flagg EW. Glutathione in foods listed in the National Cancer Institute's Health Habits and History Food Frequency Questionnaire. Nutr Cancer. 1992; 17: 57-75.
83. Jones DP, Hagen TM, Weber R, Wierzbicka GT, Bonkovsky HL. Oral administration of glutathione (GSH) increases plasma GSH concentrations in humans (abstract). (abstract). FASEB. 1989; J 3: A1250.
84. Kapadia GJ, Tokuda H, Konoshima T and Nishino H. Chemoprevention of lung and skin cancer by *Beta vulgaris* (beet) root extract. Cancer Letters. 1996; 100: 211–214.
85. Kiefer I, Prock P, Lawrence C, Wise J, Bieger W. Supplementation with mixed fruit and vegetable juice concentrates increased serum antiox-idants and folate in healthy adults. J. Am. Coll. Nutr. 2004; 23: 205-211.
86. Kohlmeier L, Kark JD, Gomez-Gracia E, Martin BC, Steck SE, Kardinaal AFM, Ringstad J, Thamm M, Masaev V, Riemersma R, Martin-Moreno JM, Huttunen JK, Kok FJ. Lycopene and myocardial infarction risk in the EURAMIC study. Am. J. Epidemiol. 1997; 146: 618-626.
87. Krinsky NI. Carotenoids as antioxidants . Nutrition. 2001; 17: 815–817.
88. Kris-Etherton PM, Etherton TD, Carlson J, Gardner C. Recent discoveries in inclusive food-based

approaches and dietary patterns for reduction in risk for cardiovascular disease Current Opinion in Lipidology. 2002; 13: 397–407.

89. Kucuk O, Sakr FH, Djuric Z, Li YW, Velazquez F, Banerjee M. Lycopene supplementation in men with prostate cancer (PCa) reduces grade and of preneoplasia (PIN) and tumor, decreases serum prostate specific antigen and modulates biomarkers of growth and differentiation. International Conference on Diet and Prevention of Cancer; 1999 May 28-June 2; Tampere, Finland. P1.13.
90. Kujala TS, Vienola MS, Klika KD, Loponen JM and Pihlaja K. Betalains and phenolic compositions of four beetroots (*Beta vulgaris*) cultivars. Eur Food Res Technol., 2002; 214: 505-510.
91. Kujala TS, Loponen JM, Klika KD and Pihlaja K. Phenolics and betacyanins in red beetroot (*Beta vulgaris*) root: Distribution and effect of cold storage on the content of total phenolics and three individual compounds. Journal of Agricultural and Food Chemistry. 2000; 48: 5338–5342.
92. Kumar A, Rahal A, Mandil R, Prakash A, Shaikh MZ. Reparative potential of ascorbic acid on subacute co-exposure of lead and cypermethrin induced oxidative stress in the erythrocytes of wistar rats. Proceedings of the 32nd Annual Conference of Society of Toxicology, India and International Symposium on New Frontiers in Toxicology, December 5-7, 2012, CSIR-Indian Institute of Toxicology Research, Lucknow, pp: 150-150.
93. Keum YS, Jeong WS, Kong ANT. Chemoprevention by isothiocyanates and their underlying molecular signaling mechanisms. Mutation Research. 2004; 555: 191–202.
94. Kuntz S, Wenzel U, Daniel H. Comparative analysis of the effects of flavonoids on proliferation, cytotoxity, and apoptosis in human colon cancer cell lines. European J Nutrition. 1999; 38 (3): 133–142.
95. Kurilich AC, Tsau GJ, Brown A, Howard L, Klein BP, Jeffery EH. Carotene, tocopherol, and ascorbate contents in subspecies of Brassica oleracea. J Agril. Food Chemistry. 1999; 47: 1576–1581.
96. Lampi AM, Kamal-Eldin A, Piironen V. Tocopherols and tocotrienols from oil and cereal grains. In: J. Shi, G. Mazza, M. LeMaguer, (Eds.), *Functional food – Biochemical and processing aspects*. Boca Raton, FL: CRC Press LLC. 2002.
97. Law MR, Morris JK. By how much does fruit and vegetable consumption reduce the risk of ischemic heart disease? *European Clinical Nutrition*. 1998; 52: 549–556.
98. Lawson LD, Wang ZYJ, Hughes BG. Identification and HPLC quantitation of the sulfides and dialk(en)ylthiosulfinates in commercial garlic products. Planta Med. 1991; 57: 363-370.
99. Lee SK, Kader AA. Preharvest and postharvest factors influencing vitamin C content of horticultural crops. Postharvest Biology and Technology. 2000; 20: 207–220.
100. Li Y, Elie M, Blaner WS, Brandt-Rauf P, Ford J. Lycopene, smoking and lung cancer. Proc. Am. Assoc.. Cancer Res. 1997; 38: 113.
101. Liao KI, Yin MC. Individual and combined antioxidant effects of seven phenolic agents in human erythrocyte membrane ghosts and phosphatidylcholine liposome systems: Importance of the partition coefficient. J Agril.Food Chemistry 2000; 48: 2266–2270.
102. Liu RH. Potential synergy of phytochemicals in cancer prevention: mechanism of action. *J Nutr.* 2004; 134*:* 3479S–85S.
103. Mahima AK, Verma, Kumar A. How to feed an older dog. Indian Pet J Online J. Canine, Feline Exotic Pets. 2011; 3: 63-65.
104. Mahima A, Rahal R, Deb SK, Latheef HA, Samad. Immunomodulatory and therapeutic potentials of herbal, traditional/indigenous and ethnoveterinary medicines. Pak. J. Biol. Sci. 2012; 15: 754-774.
105. Mannervik B, Carlberg I, Larson K. In : Glutathione. Chemical, Biochemical and Medical Aspects. Dolphin. D., Avramovic, O and Pulson, R. (eds). New York, Wiley, pt. A. 1989; pp 475-516.
106. Mattoo AK, Chung SH, Goyal RK, Fatima T, Solomos T, Srivastava A, Handa AK. Overaccumulation of higher polyamines in ripening transgenic tomato fruit revives metabolic memory, upregulates anabolism-related genes and positively impacts nutritional quality. J. AOAC Int. 2007; 90: 1456-1464.
107. Matsuura N, Obata A, Fukushima D. Objectionable flavor of soy milk developed during the soaking of soybeans and its control. J Food Sci. 1989; 54: 602–5.
108. Mazza G, Miniati E. Anthocyanins in fruits, vegetables and grains. Boca Raton FL: CRC Press. 1993; 283–288.
109. Michaud DS, Giovannucci EL, Ascherio A, Rimm EB, Forman MR, Sampson L. Associations of plasma carotenoid concentrations and dietary intake of specific carotenoids in samples of two prospective cohort studies using a new carotenoid database. Cancer Epidemiol Biomarkers Prev. 1998; 7: 283-290.
110. Michaud DS, Spiegelman D, Clinton SK, Rimm EB, Willett WC, Giovannucci EL. Fruit and vegetable intake and incidence of bladder cancer in a male prospective cohort. J. Natl. Cancer Inst. 1999; 91: 605-613.
111. Mohale DS, Dewani AP, Saoji AN and Khadse CD. Antihyperlipidemic activity of isolated constituents from the fruits of *Lagenaria siceraria* in albino rats. International Journal of Green Pharmacy. 2008; 2(2): 104-107.
112. Mudgal V, Madaan N, Mudgal A, Mishra S. Dietary polyphenols and human health. Asian J. Biochem., 2010; 5: 154-162.
113. Murakami M, Yamaguchi T, Takamura H, Matoba T. Effects of ascorbic acid and *â*-tocopherol on antioxidant activity of polyphenolic compounds J Food Sci. 2003; 68 (5) : 1622–1625.

114. Murphy MM, Barraj LM, Herman D, Bi X, Cheatham R, Randolph RK. Phytonutrient intake by adults in the United States in relation to fruit and vegetable consumption. J. Acad. Nutr. Diet. 2012; 112: 222-229.

115. Nagourney RA. Garlic: Medicinal food or nutritious medicine? J. Medicinal Food. 1998; 1: 13-28.

116. Nestle M. Broccoli sprouts in cancer prevention. Nutr. Rev. 1998; 56: 127-130.

117. Nguyen ML, Schwartz S. Lycopene: chemical and biological properties. J Food Technol. 1999; 53:38-45.

118. Nielsen JK, Norbek R, Olsen CE. Kaempferol tetraglucosides from cabbage leaves. Phytochemistry. 1998; 34 : 539–544.

119. Nielsen JK, Olsen CE, Petersen MK. Acylated flavonol glycosides from cabbage leaves. Phytochemistry. 1993; 49: 2171–2176.

120. Nijveldt RJ, Van Nood E, Van Hoorn EC, Boelens PG, Van Norren K, Van Leeuwen PAM. Flavonoids: a review of probable mechanisms of action and potential applications Am. J. Clin. Nutr. 2001; 74: 418-425.

121. Odukoya OA, Inya-Agha SI, Segun FI, Sofidiya MO, Ilori OO. Antioxidant activity of selected Nigerian green leafy vegetables. Am. J. Food Technol. 2007; 2: 169-175.

122. Oleinick NL, Xue L, Friedman LR, Donahue LL, Biaglow JE. Inhibition of radiation-induced DNA-protein cross-link repair by glutathione depletion with L-buthionine sulfoximine. NCI Monogr. 1988; 6: 225-229.

123. Orech FO, Christensen DL, Larsen T, Friis H, Aagaard-Hansen J, Estambale BA. Mineral content of traditional leafy vegetables from Western Kenya. Int. J. Food Sci. Nutr. 2007; 58: 595-602.

124. Patkai G, Barta J and Varsanyi I. Decomposition of anticarcinogen factors of the beetroot during juice and nectar production. Cancer Letters. 1997; 114: 105–106.

125. Paolini M. Brussels sprouts: An exceptionally rich source of ambiguity for anticancer strategies. Toxicology and Applied Pharmacology. 1998; 152 :293–294.

126. Pedreno MA and Escribano J. Studying the oxidation and the antiradical activity of betalain from beetroot. Journal of Biological Education. 2000; 35(1): 49-51.

127. Piironen V, Syvaoja EL, Varo P, Salminen K, Koivistoinen P. Tocopherols and tocotrienols in Finnish foods: vegetables, fruits, and berries J Agril Food Chemistry. 1986; 34: 742–746.

128. Pitalua E, Jimenez M, Vernon-Carter EJ and Beristain CI. Antioxidative activity of microcapsules with beetroot juice using gum Arabic as wall material. Food and Bioproducts Processing. 2010; 88: 253–258.

129. Plumb GW, Lambert N, Chambers SJ, Wanigatunga S, Heaney RK, Plumb JA. Are whole extracts and purified glucosinolates from cruciferous vegetables antioxidants? Free Radical Research. 1996; 25(1): 75–86.

130. Potter JP. Food, nutrition and the prevention of cancer: a global perspective. Washington, D.C. World Cancer Research Fund. 1997.

131. Price KR, Casuscelli F, Colquhoun IJ, Rhodes MJC. Composition and content of flavonol glycosides in broccoli florets (Brassica olearacea) and their fate during cooking. J Sci. Food Agril. 1998; 77: 468–472.

132. Rao AV, Agarwal S. Role of lycopene as antioxidant carotenoid in the prevention of chronic diseases: a review. *Nutr Res.* 1999; 19: 305-323.

133. Rao AV, Waseem Z, Agarwal S. Lycopene contents of tomatoes and tomato products and their contribution to dietary lycopene. Food Res Int. 1998; 31 :737-741.

134. Re R, Pellegrini N, Proteggente A, Pannala A, Yang MC. Rice-Evans Antioxidant activity applying an improved ABTS radical cation decolorization assay. Free Radical Biology & Medicine. 1999; 26:1231–1237.

135. Rhodes MJC. Physiologically-active compounds in plant foods: an overview. Proc Nutr Soc. 1996; 55: 371–384.

136. Rice-Evans C, Sampson J, Bramley PM, Holloway DE. Why do we expect carotenoids to be antioxidants in vivo?. Free Radical Research. 1997; 26 : 381–398.

137. Rossetto M, Vanzani P, Mattivi F, Lunelli M, Scarpa M, Rigo A. Synergistic antioxidant effect of catechin and malvidin 3-glucoside on free radical-initiated peroxidation of linoleic acid in micelles Archives of Biochemistry and Biophysics. 2002; 408: 239–245.

138. Rouseff RL. Bitterness in food products: an overview. In: Rouoseff RL, Bitterness in foods and beverages. Developments in food science. Amsterdam: Elsevier. 1990; 25: 1–14.

139. Roy GM. The applications and future implications of bitterness reduction and inhibition in food products. Food Sci. Nutr. 1990; 29:59–71.

140. Sahib HB, Harchan NAH, Atraqchi SAM, Abbas AA. The role of medicinal herbs in angiogenesis related diseases. Int. J. Pharmacol., 2010; 6: 616-623.

141. Salawu SO, Akindahunsi AA. Protective effects of some tropical vegetables against CCl_4 induced hepatic damage. J. Pharmacol. Toxicol. 2006; 1: 478-484.

142. Samman S, Sivarajah G, Man JC, Ahmad ZI, Petocz P, Caterson ID. A mixed fruit and vegetable concentrate increases plasma antioxidant vitamins and folate and lowers plasma homocysteine in men. J. Nutr., 2003; 133: 2188-2193.

143. Sharma S, Stutzman JD, Kelloff GJ, and Steele VE. Screening of potential chemopreventive agents using biochemical markers of carcinogenesis. Cancer Res. 1994; 5848–55.

144. Shi H, Noguchi N, Niki E. Natural antioxidants. In: Antioxidants in food: Practical application. Pokorny, J., Yanishlieva, N. and Gordon, M. (Eds.), (1st ed). Cambridge: CRC Press Woodhead Publishing Ltd. 2001.

145. Silagy CA, Neil HAW. A meta-analysis of the effect

of garlic on blood pressure. J. Hyper. 1994a;12: 463-468.

146. Silagy C, Neil A. Garlic as a lipid-lowering agent — a meta-analysis. J. Royal Coll. Physicians Lond. 1994b; 28: 39-45.

147. Singh R, Singh PP, Rathore RS, Dhama K, Malik SVS. Prevalence of *Campylobacter jejuni* and *Campylobacter coli* in chicken meat and carcasses collected from local poultry farms and retail shops of Bareilly, Uttar Pradesh India. Indian J. Comp. Microbiol. Immunol. Infect. Dis. 2009; 30: 35-38.

148. Singh V, Singh KP, Kaleshwari L, Rahal A, Ahmad AH. The cytoprotective effect of *Emblica officinalis* root extract against mercury induced cytotoxicity in Hep G2 cell line. Proceedings of the 7th Annual Conference of ISVPT and Symposium on Ethnopharmacology in Clinical Veterinary Practice and Role of Nanotechnology in Drug Delivery Systems, November 28-30, 2007, Wayand, India.

149. Song W, Derito CM, Liu KM . Liu HX, Dong M, Liu RH. Cellular antioxidant activity of common vegetables. *J Agric Food Chem.* 2010; 58*: 6621–6629.*

150. Srivastava KC, Bordia A, Verma SK. S. Garlic (Allium sativum) for disease prevention. Afr. J. Sci. 1995; 91: 68-77.

151. Stahl W, Sies H. â-Carotene and other carotenoids in protection from sunlight. Am. J. Clin. Nutr. 2012; 96: 1179S-1184S.

152. Stahl W, Sies H. Lycopene: A biologically important carotenoid for humans. Archives of Biochemistry and Biophysics. 1996; 336:1–9.

153. Stampfer MJ, Rimm EB. Epidemiologic evidence for vitamin E in prevention of cardiovascular disease. American J Clinical Nutrition. 1995; 62: 1365–1369.

154. Steinmetz KA, Potter JD. Vegetables, fruit and cancer prevention: a review. J Am Diet Assoc. 1996; 96: 1027–1039.

155. Steinmetz KA, Potter JD. Vegetables, fruit and cancer II. Mechanisms. Cancer Causes Control 1991a; 2: 427-442.

156. Steinmetz KA, Kushi H, Bostick RM, Folsom AR, Potter JD. Vegetables, fruit, and colon cancer in the Iowa Women's Health Study. Am. J. Epidemiol. 1994; 139: 1-15.

157. Temple NJ. Antioxidants and disease: More questions than answers Nutrition Research. 2000; 20(3): 449–459.

158. Thomas SC. Nutritional and therapeutic values of vegetables in: vegetables and fruits: nutritional and therapeutic values, Chap. 1. CRC Press, London, 2008; pp. 23-24.

159. Thompson CA, Habermann TM, Wang AH, Vierkant RA, Folsom AR, Ross JA, Cerhan JR. Antioxidant intake from fruits, vegetables and other sources and risk of non-Hodgkin's lymphoma: The Iowa women's health study. Int. J. Cancer. 2010; 126: 992-1003.

160. Trock B, Lanza E, Greenwald P. Dietary fiber, vegetables, and colon cancer: critical review and meta-analyses of the epidemiological evidence. J Natl Cancer Inst. 1990; 82:650–61.

161. Trombino S, Serini S, Di Nicuolo F, Celleno L, Ando S, Picci N. Antioxidant effect of ferulic acid in isolated membranes and intact cells: Synergistic interactions with *â*-tocopherol, *â*-carotene, and ascorbic acid. J Agril Food Chemistry. 2004; 52: 2411–2420.

162. USDA National Nutrient Database for Standard Reference, Release 24, 2011, accessed on June 12, 2012.http://ndb.nal.usda.gov/.

163. Vallejo F, Tomas-Barberan F, Garcia-Viguera C. Health-promoting compounds in broccoli as influenced by refrigerated transport and retail sale period. J Agril Food Chemistry. 2003; 51: 3029–3034.

164. Vali L, Stefanovits-BE, Szentmihalyi K, Febel H, Sardi E, Lugasi A, Kocsis I and Blazovics A. Liver-protecting effects of table beet (*Beta vulgaris var. Rubra*) during ischemia-reperfusion. Nutrition. 2007; 23: 172–178.

165. Vallejo F, Tomas-Barberan F, Garcia-Viguera C. Total and individual glucosinolate contents in inflorescences of eight broccoli cultivars grown under various climatic and fertilization conditions. J. Sci. Food and Agril. 2002; 82: 1293–1297.

166. Van Doorn HE, van der Kruk GC, van Holst GJ. The glucosinolates sinigrin and progoitrin are important determinants for taste preferences and bitterness of Brussels sprouts. J Sci Food Agric. 1998; 78: 30–38.

167. Vanderslice JT, Higgs DJ, Hayers JM, Block G. J. Food Composition and Analysis. 1990; 3: 105–118.

168. Vazquez-Prieto MA, Miatello RM. Organosulfur compounds and cardiovascular disease. Mol. Aspects Med., 2010; 31: 540-545.

169. Verhoeven DTH, Goldbohm RA, van Poppel G, Verhagen H, van den Brandt PA. Epidemiological studies on brassica vegetables and cancer risk. Cancer Epidemiol. Biomarkers Prev. 1996; 5: 733-748.

170. Verhoeven DTH, Verhagen H, Goldbohm RA, van den Brandt PA, van Poppel G. A review of mechanisms underlying anticarcinogenicity by brassica vegetables. Chem. Bio. Interactions. 1997; 103: 79-129.

171. Vinson JA, Dabbagh YA, Serry MM, Jang J. Plant flavonoids, especially tea flavonols, are powerful antioxidants using an in vitro oxidation model for heart disease. J Agril Food Chemistry. 1995; 43 :2800–2802.

172. Wang H, Cao G, Prior RL. Oxygen radical absorbing capacity of anthocyanins. J Agril Food Chemistry. 1997; 45: 304–309.

173. Warshafsky S, Kamer RS, Sivak SL. Effect of garlic on total serum cholesterol. A meta-analysis. Ann. Int. Med. 1993; 119: 599-605.

174. Wattenberg LW. Chemoprevention of cancer. Cancer Res. 1985; 45: 1-8.

175. Wattenberg LW. Inhibition of carcinogenesis by nonnutrient constituents of the diet. In: Food and

cancer prevention: chemical and biological aspects. Waldron, K.W., Johnson, I.T., Fenwick, G.R. (eds). Cambridge, United Kingdom: Royal Society of Chemistry. 1993; 12–23.

176. Weisburger JH. (ed.). International symposium on lycopene and tomato products in disease prevention. Proc. Soc. Exp. Biol. Med. 1998; 218: 93-143.

177. Willett WC . Balancing life-style and genomics research for disease prevention. *Science.* 2002; 296: 695–8.

178. Williams GM, Williams CL, Weisburger JH. Diet and cancer prevention: the fiber first diet. Toxicol. Sci. 1999; 52 (Suppl): 72-86.

179. Wolfenden L, Wyse RJ, Britton BI, Campbell KJ, Hodder RK. Interventions for increasing fruit and vegetable consumption in children aged 5 years and under. Cochrane Database Syst. Rev., 2012; Vol. 11. 10.1002/14651858.

180. You WC, Blot WJ, Chang YS, Ershow AG, Yang ZT, An Q, Henderson B, Xu G.-W, Fraumeni JF, Wang TG. Diet and high risk of stomach cancer in Shandong. China. Cancer Res. 1988; 48: 3518- 3523.

181. Zhang Y, Talalay P, Cho CG, Posner GH. A major inducer of anticarcinogenic protective enzymes from broccoli: isolation and elucidation of structure. Proc Natl Acad Sci U S A. 1992; 89: 2399–2403.

182. Zhu QY, Huang ZY. Chen Interaction between flavonoids and *á*-tocopherol in human low density lipoprotein. J Nutritional Biochemistry. 2000; 11: 14–21.

183. Zitnanova I, Ranostajova S, Sobotova H, Demelova D, Pechan I and Durackova Z. Antioxidative activity of selected fruits and vegetables. Biologia. 2006; 61:279–284.

184. Zou D, Brewer M, Garcia F, Feugang JM, Wang J and Zang R. Cactus pear: A natural product in cancer chemoprevention. Nutrition Journal. 2005; 4: 25.

Review Article

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Plant Phenols and Their Health: Enhancing Properties

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Abstract

Phenolic compounds, found in all plants constitute an essential component of human diet. The major polyphenolic compounds found in plants are flavonoids, phenolic acids, stilbenes, chalcones, phenol alcohol and lignans. These compounds are secondary plant metabolites and possess various health benefits such as cardio protective effect, antidiabetic and anticancer properties along with high antioxidative activity. There properties make polyphenols interesting for the treatment of various diseases like cancer and also used for treatment of neurodegenerative diseases (such as Parkinson's and Alzheimer's). They have wide range of nutraceutical applications and exerts prebiotic effects as well. The antioxidative activity of phenolic compounds depends on their structure, in particular the number and position of the hydroxyl groups and the nature of substitutions on the aromatic rings. Fruits, vegetables and beverages are the chief sources of phenolic compounds in the human diet. This review is focused on plant polyphenols and discusses the aspects relative to their potential health benefits.

Keywords: Polyphenols; Antioxidant; Cardio-Protective; Neuro-Degenerative; Prebiotics; Secondary Metabolites.

Introduction

Phenolic compounds are secondary metabolites that are derivatives of the pentose phosphate, shikimate, and phenylpropanoid pathways in plants. They consist of flavan ring and contribute mainly to antioxidant property. They are essential to the physiology of plants, because of their involvement in various important functions such as growth, structure, defense, pigmentation and lignifications. The majority of polyphenols are synthesized by the highly branched phenyl propanoid pathway, which is responsible for the biosynthesis of a large number of chemical compounds with considerable structural diversity. They are major constituents of fruits, vegetables, cereals and beverages. Polyphenols may be classified as phenolic acids, flavonoids, stilbenes and lignans.

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In food, polyphenols may contribute to the bitterness, astringency, color, flavor, odor and oxidative stability. Phenolic compounds exhibit a wide range of physiological properties such as anti-allergenic, anti-artherogenic, anti-inûammatory, anti-microbial, antioxidant, anti-thrombotic, cardioprotective and vasodilatory eûects[1,2]. Polyphenols can act as metal chelators which adds to the antioxidant effects of these compounds through inhibition of transition metal-catalyzed free radical formation[3]. Polyphenols and other food phenolics is the subject of increasing scientific interest because of their possible beneficial effects on human health. These compounds are present in all plant foods but their type and levels vary based on the plant, genetic factors and environmental conditions [4].

Classification of Polyphenols

More than 8,000 polyphenolic compounds are structurally known and among them over 4000 flavonoids have been identified in various plant species. Structurally, phenolic compounds comprise an aromatic ring, bearing one or more hydroxyl substituent, and ranged from simple phenolic molecules to highly polymerized compounds. Plant phenolic compounds have a common intermediate

i.e. phenylalanine, or a close precursor, shikimic acid. Primarily they occur in conjugated forms with one or more sugar residues linked to hydroxyl groups, although direct linkages of the sugar (polysaccharide or monosaccharide) to an aromatic carbon also exist. Association with other compounds like carboxylic and organic acids, amines, lipids and linkage with other phenol is also common [5]. Polyphenols are classified on the basis of the number of phenol rings that they contain the structural elements that bind these rings to one another. They are broadly divided in four classes: phenolic acids, flavonoids, stilbenes and lignans. The variations among these classes are the basic chemical skeleton as also the degree of oxidation, hydroxylation, methylation, glycosylation and the possible connections to other molecules [6]. They are a diverse group of chemicals having one feature in common, which is the presence of at least one aryl ring to which a minimum one hydroxyl group is attached. The most common polyphenols are classified in Figure 1 and their structures represented in Figure 2.

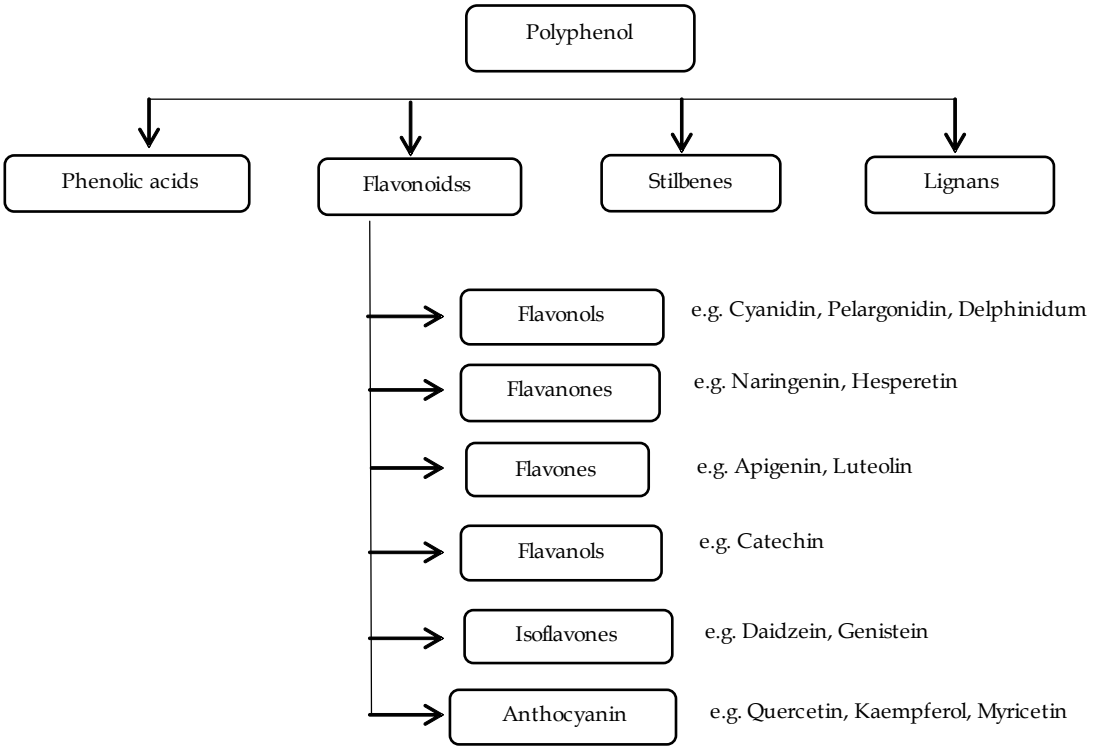

Fig. 1: Classification of polyphenols

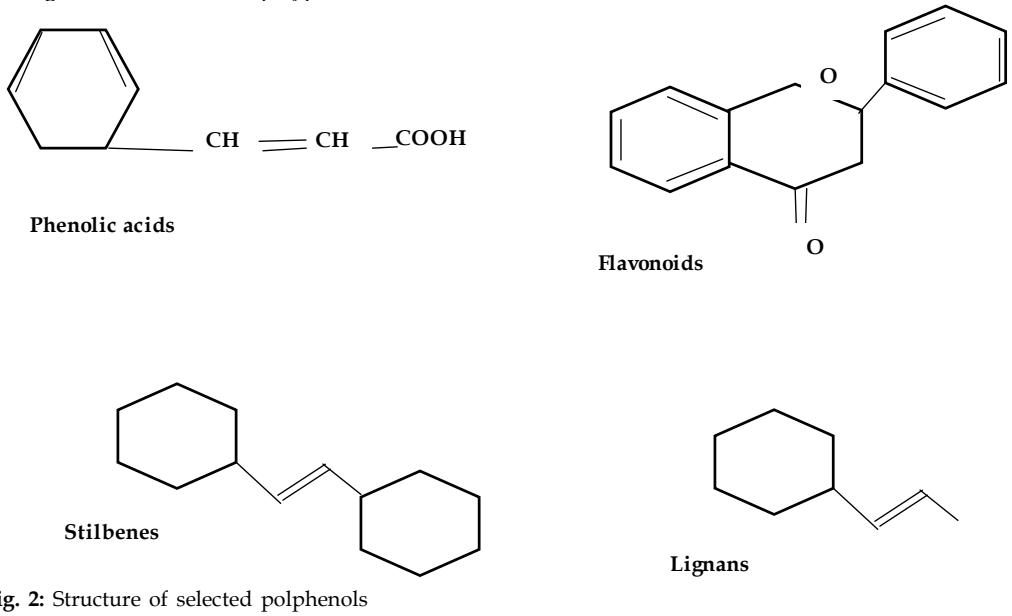

Fig. 2: Structure of selected polphenols

Phenolic Acids

Phenolic acids contain two distinguishing constitutive carbon frameworks; hydroxycinnamic (C_6C_3) and hydroxybenzoic (C_6C_1) structure. Phenolic acids have antioxidant properties due to their high redox potential, which allows them to act as reducing agents and singlet oxygen quenchers [7]. They can be hydrolyzed by acid, alkali and enzyme. Caffeic acid, gallic acid, ferulic acid are some common phenolic acids.

Flavonoids

Flavonoids constitute the largest class of phenolic compounds. They have the C6–C3–C6 general structural backbone in which the two C6 units (Ring A and Ring B) are of phenolic nature [8]. Due to the hydroxylation pattern and variations in the chromane ring (Ring C), flavonoids can be further divided into different sub-groups such as flavonols, flavones, flavanones, flavanols, isoflavones and anthocyanins [9], of which ûavones and ûavonols occur most widely. Flavonoids are produced by a combination of two mechanisms. The A ring of flavonoids is acetate-derived (resorcinol or phloroglucinol) while the B ring is produced via the shikimic acid pathway. Flavonoids can be sugar-free (aglycones) or glycosylated. The sugar moiety is usually glucose, but flavonoid glycosides containing rhamnose, xylose, arabinose, galactose, galacturonic acid or glucuronic acid also exit. Flavonols are the class of flavonoids, which have a 3-hydroxyflavone backbone and are present in wide variety of fruits and vegetable. Quercetin and kaempferol are the most common flavonol aglycones that have at least 279 and 347 different glycosidic combinations, respectively.Flavones mainly consist of glycosides of luteolin, tangeretin and apigenin. The only important edible sources of flavones identified are parsley and celery. Flavanones are generally glycosylated by a disaccharide at position 7, either a neo-hesperidose, which imparts a bitter taste (such as to naringin in grapefruit), or a rutinose, which is flavorless. The main aglycones are naringenin in grapefruit, hesperidins in oranges, and eriodictyol in lemons [10]. Isoflavones have structural similarities to estrogens i.e. hydroxyl groups in the C7 and C4 positions like estradiol molecule. Genistein and daidzein are the two main isoflavones found in soya along with glycetein, biochanin A and formononetin. Flavanols exist in monomer (catechins) as well as polymer form (proanthocyanidins). Catechin and epicatechin are the main flavanols in fruits, whereas gallocatechin, epigallocatechin, and epigallocatechin-gallate are found in certain seeds of leguminous plants and more importantly in tea [11, 12].

Proanthocyanidins, which are also known as condensed tannins, are dimers, oligomers, and polymers of catechins that are bound together by links between C4 and C8 (or C6). Anthocyanins are pigments dissolved in the vacuolar sap of the epidermal tissues of flowers and fruits, to which they impart a pink, red, blue, or purple color. Cyanidin is the most common anthocyanidin in foods. Anthocyanins are found mainly in the skin, except for certain types of red fruit, in which they also occur in the flesh (cherries and strawberries). Wine contains anthocyaninsthat are transformed into various complex structures as the wine aged [13].

Stilbenes

Stilbenes contain two phenyl moieties connected by a two-carbon methylene bridge. Stilbenes exist as stereoisomers and naturally occurring stilbenes are present in the Transform. They occur in free and glycosylated forms and as dimeric, trimeric and polymeric stilbenes, also called viniferins [14].

Lignans

Lignans are polyphenolic substances derived from phenylalanine via dimerization of substituted cinnamic acid. Lignans come under the class of phytoestrogens such as secoisolariciresinol, pinoresinol, steganacin and sesamin and its richest dietary source is linseed. Secoisolariciresinol from flaxseed reportedly slows the growth of human breast cancer in mice [15].

Polyphenols and Human Diseases

Evidence suggests that there is a strong relationship between consumption of polyphenol-rich food and reducing the risk of chronic human diseases. Polyphenols may increase plasma antioxidant capacity and help in reducing oxidative stress,therefore limiting the risk of various degenerative diseases [16]. This may be because of the reducing property of polyphenols their effect on the absorption of pro-oxidative food components such as iron[1,17]. The structural modulation/ modiûcation of polyphenol compounds could provide potential inhibition against bacterial pathogens such as *Streptococcus mutans* and *Mycobacterium tuberculosis* [18]. Cocoa polyphenol pentamers significantly reduced biofilm formation and acid production by *S. mutans* and *S. sanguinis*. Polyphenolic compounds in wine are affected by climate, CO_2 level and region [19]. Warmer climate

lowered the antioxidant capacity value, but retained good bioavailability. Polyphenols occurring in cocoa, coffee and tea had major role in prevention of cariogenic processes due to their antibacterial action [20]. Tea polyphenols exert anti-caries effect via antimicrobial mode of action, galoyl esters of epicatechin, epigallocatechin and gallocatechin showing increased antibacterial activity. Tea polyphenols also exhibit an antidepressant activity, which may relate to the alteration of monoaminergic response and antioxidant defenses [21]. Polyphenols reportedly have the potential to reduce cervical cancer by induction of apoptosis, growth arrest, and inhibition of DNA synthesis and modulation of signal transduction pathways. They can interfere with each stage of carcinogenesis: initiation, promotion and progression to prevent cancer development [22].

Cardio-Protective Effect

Polyphenols exerts an additive/ or synergistic protective effects on cardiovascular system and limit the incidence of coronary heart diseases. Cardiovascular disease (CVD) risks include arthrosclerosis, low density lipoprotein (LDL) oxidation, endothelial disfunctioning, platelet aggregation, and inflammatory reactions [17,23]. Atherosclerosis is a chronic inflammatory disease that develops in lesion-prone regions of medium-sized arteries that leads to acute myocardial infarction, unstable angina and sudden cardiac death [24] . It wasfound thatmoderate consumption of red wine (contains polyphenols, melatonin and phytosterol) provides beneficial effect on heart health [25]. Polyphenols are potent inhibitors of LDL oxidation which plays a key role in the development of atherosclerosis [26]. Other mechanisms by which polyphenols may be protective against CVDs are antioxidant, anti-platelet, anti-inflammatory effects, increasing high density lipoprotein (HDL) level and improving endothelial function [27]. Polyphenols may also contribute to stabilization of the atheroma plaque. Quercetin, the abundant polyphenol in onion inhibits the expression of metalloproteinase 1 (MMP1) that has been recognized to play an important role in matrix remodeling in cardiac disease stress and the disruption of atherosclerotic plaques that leads to CVDs [28]. It also blocks the H_2O_2- induced inflammatory response that contributes to prevent ischemic reperfusion injury in cardiomyocytes [29]. The complex biochemical composition of onion altered the individual fatty acid profile when given along with high cholesterol diet in rats [30]. Raisins (160g/d for 6 weeks) significantly lowered the level of proinflammatory cytokine and a cellular adhesion molecule in volunteers [31]. The lower level of soluble intercellular molecule can potentially prevent the progression of atherosclerosis by decreasing the adhesion of monocytes to the vascular endothelium. Tea polyphenols increase artery dilation, improve endothelial dysfunction, estrogen like activity and decrease blood pressure [32]. Tea catechins inhibit the invasion and proliferation of the smooth muscle cells in the arterial wall that contribute to slow down the formation of the atheromatous lesion [33]. EGCG from tea function as a proxidant and plays an important role in lipid metabolism [34]. It was reported that consumption of red wine or non-alcoholic wine reduces bleeding time and platelet aggregation [35]. Polyphenols can improve endothelial dysfunction associated with different risk factors for atherosclerosis before the formation of plaque [36]. It was demonstrated that resveratrol improves the vasodilatory function, cardiac hypertrophy and attenuates the development of hypertension [37]. The compound also stimulates Ca^{++}activated K^+ channels and enhances nitric oxide signaling in the endothelium, by which it exerts vasorelaxant activity[38,39]. Resveratrol is attributed to the low incidence of CVD despite the intake of high-fat diet and smoking among the people of France [40]. Oxidation of LDL particles is strongly associated with the risk of coronary heart diseases and myocardial infarctions. The intake of phenol-rich virgin olive oil decreasedtotal cholesterol (TC), LDL-cholesterol and triglyceride levels and substantially increased HDL-cholesterol concentration in rats. [41] Epidemiological and clinical studies revealed that polyphenol fraction of extra virgin oil reduces the incidence of CVDs by regulating the blood pressure through the release of potent vasodilator and vasoconstrictor or other agents such as nitric oxide and endothelin-1 [42].

Anti-Cancer Effect

Plant polyphenols represents a unique class of phytochemicals that possess excellent anti-oxidant and anti-inflammatory properties and also modulate cell signaling pathways that lead to anti-cancer effects. Polyphenols induce a reduction of the number of tumors and their growth, resulting in a protective effect at various sites including mouth, stomach, duodenum, colon, liver, lung, mammary gland or skin [43]. Many polyphenols such as quercetin, catechins, isoflavones, lignans, flavanones, curcumin, ellagic acid, epigallocatechin-3-gallate (EGCG) in green tea, resveratrol and red wine polyphenols have proven anticancer effects [17]. Several mechanisms of

action have been identified for chemoprevention effect of polyphenols. Plant polyphenols act as antioxidants, reducing free radicals and reactive oxygen species (ROS), and leading to a decrease in their damaging effects on DNA. Plant polyphenols modulate the expression of enzyme involved in inactivation of carcinogens through hormonal control, detoxification and endogenous antioxidant system [44]. The anticancer mechanism of plant polyphenols involve mobilization of endogenous copper, possibly chromatin bound copper and their consequent pro-oxidant action [45]. They can form potentially toxic quinones in the body that are substrates for these enzymes. It has been demonstrated that tea catechins have anticancer activity when given to men with high-grade prostate intraepithelial neoplasia (PIN) in the form of capsules [46]. Black tea polyphenols were found to inhibit proliferation and increase apoptosis in Du 145 prostate carcinoma cells. Insulin like growth factor 1 plays important role in signal transduction pathway, which caused proliferation of carcinoma cells [47]. Black tea polyphenol was found to inhibit the prostate carcinoma cells by blocking the Insulin like growth factor (IGF)-1, at a dose of 40 mg/ml [48]. Quercetin has also been reported to possess anticancer property against benzopyrene induced lung carcinogenesis in mice, mainly due to its free radical scavenging activity [49]. When combination of quercetin and green tea was given their chemo protective role was improved in non-toxic manner [50]. Resveratrol prevents all stages of development of cancer and has been found to be effective in most types, including lung, skin, breast, prostate, gastric and colorectal cancers. It has also been shown to suppress angiogenesis, metastasis and modulate multiple pathways involved in cell growth, apoptosis and inflammation. Apple pomace containing 63.8% procyanidins has cytotoxicity effect in bladder cancer cells that is associated with apoptosis G_2/M arrest and mitotic catastrophe. It also altered the mitochondrial function and ROS generation [51].

Anti-Diabetic Effect

Diabetes mellitus is one of the metabolic disorders characterized by impairment in glucose metabolism that leads to hyperglycemia. Hyperglycemia is associated with long term damage, dysfunction and eventually the failure of vital organs [49, 52]. Retinopathy is a persistent damage to retina of eye that seen in hypertension or diabetes. Long term diabetes leads to nephropathy in which the renal functions are altered or disturbed and neuropathy which is associated with the risks of amputations, foot ulcers and features of autonomic disturbance including sexual dysfunctions. Numerous studies reported the anti-diabetic effects of polyphenols, especially tea catechins [53]. Polyphenols may affect glycemia through different mechanisms, including the inhibition of glucose absorption in the gut or of its uptake by peripheral tissues. The hypoglycemic effects of diacetylated anthocyanins @ 10 mg/kg diet dosage were observed with maltose as a glucose source, but not with sucrose or glucose [54]. This suggests that these effects are due to an inhibition of á-glucosidase in the gut mucosa. It was also observed that catechins at a dose of about 50 mg/kg diet or higher inhibited á-amylase and sucrose in rats. The inhibition of intestinal glycosidases and glucose transporter by polyphenols has been studied [55]. Individual polyphenols such as (+)catechin, (-)epicatechin, (-)epigallocatechin, epicatechingallate, isoflavones from soyabeans, tannic acid, glycyrrhizin from licorice root, chlorogenic acid and saponins also decreased S-Glut-1 mediated intestinal transport of glucose. Saponins additionally delay the transfer of glucose from stomach to the small intestine [56]. Grape polyphenols namely myricetin and resveratrol possess strong ability to ameliorate the biological events responsible for the hyperglycemia [57]. Grape seed polyphenols inhibit high glucose induced cytotoxicity and oxidative stress. Resveratrol inhibited diabetes-induced changes in the kidney (diabetic nephropathy) and significantly reduced renal dysfunction and oxidative stress in diabetic rats. It also decreased insulin secretion and delayed the onset of insulin resistance due to inhibition of K^+ ATP and K^+channel in β cells [58]. Quercetin from onion significantly protected lipid peroxidation and inhibited antioxidant system in diabetics [59]. Ferulic acid (FA), another polyphenol very abundant in vegetables and maize bran lowered blood glucose, followed by a significant increase in plasma insulin [17, 60].

Anti-Aging Effect

Aging is inevitable and multifactorial biological process. It involves accumulation of free radical in the body which leads to oxidative damage of cell and tissue and impairment in repair mechanism [61]. Polyphenols present in medicinal and dietary plants may help in preventing oxidative damage. Anthocyanins (color pigment) have been shown to inhibit lipid peroxidation and the inflammatory mediators cyclo-oxygenase (COX)-1 and (COX)-2, besides possessing potent antioxidant/anti-inflammatory activities [62]. Tea catechins carried strong anti-aging activity and delayed the onset of

aging, as per a study[63]. Polyphenols are also beneficial in decreasing the adverse effects of aging on nervous system or brain. The predominant importance of food polyphenols in the protection of the aging brain is the ability of these compounds to cross the blood-brain barrier, which tightly controls the influx in the brain of metabolites and nutrients as well as of drugs. Resveratrol has several biological effects including the activation of sirtuins, a protein that influence the cellular processes such as aging transcription, inflammation and apoptosis[64]. Resveratrol consistently prolongs the life span, as theiraction linked to caloric restriction or partial food deprivation [56]. Seven sirtuins have been identified in mammals, of which Sirtuin (SIRT)-1 is believed to mediate the beneficial effects on health and longevity of both caloric restriction and resveratrol [65]. Resveratrol increased insulin sensitivity, decreased the expression of IGF-1 and increased AMP-activated protein kinase (AMPK) and peroxisome proliferator-activated receptor-c coactivator 1a (PGC-1a) activity[66]. There are experimental evidences that resveratrol extended lifespan in the yeast *Saccharomyces cerevisiae*, the fruit fly *Drosophila melanogaster*, the nematode worm *Caenorhabditis elegans* and seasonal fish *Nothobranchius furzeri* [39]. Quercetin has also been reported to exert preventive effect against aging [67].

Neuro-Degenerative Effect

Neurodegenerative diseases occur due to oxidative stress and damage to brain macromolecules and are becoming an increasing health related burden in old age people. Alzheimer's diseaseis one of the most commonly occurring neurological disorders affecting up to 18 million people worldwide. Because polyphenols are highly antioxidative in nature, their consumption may provide protection in neurological diseases [68]. Polyphenol mainly resveratrol, epigallocatechin gallate and curcumin have immense potential to slowdown cognitive decline. They have shown to produce other important effects including anti-amyloidogenic activity, cell signaling modulation, effects on telomere length and modulation of sirtuin proteins [69]. It was observed that the people drinking three to four glasses of wine per day had 80% decreased incidence of dementia and Alzheimer's disease compared to those who drank less or did not drink at all [70]. Resveratrol, abundantly present in wine scavenges O_2 and OH *in vitro*, and also lipid hydroperoxyl free radicals. Fruits and vegetable juices contain high concentrations of polyphenols and consumption of their juices at least three times per week may play an important role in delaying the onset of Alzheimer's disease [71]. It has been found that apple polyphenol extract has neuroprotective effects against aluminum-induced biotoxicity as aluminum has been implicated in the pathogenesis of Alzheimer's disease [72]. They have the ability to influence and modulate several cellular processes such as signaling, proliferation, apoptosis, redox balance and differentiation [73].

The administration of polyphenols provide protective effects against Parkinson's disease, a neurological disorder characterized by degeneration of paminergic neurons in the *substantia nigra zona compacta* [74]. Nutritional studies have linked the consumption of green tea to the reduced risk of developing Parkinson's disease. In animals, EGCG has been shown to exert a protective role against the neurotoxin MPTP (N-methyl-4- phenyl-1,2,3,6-tetrahydropyridine), an inducer of a Parkinson's like disease, either by competitively inhibiting the uptake of the drug by scavenging MPTP mediated radical formation. EGCG may also protect neurons by activating several signaling pathways, involving MAP kinases which are fundamental for cell survival [75]. The therapeutic role of catechins in Parkinson's disease is also due to their ability to chelate iron. This property contributes to their antioxidant activity by preventing redox-active transition metal from catalyzing free radicals formation. Moreover, the antioxidant function is also related to the induction of the expression of antioxidant and detoxifying enzymes particularly in the brain, which does not have a well-organized antioxidant defense system.[74] Maize bran polyphenol ferulic acid has antioxidant and anti-inflammatory properties and reported to be beneficial in Alzheimer's disease [60].

Prebiotic Effect of Polyphenols

Prebiotics are non-digestible food components which have beneficial effect on intestinal bacteria. Human gut consists of a vast number of microflora that reaches the highest concentrations in the colon (up to 10^{12} cells per g of faeces), the predominant ones being bifidobacteria and enterobacteria. Prebiotic components should have resistance to gastric acidity and mammalian enzymes, be amenable to fermentation by gut microbiota and have stimulating effect on the growth or activity of benefical intestinal bacteria. Inulin and oligofructose (or fructo-oligosaccharides - FOS), galacto-oligosacchardies (GOS) and lactulose were well established prebiotic components. Polyphenols have also recently been characterized as effective prebiotics [76]. Polyphenols travel to the colon, where they undergo extensive bioconversion and metabolism. They have a lower

uptake level in gastrointestinal tract and low circulating level in plasma. Polyphenols are then deconjugated by bacterial glycosidases, glucuronidases, and sulfatases and further fermented to a wide range of low-molecular-weight phenolic acids. Gut microbiota play an important role in the health promoting activity of polyphenols through transformation to more active derivatives [77]. The most common dietary polyphenols [(–)epicatechin and (+)-catechin] can be metabolized by fecal bacteria even in the presence of favorable carbon sources such as sucrose and FOS [78], leading to the production of the their metabolites. Itwas found that the administration of extraction juices from apples, rich in polyphenols, increased rat fecal counts of lactobacilli and bifidobacteria [79]. In the intestines of red wine polyphenol-fed rats, the bacteroides, lactobacilli and bifidobacteriaincreased significantly [80]. Consumption of proanthocyanidin rich extract from grape seeds for 2 weeks increases the number of bifiodobacteria [81]. Resveratrol from grapes promoted fecal cell counts of bifidobacteria and lactobacilli in a rat model [82]. These animal studies strongly suggest that polyphenols may act as promoting factors of growth and proliferation or survival for beneficial members of the gut microbiota.

A number of mechanisms may account for the stimulatory effect of phenolic compounds. One of the study suggested that lactic acid bacteria degraded tannic acid to obtain energy and that certain Lactobacilli, such as *Lactobacillus plantarum* degraded the complex esters of gallic acid and glucose containing galloyl groups directly to the glucose molecule [83]. Tannic acid is hydrolyzed to gallic acid and glucose and further decarboxylated to pyrogallol with the help of the enzymes tannase and decarboxylase gallate. Some microorganisms can tolerate and metabolize hydroxycinnamic acid to p-ethylphenols [84]. Phenolic compounds can enhance consumption of nutrients and positively affect the bacterial metabolism, especially in Lactobacilli, during their growth phase. Antioxidant property of flavon-3-ols stimulates the growth of *Lactobacillus hilgardii*. Their chelating activity mainly affects aerobic micro-organisms. Dietary polyphenols may also influence the adhesion and proliferation of probiotic *Lactobacillus rhamnosus* to Caco-2 cells, mainly phloridzin and rutin. This may be due to imitation of acetylated homoserine lactones by catechin and EPCG, that act as regulating factors of biofilm formation involved in bacterial adhesion [85].

Miscellaneous Activities

Dietary polyphenols exert preventive effects in the treatment of asthma, a condition when the airways react by narrowing or obstructing when they become irritated, making it difficult for the air to move in and out. This narrowing or obstruction can cause one or a combination of symptoms such as wheezing, coughing, shortness of breath and chest tightness under asthmatic conditions. Epidemiological evidence shows that polyphenols might protect against obstructive lung disease. Apple pomace consumption has been inversely associated with asthma and positively associated with pulmonary health [86]. Increased consumption of the genistein soy isoflavone was associated with better lung function in asthmatic patients [87]. Intake of polyphenols is also reported as beneficial in osteoporosis. Supplementation of diet with genistein, daidzein or their glycosides for several weeks prevent the loss of bone mineral density and trabecular volume caused by the ovariectomy [88]. Polyphenols also protect skin damages induced from sunlight. Study on animals provide evidence that polyphenols present in tea, when applied orally or topically, ameliorate adverse skin reactions following UV exposure, including skin damage, erythema and lipid peroxidation [89]. Black tea polyphenols are reported to be helpful in mineral absorption in intestine as well as asserts antiviral activity. Theaflavins present in black tea were found to possess anti HIV-1activity by inhibiting the entry of HIV-1 cells into the target cells [44].

Conclusion

Polyphenols are widely distributed in plants such as fruits, vegetables, tea, olive oil, tobacco, cocoa, coffee beans and so on. In this review article we summarize the various health benefits of polyphenols. These polyphenols provide an alternative to conventional medicine toward prevention and management of diseases and related complications either alone or in combination with other therapies. Recent molecular, cellular, and animal studies have begun to reveal detailed mechanisms linking consumption of polyphenols and life-style adjustment with prevention of chronic diseases including cardiovascular disorders, cancer, and diabetes, aging and neuro-degenerative. The bioavailability and effects of polyphenols greatly depend on their metabolism in gut. It was found that they contribute to the maintenance of gut health by the modulation of the gut microbial balance through the stimulation of the growth of beneficial bacteria and the inhibition of pathogen bacteria, exerting prebiotic-like effects.

Although, there have been considerable scientific progress over the past few years but we still need to define missing steps in polyphenol signaling network and elucidate the mechanism based on the complexity of diseases.

References

1. Arts ICW, Hollman PCH. Polyphenols and disease risk in epidemiologic studies. Am J ClinNutr. 2005; 81: 317-25.
2. Graf BA, Milbury PE, Blumberg JB. Flavonols, flavonones, flavanones and human health: Epidemiological evidence. J Med Food. 2005; 8(3): 281-290.
3. Jomova K, Vondrakova D, Lawson M, Valko M. Metals, oxidative stress and neurodegenerative disorders. Mol Cell Biochem. 345(1-2): 91–104.
4. Etherton K, HarrisPM,Appel LJ.Nutrition Committee: Fish consumption, fish oil, omega-3 fatty acids, and cardiovascular disease. Am Heart Assoc. 106(21): 2747-57.
5. Kondratyuk TP, Pezzuto JM. Natural product polyphenols of relevance to human health. Pharm Biol. 2004; 42(1): 46-63.
6. Munin A, Edwards-Lévy F. Encapsulation of natural polyphenolic compounds: A Review. Pharma. 2011; 3(4): 793-829.
7. Ignat I, Volf I, Popa VI. A critical review of methods for characterization of polyphenolic compounds in fruits and vegetables. Food Chem. 2011; 126(4): 1821-1835, ISSN 0308-8146.
8. Tsao R. Chemistry and biochemistry of dietary polyphenols. J Nutr. 2012; 2(12): 1231-1246.
9. Merken HM, Beecher GR. Measurement of food ûavonoids by high performance liquid chromatography: A review. J Agric Food Chem. 2000; 48(3): 577–599.
10. Tomas-Barberan FA, Clifford MN. Flavanones, chalcones and dihydrochalcones-nature, occurrence and dietary burden. J Sci Food Agric. 2000; 80(7): 1073–80.
11. Lakenbrink C, Lapczynski S, Maiwald B, Engelhardt UH. Flavonoids and other polyphenols in consumer brews of tea and other caffeinated beverages. J Agric Food Chem. 2000; 48(7): 2848–52.
12. Arts IC, Van De Putte B, Hollman PC. Catechin contents of foods commonly consumed in the Netherlands. 2. Tea, wine, fruit juices, and chocolate milk. J Agric Food Chem. 2000; 48(5): 1752–7.
13. Clifford MN. Anthocyanins- Nature, Occurrence and Dietary burden. J Sci Food Agric. 2000; 80(7): 1063–72.
14. de Rijke E, Out P, Niessen WM, Ariese F, Gooijer C, Brinkman UA. Analytical separation and detection methods for flavonoids. J Chromatogr A. 2006; 1112(1-2): 31-63, ISSN 0021-9673.
15. Chen W. Flaxseed and pure secoisolariciresinol diglucoside, but not flaxseed hull, reduce human breast tumor growth (MCF-7) in athymic mice. Nutr. 2009; 139(11): 2061–6, doi:10.3945/jn.109.112508. PMID 19776177.
16. Vitrac X, Moni JP, Vercauteren J, Deffieux G, Mérillon JM. Direct liquid chromatography analysis of resveratrol derivatives and flavonols in wines with absorbance and fluorescence detection. Anal ChimActa. 2002; 458: 103-10.
17. Scalbert A, Manach C, Morand C,Remesy C. Dietary polyphenols and the prevention of diseases. Crit Rev Food SciNutr. 2005; 45(4): 287-306.
18. Ahmad Z, Ahmad M, Okafor F, Jones J, Abunameh AM, Cheniya RK*et al*. Effect of structural modulation of polyphenolic compounds on the inhibition of *Escerichia coli* ATP synthase. Int J Macromol. 2012; 50(3): 476-486.
19. Green Tea Polyphenol Epigallocatechin-3-Gallate Enhance Glycogen Synthesis and Inhibit Lipogenesis in HepatocytesStockham K, Sheard A, Paimin R, Buddhadasa S, Duong S,Orbell JD. Comparative studies on the antioxidant properties and polyphenolic content of wine from different growing regions and vintages: A pilot study to investigate chemical markers for climate change. Food Chem. 2013; 140(3): 500-6.
20. Ferrazzano GF, Amato I, Ingenito A, Natale AD,Pollio A.Anti-cariogenic effects of polyphenols from plant stimulant beverages (cocoa, coffee, tea). Fitoterapia. 2009; 80(5): 255-262.
21. Kim HS, Montana V, Jang HJ, Parpura V, Kim JA. Epigallocatechin gallate (EGCG) stimulates autophagy in vascular endothelial cells: A potential role for reducing lipid accumulation. J Biol Chem. 2013; 288(31): 22693–22705.
22. Domenico FD, Fopoli C, Coccia R, Perlugi M. Antioxidants in cervical: Chemopreventive effects of polyphenols. BiochimBiophysActa. 2012; 1822(5): 734-747.
23. Quinones M, Miguel M, Aleixandre A. Beneficial effects of polyphenols on cardiovascular disease. Pharmacol Res. 2013; 68(1): 125-131.
24. Vita JA. Polyphenols and cardiovascular disease: Effects on endothelial and platelet function. Am J ClinNutr. 2005; 81(1): 292-7.
25. Iriti M, Varoni EM. Cardioprotective effects of moderate red wine consumption: Polyphenols vs. ethanol. J Appl Biomed. 2014; 12(1): 193-202.
26. Aviram M, Dornfeld L, Rosenblat M, Volkova N, Kaplan M, Coleman R et al. Pomegranate juice consumption reduces oxidative stress, atherogenic modifications to LDL, and platelet aggregation: Studies in humans and in atherosclerotic apolipoprotein E-deficient mice. Am J ClinNutr. 2000; 71(5): 1062-76.
27. García-Lafuente A, Guillamón E, Villares A, Rostagno MA,Martínez JA. Flavonoids as anti-

inflammatory agents: Implications in cancer and cardiovascular disease. J Inflamm Res. 2009; 58(9): 537-52.

28. Song L, Xu M, Lopes-Virella MF, Huang Y. Quercetin inhibits matrix metalloproteinase-1 expression in human vascular endothelial cells through extracellular signal-regulated kinase. Arch BiochemBiophys. 2001; 391(1): 72-78.
29. Chen YW, Chou HC, Lin ST, Chen YH, Chang YJ, Chen L *et al*.Cardioprotective effects of quercetin in cardiomyocyte underischemia/reperfusion injury.Evi Based Complement Alternat Med. 2013; 20: 364519, http://dx.doi.org/10.1155/2013/364519.
30. Colina-Coca C, Rodriguez-Alcala LM, Fontecha J, Gonzalez-Pena D, Ancos BD, Sanchez-Moreno C. Effects of hypocholesterolemic diet enriched with onion as functional ingredient on fatty acid metabolism in Wistar rats. Food Res Int. 2014; 64: 546–552.
31. Puglisi MJ, Vaishnav U, Shrestha S, Torres-Gonzalez M, Wood RJ, Volek J *et al*.Raisins and additional walking have distinct effects on plasma lipidsand inflammatory cytokines.Lipid Health Dis. 2008;7:14, doi: 10.1186/1476-511X-7-14.
32. Duffy SJ, Keaney JF, Holbrook MJ, Gokce N, Swerdloff PL, Frei B *et al*. Short- and long-term black tea consumption reverses endothelial dysfunction in patients with coronary artery disease. Circ. 2001; 104(2):151-156.
33. Maeda K, Kuzuya M, Cheng XW. Green tea catechins inhibit the cultured smooth muscle cell invasion through the basement barrier. Atherosclerosis. 2003; 1(66): 23-30.
34. Kim HK,QuonMJ,Kim JK. New insights into the mechanisms of polyphenols beyond antioxidant properties; lessons from the green tea polyphenol, epigallocatechin 3 gallate. Redox Biol. 2014; 2: 187–195.
35. Naveena BM, Sen AR, Vaithiyanathan S, Babji Y, Kondaiah N. Comparative efficacy of pomegranate juice, pomegranate rind powder extract and BHT as antioxidants in cooked chicken patties. Meat Sci. 2008; 80(8): 1304–8.
36. Schachinger V, Britten MB, Zeiher AM. Prognostic impact of coronary vasodilator dysfunction on adverse long-term outcome of coronary heart disease. Circulation. 2011; 101: 1899-906.
37. Dolinsky VW, Chakrabarti S, Pereira TJ, Oka T, Levasseur DB, Zordoky BN *et al*.Resveratrol prevents hypertension and cardiac hypertrophy in hypertensive rats and mice. Biochim Biophys Acta. 2013; 1832(10): 1723–1733.
38. Cucciolla V, Borriello A, Oliva A, Galletti P, Zappia V, Della Ragione F. Resveratrol: From basic science to the clinic. Cell Cycle. 2007; 6(20): 2495-510.
39. Shakibaei M, Harikumar KB, Aggarwal BB. Resveratrol addiction: To die or not to die. MolNutr Food Res. 2009; 53:115-28.
40. Yang CS, Landau JM, Huang MT, Newmark HL. Inhibition of carcinogenesis by dietary polyphenolic compounds. Annu Rev Nutr. 2001; 21:381-406.
41. Gorinstein S, Pawelzik E, Delgado-Licon E, Haruenkit R, Weisz M,Trakhtenberg S.Characterisation of pseudocereal and cereal proteins by protein and amino acid analyses. J Sci Food Agric. 2002; 82(8): 886-891.
42. Storniolo CE, Rosell-Catafau J, Pinto X, Mitjavila MT, Moreno JJ. Polyphenol fraction of extra virgin olive oil protects against endothelial dysfunction induced by high glucose and free fatty acid through modulation of nitric oxide and endothelin-1. Redox Biol. 2014; 2: 971-977.
43. Martins S, Mussatto SI, Martínez-Avila G, Montañez Saenz J, Teixeira A. Bioactive phenolic compounds production and extraction by solid-state fermentation. Biotechnol Adv. 2011; 29(3): 365–373.
44. Sharma V, Rao LJ. A thought on the biological activities of black tea. Crit Rev Food Sci. Nutr. 2009; 49(4): 379-404.
45. Azmi AS, Bhat SH, Hanif S, Hadi SM. Plant polyphenols mobilize endogenous copper in human peripheral lymphocytes leading to oxidative DNA breakage: A putative mechanism for anticancer properties. FEBS Letters. 2006; 580(2): 533–538.
46. Wang P, Vadgama JV, Said JW, Magyar CE, Doan N, Heber D et al. Green tea polyphenols and metabolites in prostatectomy tissue: Implications for cancer prevention. Cancer Prev Res. 2010, DOI: 10.1158/ 1940-6207.CAPR-09-0210.
47. Kamaraj S, Vinodhkumar R, Anandakumar P, Jagan S, Ramakrishnan G, Devaki T. The effects of quercetin on antioxidant status and tumor markers in the lung and serum of mice treated with benzo(a)pyrene. Biol Pharm Bull. 2007; 30(12):2268-73.
48. Athar M, Back JH, Tang X, Kim KH, Kopelovich L, Bickers DR *et al*. Resveratrol: A review of preclinical studies for human cancer prevention. ToxicolApplPharmacol. 2007; 224(3): 274-83.
49. Rizvi SI, Zaid MA. Insulin like effect of epicatechin on membrane acetylcholinesterase activity in type 2 diabetes mellitus. ClinExpPharmacol Physiol. 2001; 28(9): 776-8.
50. Wang P, Vadgama JV, Said JW, Magyar CE, Doan N, Heber D *et al*. Enhanced inhibition of prostate cancer xenograft tumor growth by combining quercetin and green tea. J NutrBiochem. 2014; 25(1): 73–80.
51. Kao YL, Kuo YM, Lee YR, Yang SF, Chen WR, Lee HJ.Apple polyphenol induces cell apoptosis, cellcycle arrest at G2/M phase, and mitoticcatastrophe in human bladder transitionalcarcinoma cells. J Funct Foods. 2015; 14: 384–394.
52. Rizvi SI, Zaid MA, Anis R, Mishra N. Protective role of tea catechins against oxidation induced damage of type 2 diabetic erythrocytes. ClinExpPharmacol Physiol. 2005; 32: 70-5.
53. Matsui T, Ebuchi S, Kobayashi M, Fukui K. Anti-hyperglycemic effect of diacylated anthocyanin derived from Ipomoea batatas cultivar Ayamurasaki can be achieved through the alpha-glucosidase

inhibitory action. J Agric Food Chem. 2002; 50(25): 7244-8.

54. Matsui T, Ueda T, Oki T. Alpha-Glucosidase inhibitory action of natural acylated anthocyanins. 2. alpha-Glucosidase inhibition by isolated acylated anthocyanins. J Agric Food Chem. 2001; 49(4): 1952-6.
55. Dembinska-Kiec A, Mykkänen O, Kiec-Wilk B, Mykkänen H. Antioxidant phytochemicals against type 2 diabetes. Br J Nutr. 2008; 99: 109-17.
56. Harikumar KB, Aggarwal BB. Resveratrol: A multitargeted agent for age-associated chronic diseases. Cell Cycle. 2008; 7(8): 1020-35.
57. Pandey S, Rizvi SI. Role of red grape polyphenols as antidiabetic agents. Integr Med Rev. 2014; 3: 119-125.
58. Chen WP, Chi TC, Chuang LM, Su MJ. Resveratrol enhances insulin secretion by blocking K(ATP) and K(V) channels of beta cells. Eur J Pharmacol. 2007; 568(1-3): 269-77.
59. Rizvi SI, Mishra M. Anti-oxidant effect of quercetin on type 2 diabetic erythrocytes.J Food Biochem. 2009; 33(3): 404-15.
60. Barone E, Calabrese V, Mancuso C. Ferulic acid and its therapeutic potential as a hormetin for age-related diseases. Bio ger. 2009; 10(2): 97-108.
61. Rizvi SI, Maurya PK. Alterations in antioxidant enzymes during aging in humans. MolBiotechnol. 2007; 37(1): 58-61.
62. SeeramNP, Cichewicz RH, Chandra A, Nair MG. Cyclooxygenase inhibitory and antioxidant compounds from crabapple fruits. J Agric Food Chem. 2003; 51(7): 1948-51.
63. Maurya PK, Rizvi SI. Protective role of tea catechins on erythrocytes subjected to oxidative stress during human aging. J Asian Nat Prod Res. 2009; 23(12): 1072-1079.
64. Ramis MR, Esteban S, Miralles A, Tan DX, Reiter RJ. Caloric restriction, resveratrol and melatonin: Role of SIRT1 and implications for aging and related diseases. Mech Ageing Dev.2015; 146: 28-41.
65. Markus MA, Morris BJ. Resveratrol in prevention and treatment of common clinical conditions of aging. ClinInterv Aging. 2008; 3(2): 331-9.
66. Barger JL, Kayo T, Vann JM, Arias EB, Wang J, Hacker TA. A low dose of dietary resveratrol partially mimics caloric restriction and retards aging parameters in mice. PLOS One. 2008; 3(6): 2264.
67. Belinha I, Amorim MA, Rodrigues P, Freitas V, Moradas-Ferreira P, Mateus N *et al*.Quercetin increases oxidative stress resistance and longevity in *Saccharomyces cerevisiae*. J Agric Food Chem. 2007; 55(6): 2446-2451.
68. Letenneur L, Proust-Lima C, Le Gouge A, Dartigues J, Barberger-Gateau P. Flavonoid intake and cognitive decline over a 10-year period. Am J Epidemiol. 2007; 165(12): 1364-71.
69. Jayasenna T, Poljakb A, Smytheb G, Braidya, N, Münchd G, Sachdeva P. The role of polyphenols in the modulation of sirtuins and other pathways involved in Alzheimer's disease. Aging Res Rev. 2013; 12: 867– 883.
70. Scarmeas N, Luchsinger JA, Mayeux R, Stern Y. Mediterranean diet and Alzheimer disease mortality. Neurology. 2007; 69(11): 1084-93.
71. Dai Q, Borenstein AR, Wu Y, Jackson JC, Larson EB. Fruit and vegetable juices and Alzheimer's disease: The kame project. Am J Med. 2006; 119(9): 751-759.
72. Cheng D, Xi Y, Cao J, Ma Y, Jiang W. Protective effect of apple (Ralls) polyphenol extract against aluminum-induced cognitive impairment and oxidative damage in rat. Neurotoxicol. 2014; 45: 111–120.
73. Singh M, Arseneault M, Sanderson T, Murthy V, Ramassamy C. Challenges for research on polyphenols from foods in Alzheimer's disease: Bioavailability, metabolism, and cellular and molecular mechanisms. J Agric Food Chem. 2008; 56(13): 4855-73.
74. Aquilano K, Baldelli S, Rotilio G, Ciriolo MR. Role of nitric oxide synthases in Parkinson's disease: A review on the antioxidant and anti-inflammatory activity of polyphenols. J Neurosci Res. 2008; 33(12): 2416-26.
75. Rossi L, Mazzitelli S, Arciello M, Capo CR, Rotilio G. Benefits from dietary polyphenols for brain aging and Alzheimer's disease. Neurochem Res. 2008; 33(12): 2390-400.
76. Cardona F, Andres-Lacueva C, Tulipani S, Tinahones FJ, Queipo-Ortuno MI. Benefits of polyphenols on gut microbiota and implications in human health. J NutrBiochem. 2013; 24(8): 1415–1422.
77. Walle T.Absorption and metabolism of flavonoids. Free Radical Bio Med. 2004; 36(7): 829–37.
78. Tzounis X, Vulevic J, Kuhnle GGC, George T, Leonczak J, Gibson GR *et al*.Flavanol monomer-induced changes to the human faecal microflora. Br J Nutr. 2008; 99(4): 782–792.
79. Sembries S, Dongowski G, Mehrländer K, Will F, Dietrich H. Physiological effects of extraction juices from apple, grape, and red beet pomaces in rats. J Agric Food Chem. 2006; 54(26): 10269–10280.
80. Dolara P, Luceri C, De Filippo C, Femia AP, Giovannelli L, Caderni G *et al*. Red wine polyphenols influence carcinogenesis, intestinal microflora, oxidative damage and gene expression profiles of colonic mucosa in F344 rats. Mut Res. 2005; 59(1-2): 231–246.
81. Yamakoshi J, Tokutake S, Kikuchi M, Kubota Y, Konishi H, Mitsuoka T.Effect of proanthocyanidin-rich extract from grape seeds on human fecal flora and fecal odor. Microb Eco Health Dis. 2001; 13(1): 25-31.
82. Larrosa M, Yáñez-Gascón MJ, Selma MA, González-Sarrías A, Toti S, Cerón JJ *et al*.Effect of a low dose of dietary resveratrol on colon microbiota, inflammation and tissue damage in a DSS-Induced colitis rat model. J Agric Food Chem. 2009; 57: 2211–2220.

83. Rodriguez H, de Las Rivas B, Gómez-Cordovés C, Muñoz R. Degradation of tannic acid by cell-free extracts of *Lactobacillus plantarum*. Food Chem. 2008; 107: 664-670.

84. Alberto MR, Gómez-Cordovés C, Manca de Nadra MC. Metabolism of gallic acid and catechin by *Lactobacillus hilgardii* from wine. J Agric Food Chem. 2004; 52: 6465–6469.

85. Huber B, Eberl L, Feucht W, Polster J. Influence of polyphenols on bacterial biofilm formation and quorum-Sensing. Z. Naturforsch. Sect. C. J Biosci. 2003; 58(11-12): 879–884.

86. Boyer J, Liu RH. Apple phytochemicals and their health benefits. Nutr. 2004; 3(12): 1-5.

87. Smith LJ, Holbrook JT, Wise R, Blumenthal M. Dietary intake of soy genistein is associated with lung function in patients with asthma. J Asthma. 2004; 41(8): 833-43.

88. Kim J, Hwang JS, Cho YK, Han Y, Jeon YJ, Yang KH.Protective effects of (")-epigallocatechin-3-gallate on UVA and UVB-induced skin damage. Skin PharmacolApplSkin Physiol. 2001; 14: 11-9.

89. Nakajima D, Kim CS,Oh TW. Suppressive effects of genistein dosage and resistance exercise on bone loss in ovariectomized rats. JPhysiolAnthropolAppl Human Sci. 20(5): 285-91.

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Dietary and Nutritional Interventions for Chronic Pain: Exploring the Behavioral Perspective

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Abstract

Chronic pain was globally recognized as a condition with multifactorial etiology, multidimensional clinical presentation and multidisciplinary therapeutic delivery. The objective of this short communication was to throw light on dietary and nutritional supplementation as a management option for people with chronic pain. Although goal-directed healthcare and multidisciplinary rehabilitation dictated a comprehensive biopsychosocial approach to management, dietary interventions such as therapeutic fasting, oral cannabis, and oral tryptophan were reported to be effective dietary treatment options for people with chronic pain. The evidence however is too insufficient to provide any recommendation for practice.

Keywords: Analgesic Dietetics; Nutritional Analgesia; Dietetic Rehabilitation; Pain Management.

Chronic pain was framed as a complex adaptive system with paradoxical beliefs and experiences being a part of the core characteristics of pain experience [1]. The implementation of Goal-Directed Health Care (G-DHC) involves a shift in process from the usual focus on disease-related goals such as relief of pain, titrating narcotic refills, and working on condition management to broader, long-term, personal goals along a model of patient-centered care [2].

Mainline therapy in the management of people with chronic pain involves medical/pharmacological therapy [3] whilst recent scientific developments and evidence-informed paradigm shift directed a rational integration of pharmacologic, behavioral and rehabilitation strategies in the treatment of chronic pain [4].

Multidisciplinary rehabilitation involves a team of skilled professionals employing multiple therapies and a structured treatment plan to address all the dimensions of chronic painsuch as physical, emotional and social-role dysfunction [5]. An integrative medicine approach including complementary and alternative medicine therapies such as nutrition, supplements and herbs, manual medicine, acupuncture, yoga, and mind-body approaches is growing in popularity and use among chronic pain patients [6].

Therapeutic Fasting

Recent evidence from clinical trials shows that medically supervised modified fasting (200-500 kcal nutritional intake/day) with periods from 7 to 21 days is efficacious in the treatment of rheumatic diseases and chronic pain syndromes [7].

Cannabis

Martín-Sánchez et al [8] in their systematic review and meta-analysis of double-blind randomized controlled trials through search of Medline/Pubmed, Embase, and The Cochrane Controlled Trials Register (TRIALS CENTRAL) databases and identified 18 trials which concluded that cannabis treatment is moderately efficacious for treatment of chronic pain, but beneficial effects may be partially (or completely) offset by potentially serious harms.

Dietary Supplementation Using L-Tryptophan

Haze [9] explained that oral L-tryptophan

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administration decreased the perception of pain, dacting synergistically with the enkephalins and endorphins. Thus use of Drugs that either increased the serotonin level or block reuptake were associated with decreased pain perception, increased pain threshold, and improved sleep.

Anecdotally, chronic pain patients were managed using a traditional "patient and treatment uniformity myths" and the ensuing evidence recommends an individualized comprehensive treatment by subgrouping biophysical, psychosocial and behavioral measures that influence chronic pain and its experience [10].

Mechanism-based classification of chronic pain is essential for understanding and evaluating chronic pain as a condition with multifactorial etiology, multidimensional clinical presentation and multidisciplinary therapeutic delivery [11]. Such an approach not only facilitate symptom control but also improve quality of life in people with chronic pain [12].

From a therapeutic standpoint, dietary modification appears to be attractive, due to its low economic basis, decreased risk of addiction and dependence, as well as simplicity. Healthcare professionals need to shift their focus from a biomedical dimension to a behavioral dimension [13], when they encounter people with chronic pain a lumping-to-splitting paradigm shift in clinical decision making is essential for successfully combating the chronic pain epidemic [14] along a 'think-out-of-the-box' perspective [15].

References

1. Brown CA.Mazes, conflict, and paradox: tools for understanding chronic pain.Pain Pract. 2009; 9(3): 235-43.
3. Ericksen JJ, Braverman DL, Shah RV.Interventions in chronic pain management. 4. Medications in pain management.Arch Phys Med Rehabil. 2003; 84(3 Suppl 1): S50-6.
4. Gallagher RM.Rational integration of pharmacologic, behavioral, and rehabilitation strategies in the treatment of chronic pain.Am J PhysMed Rehabil. 2005; 84(3 Suppl): S64-76.
5. Rudin NJ. Chronic pain rehabilitation: principles and practice. WMJ. 2001; 100(5): 36-43, 66.
6. Teets RY, Dahmer S, Scott E. Integrative medicine approach to chronic pain. Prim Care. 2010; 37(2): 407-21.
7. Michalsen A. Prolonged fasting as a method of mood enhancement in chronic pain syndromes: a review of clinical evidence and mechanisms. Curr Pain Headache Rep. 2010; 14(2): 80-7.
8. Martín-Sánchez E, Furukawa TA, Taylor J, Martin JL. Systematic review and meta-analysis of cannabis treatment for chronic pain.Pain Med. 2009; 10(8): 1353-68.
9. Haze JJ.Toward an understanding of the rationale for the use of dietary supplementation for chronic pain management: the serotonin model.Cranio. 1991; 9(4): 339-43.
10. Turk DC. Customizing treatment for chronic pain patients: who, what, and why. Clin J Pain. 1990; 6(4): 255-70.
11. Kumar SP, Saha S.Mechanism-based Classification of Pain for Physical Therapy Management in Palliative care: A Clinical Commentary.Indian J Palliat Care. 2011; 17(1): 80-6.
12. Kumar SP, Jim A.Physical therapy in palliative care: from symptom control to quality of life: a critical review.Indian J Palliat Care. 2010; 16(3): 138-46.
13. Prem V, Karvannan H, Chakravarthy R, Binukumar B, Jaykumar S, Kumar SP. Attitudes and Beliefs About Chronic Pain Among Nurses-Biomedical or Behavioral? A Cross-sectional Survey.Indian J Palliat Care. 2011; 17(3): 227-34.
14. Turk DC. The potential of treatment matching for subgroups of patients with chronic pain: lumping versus splitting. Clin J Pain. 2005; 21(1): 44-55.
15. Kumar SP. Thinking out of the box- from physiotherapy to rehabilitation. International Journal of Physiotherapy and Rehabilitation 2010; 1(1): 01-04.
16. Waters D, Sierpina VS.Goal-Directed Health Care and the chronic pain patient: a new vision of the healing encounter.Pain Physician. 2006; 9(4): 353-60.

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[1] Flink H, Tegelberg Å, Thörn M, Lagerlöf F. Effect of oral iron supplementation on unstimulated salivary flow rate: A randomized, double-blind, placebo-controlled trial. J Oral Pathol Med 2006; 35: 540-7.

[2] Twetman S, Axelsson S, Dahlgren H, Holm AK, Källestål C, Lagerlöf F, et al. Caries-preventive effect of fluoride toothpaste: A systematic review. Acta Odontol Scand 2003; 61: 347-55.

Article in supplement or special issue

[3] Fleischer W, Reimer K. Povidone iodine antisepsis. State of the art. Dermatology 1997; 195 Suppl 2: 3-9.

Corporate (collective) author

[4] American Academy of Periodontology. Sonic and ultrasonic scalers in periodontics. J Periodontol 2000; 71: 1792-801.

Unpublished article

[5] Garoushi S, Lassila LV, Tezvergil A, Vallittu PK. Static and fatigue compression test for particulate filler composite resin with fiber-reinforced composite substructure. Dent Mater 2006.

Personal author(s)

[6] Hosmer D, Lemeshow S. Applied logistic regression, 2nd edn. New York: Wiley-Interscience; 2000.

Chapter in book

[7] Nauntofte B, Tenovuo J, Lagerlöf F. Secretion and composition of saliva. In: Fejerskov O, Kidd EAM,

editors. Dental caries: The disease and its clinical management. Oxford: Blackwell Munksgaard; 2003. p. 7-27.

No author given

[8] World Health Organization. Oral health surveys - basic methods, 4th edn. Geneva: World Health Organization; 1997.

Reference from electronic media

[9] National Statistics Online—Trends in suicide by method in England and Wales, 1979-2001. www.statistics.gov.uk/downloads/theme_health/HSQ 20.pdf (accessed Jan 24, 2005): 7-18. Only verified references against the original documents should be cited. Authors are responsible for the accuracy and completeness of their references and for correct text citation. The number of reference should be kept limited to 20 in case of major communications and 10 for short communications.

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