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Original Article

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Optimization of High Fiber Bun Formula and its Nutritional Evaluation

Kamaliya Keshav B.

Abstract

Dietary fibers play a multifaceted role in preventing a number of health disorders Bakery products now become essential food items of a vast majority of the population in India. These are bearing negligible fiber. *"Tur"* husk - bran is byproduct of milling industry and used mainly for cattle feed hence possesses low economical value. This study is therefore planned with a view to develop standardized process for high fiber bun using Pigeon pea husk. For that, Refined Wheat Flour was replaced with 2, 4, 6, 8 and 10% of PPH in the commercial bun formula and product optimization was carried out using sensory evaluation. Raw material, control and experimental buns were analysed for various nutrients using standard methods. Coast is also calculated for economical evaluation for industrial viability. Data analysed statistically. An acceptable quality high fiber bun by replacing maximum 8% RWF with PPH could be prepared by the final formula and procedure standardized. It contains more fiber and less energy as compared to control biscuit. It found economically viable and thus could easily marketed among Indian consumer chiefly consist of middle class population.

Keyword: Health Food; Bakery Products; Pigeon Pea Husk; High Fiber Food.

Introduction

Increasing health consciousness increased demand for "health food", including bakery products (Rao, 1993). Dietary fibers play a multifaceted role in preventing a number of health disorders (i.e. hypercholesteremia, diabetes and cancer), increases bulk of fecal mass, reducing the transit time of fecal mass in the small intestine (Potty, 1996). In India, bakery products now become essential food items of a vast majority of the population (Kamaliya, 2005). But still per capita consumption of bakery products at present is very low as compared to developed countries. There is a need for diversification of baked products for further growth. One of the ways of achieving it is by producing various healthy and therapeutic bakery products (Rao, 1993). Normally bakery products are prepared with refined wheat flour (*maida*), hydrogenated fat (*vanspati*) / shortening and sugar as the principle ingredients. These are calorie dense, bearing negligible fiber and contain a low quantity and quality of protein. *"Tur"* husk - bran is byproduct of milling industry and used mainly for cattle feed hence possesses low economical value. Bakers have limited funds and facilities to develop bakery products. This study is therefore planned with a view to develop standardized process for high fiber bun using Pigeon pea husk (PPH) having low cost technology.

Objectives

1. To investigate the possibility of developing high fiber bun using pulse bran, in particular PPH.
2. To standardize the process parameters of high fiber bun based on sensory properties.
3. To evaluate the nutritional quality of the developed bun.

Methodology

Good quality raw materials were purchased from the local market of Anand except PPH, which was supplied by "Laxmi Proteins Ltd., Vasad". PPH was

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soaked overnight in water, followed by pressure cooking for 10 minutes, then it was allowed to dry overnight, ground and sieved with 240m mesh size and used for bun preparation. Soaking, cooking, fermentation reduces the oligosaccharides, which are responsible for causing flatulence in the pulses (Khattab and Arntfield, 2009). Bun was prepared as per the commercial formula suggested by Kamaliya and Kamaliya (2001).

Refined Wheat Flour (RWF) was replaced with 2, 4, 6, 8 and 10% of PPH in the commercial bun formula. Repeated trials with changes in quantity of raw materials (yeast, water and acetic acid) as well as processing conditions (time and temperature for fermentation, final proofing and baking) were carried out to standardize the recipe. The bun prepared using the adopted formulas were sliced, randomized and presented to the panelists for evaluation of sensory characteristics. The buns were evaluated first for initial acceptability using a 9 point hedonic scale (Larmond 1977) (6 members X 3 replications) on the day of preparation (i.e. day 0). For this, products were served on randomly coded paper plates at room temperature. Panelists were supplied with tap water for cleansing the palate between samples. Product evaluation was carried out under 'day light' illumination and in isolated booths within the laboratory. The ranks of hedonic rating were converted to scores and analysed statistically. The bun that scored atleast up to 5 points with maximum incorporation of the PPH was selected for final study. Replacement rate of newly introduced raw ingredients were narrowed down in such a way that percent replacement of PPH of "selected product" remains some were in the middle.

On the bases of these results, RWF was replaced with 4,5,6,7 and 8% PPH for the final selection. That was carried out again by sensory evaluation using a composite scoring test on the day of preparation. The proforma used was prepared on the basis of the composite scoring test of Pyler (1988). A sensory judging panel was constituted with six panelists from among the faculties and Students of the Faculty of food processing technology as well as dairy science. The panelists evaluated volume, colour and nature of crust, uniformity of bake and shape, texture and grain, crumb colour, taste and aroma and overall acceptability. Bun prepared using the commercial formula (i.e. 0% PPH) served as the control bun (CB) and was used for comparison.

Refined wheat flour, PPH and control and experimental buns were analysed for various nutrients namely moisture, protein (macro-Kjeldahl method), fat (soxhlet method), carbohydrate (anthrone method), energy (calculated), fiber and ash using standard methods.

The coast is also calculated for normal as well as experimental bun and compared for economical evaluation for industrial viability as per the procedure followed at the School of Baking, Anand Agricultural University, Anand.

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 and Discussions

As mentioned earlier the present study was planned to develop value added bun and also to assess the food properties and nutritional quality. The results obtained are discussed in to four categories.

Recipe Optimization

When RWF was replaced with PPH in the CB formula, quantity of yeast and acetic acid was increased from 1.5 to 1.75 % and 0.04 to 0.05 %, respectively in order to speedup the fermentation. For the same purpose fermentation and proofing temperature was increased from 26.6^{0}C to 37^{0}C and from 37^{0}C to 50^{0}C, respectively. As a result fermentation and proofing time was decreased by 45 minutes. The baking was carried out at 220^{0}C for 15 minutes instead of 205^{0}C for 20 minutes.

Sensory Evaluation

The bun prepared by replacing 6 % PPH scored "Neither like nor Dislike" when judged using nine point hedonic scale during primary screening. Therefore, it was decided to prepare bun with 4, 5, 6, 7 and 8 % PPH replacement level for final selection.

Composite scoring test was conducted for the selection of supplementation level of PPH. The results obtained are depicted in Table 1. Control bun containing no PPH scored the highest for all the sensory attributes studied. In contrast to this buns prepared using maximum (i.e. 8%) replacement of RWF with PPH scored the least in all the sensory characteristics. A decreasing trend in all the sensory attributes was observed upon increasing the levels of PPH supplementation.

Volume of the control and up to 6% PPH replacement do not differ significantly however rest both the replacements were differ significantly but scored more than acceptable. Similar the case with the symmetry of shape and uniformity of bake characteristic. The colour and nature of the crust character and of the control bun differ significantly to the experimental buns but were found acceptable by the panel of judges. Texture and grain as well as taste and aroma characteristics of bun prepared with 8% PPH replacement were significantly different than other buns including control. However, in case of control bread both the characteristics were significantly differ than experimental bun.

The bun prepared up to 6% replacement of PPH found satisfactory during first year and upto maximum (8%) during next two years in all the sensory characteristics with an overall quality. The soaking and steaming treatment given to PPH may increase acceptability alongwith decrease in flatulence. Thus bun with 8% PPH replacement was considered as Experimental Biscuit (EB) for further experimentation.

However judges commented that, replacement of PPH at 4 and 5% level improved the taste and aroma. During second year of experiment some judges commented that, some grittiness was found at the end of chewing or when chewing was about to complete. Therefore, the ground PPH was sieved with 240 m mesh size and no such comment was found during third year experimentation.

Nutritional Composition

The protein content of PPH found about 75% less as compared to RWF because of very high content of fiber. The **fiber** content of 8% PPH replaced bun was found twentytwo times higher as compared to CB due to addition of PPH containing 85.89% total fiber. The carbohydrate and energy value were reduced in EB as compared to CB. Both the situations have

Table 1: Sensory (composite) scores of buns prepared by replacing refined wheat flour with different levels of pigeon pea husk

Charact eristic Product	Volume (15)	Crust character$ (5)	Shape and bake@ (10)	Crumb colour (10)	Texture and Grain (30)	Taste and aroma (20)	Overall acceptability (10)
Control #	11.86a ± 0.17	4.12a ± 0.07	7.83a ± 0.14	8.37a ± 0.12	23.67a ± 0.42	16.30a ± 0.23	8.20a ± 0.10
4 % PPH	11.07ab ± 0.19	3.40b ± 0.08	7.20ab ± 0.15	6.93b ± 0.16	21.22b ± 0.48	14.59b ± 0.29	7.16b ± 0.12
5 % PPH	10.67abc ± 0.20	3.32bc ± 0.08	6.94ab ± 0.14	6.64bc ± 0.17	20.28bc ± 0.50	13.72bc ± 0.27	6.94b ± 0.12
6 % PPH	10.31abc ± 0.21	3.14bc ± 0.08	6.74ab ± 0.16	6.41bc ± 0.13	20.00bcd ± 0.50	12.87bcd ± 0.28	6.56b ± 0.13
7 % PPH	9.44bc ± 0.32	2.97bc ± 0.09	6.14b ± 0.19	5.80bc ± 0.18	17.96cd ± 0.56	11.84cd ± 0.31	5.85c ± 0.15
8 % PPH	8.81c ± 0.36	2.71c ± 0.10	5.73c ± 0.21	5.55c ± 0.21	17.33d ± 0.53	11.33d ± 0.37	5.46c ± 0.18
F Value	19.39**	34.63**	20.47**	37.24**	21.02**	38.62**	50.01**

PPH = Pigeon Pea Husk
# Control = 100% Refined wheat flour (Baker's %)
$ Crust character = Colour and nature of the crust
@ Shape and bake = Symmetry of shape and uniformity of bake
All the replacements are based on baker's percentage
Values are Pooled Mean ± SEM scores for three years of a composite scoring test by a panel of 6 judges X 3 replications
Means bearing the same superscript within the column do not differ significantly (p d" 0.05), ** p d" 0.01
Values in parentheses indicate number of maximum score

Table 2: Nutritional composition of major raw ingredients, control and sensorily selected experimental bun

Characte ristics Product	Moisture (%)	Protein (%)	Fat (%)	Carbohy drate (%)	Energy (K.Cal)	Total fiber (%)	Ash (%)
RWF	10.60 ± 0.03	12.24 ± 0.10	1.63 ± 0.02	85.01 ± 0.58	404.00 ± 2.38	0.34 ± 0.03	0.78 ± 0.02
PPH	6.79 ± 0.13	4.11 ± 0.10	1.66 ± 0.03	5.74 ± 0.15	54.34 ± 2.54	85.89 ± 0.32	2.60 ± 0.12
Control	41.20 ± 0.72	11.16 ± 0.33	3.54 ± 0.35	82.65 ± 1.11	407.10 ± 2.88	0.31 ± 0.06	0.71 ± 0.03
8 % PPH	41.08 ± 0.94	11.35 ± 0.20	3.63 ± 0.07	77.09 ± 0.50	368.51 ± 1.62	7.03 ± 0.04	0.91 ± 0.01

RWF = Refined wheat flour
PPH = Pigeon pea husk
Control = 100% refined wheat flour (bakers %)
All replacements are based on baker's percentage
Except moisture content all parameters are expressed on dry weight basis
Values are mean ± SEM scores of three replications

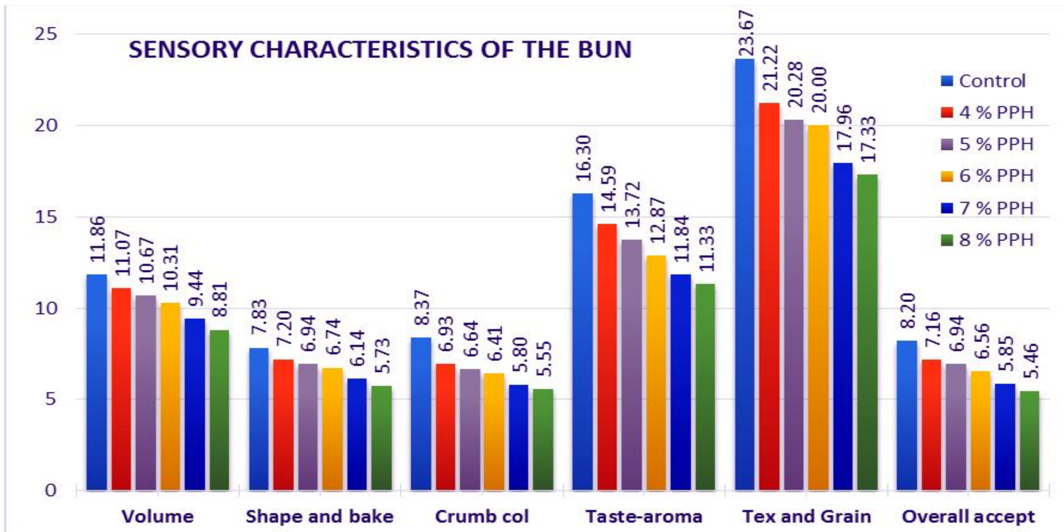

Fig. 1:

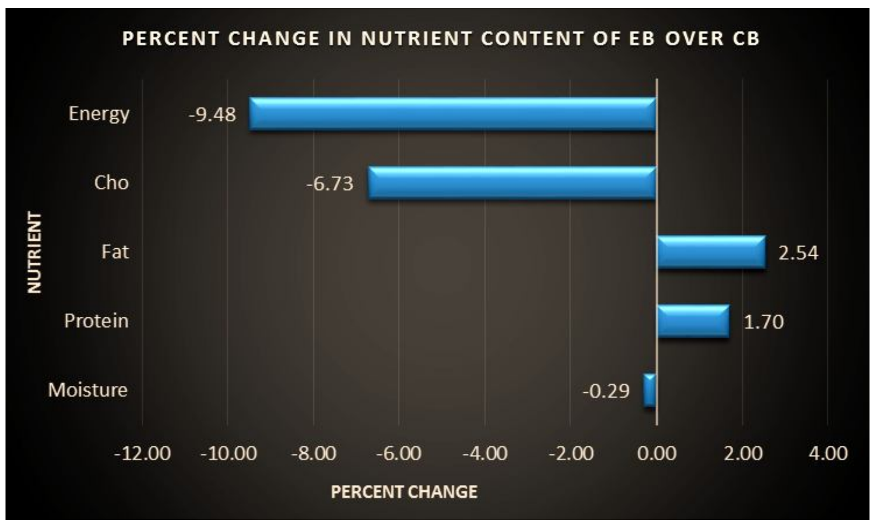

Fig. 2:

beneficial effect on chronic diseases. The protein and fat content was found more or less similar for both the types of buns. Nutritional composition of principle raw ingredients and commercial and developed buns are given in Table–2.

Economical Evaluation

Cost price of EB was slightly reduced as compared to CB because of the lower price of PPH as it is considered as a byproduct of the *"tur-dal"* milling industry.

Conclusion

An acceptable quality high fiber bun by replacing maximum 8% RWF with PPH could be prepared by the final formula and procedure mentioned earlier. It contains more fiber and less energy as compared to CB. Thus it may be useful in the dietary management of patient suffering from diabetes, hypercholestremia, constipation etc. chronic diseases. It found economically viable and thus could easily marketed among Indian consumer chiefly consist of middle class population.

Future Scope

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

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Original Article

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Study on Hemoglobin Content, Blood Glucose Level and Lipid Profile of Elderly

Nalwade Vijaya*, Pawar Chandrabhaga**

Abstract

A total of 147 rural adult males from two villages of Ludhiana district, Punjab belonging to low (LIG), medium (MIG) and high income groups (HIG) were surveyed for their nutrient adequacy. The daily intake of cereals, pulses, green leafy vegetables, roots and tubers, other vegetables, fruits, sugars and fats and oils was less than suggested intake, while that of milk and milk products was higher. Diets of the individuals were deficient in energy, â-carotene, riboflavin, niacin and vitamin B_{12} but contained higher amount of thiamine and calcium compared to ICMR's recommendation. Intake of protein, fat, folic acid and iron was higher in MIG and HIG than RDA as compared to LIG. Income significantly ($P<0.05$) affected fat, â-carotene, folic acid, calcium and iron consumption, whereas energy, protein, carbohydrate, thiamine, riboflavin, ascorbic acid intake of individuals was significantly ($P<0.05$) more in HIG as compared to LIG.

Keywords: Adult Males; Income Groups; Nutrient Adequacy.

Introduction

In India, the elderly people suffer from dual medical problems,i.e., both communicable as well as non–communicable diseases. Ageing is associated with a progressive decline in the function of multiple organ systems thereby making individuals vulnerable to various disease and illness (Lipsitz, 2004). Ross (2000) explained that the aged may suffer coronary heart disease (CHD), strokes, type II diabetes, obesity hypertension, cancer, osteo-arthritis, low back pain, weakness and headache and disabled body among others.

Ageing implies predictable progressive universal deterioration in various physiological systems. Due to physiological and structural changes like to reduced metabolism including reduced BMR, lack of physical activity and lack of appetite mostly due to lack of interest in food; loss of teeth and difficulty in mastication; atrophy of taste buds; reduction of gastric volume associated with atrophy of gastrointestinal tract musculature. This is further compounded by impairment of special sensory functions like vision and hearing. A decline in immunity as well as age related physiological changes leads to an increased burden of communicable diseases in the elderly. Hence the present study is planned to find out the bloodhaemoglobin content , fasting blood glucose level and lipid profile of the selected elderly.

Material and Methods

A total sample of 30 elderly 15 men and 15 women from the age group of 60 to 80 years was selected randomly from parbhani city for the study. Also they were divided in to three groups according to their family income such as low, middle and high income group 10 in each group.Blood sample of the selected elderly were collected andestimated for blood haemoglobin level, lipid profile andfasting blood glucose content was estimated.Haemoglobin content in the blood of all the selected elderly was estimated by Cyanometheamoglobin method Crossby*et al.* (1954). According to the haemoglobin content in the blood (g/dl) of theselected elderly were categorized in to four groups (Demaeyer, 1989)as a normal,mild

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anaemia,moderate anaemia, andSevere anaemia.

Total cholesterol in serum was determined by CHOD-PAP method (Schettler and Nussel, 1975).The level of triglycerides in serum was estimated by followingenzymatic colorimetric method GPO-PAP as described by Bucolo*et al.,*(1973). HDL-cholesterol and LDL-cholesterol in the serum samples wereestimated by high performance CHOD-PAP method as described by Lopes (1977) and blood fasting glucose level by GOD-POD method. Statistical analysis was carried out.

Result and Discussion

Haemoglobin content of the selected elderly men and women ispresented in Table 1.Haemoglobin content in the blood of elderly men varied widelyfrom 8-15.2 g/dl with mean value of 11.04±1.75 g/dl and that in the elderlywomen it ranged from 7 to 12 g/dl with mean of 9.68±1.17 g/dl. Thehaemoglobin content in the blood of elderly men was more than that in theblood of the elderly women but the difference in the haemoglobin content between the men and women was not significant statistically ($p<0.05$).

Distribution of the selected elderly of different groups intonormal, mild and moderate anaemia on the basis of blood haemoglobincontent according to their family income is given in Table 2. On the basis of family income a higher per cent of the elderlyof low income group was normal than that of middle and high incomegroups. In contrast the mild anaemia was more among high incomegroup and moderate anaemiawasrelatively more among middle incomegroup. This indicates that more number of elderly from families of middleincome group was suffering from moderate degrees of anaemia than thenumber of elderly from families of higher and lower income groups.However, it can be concluded from the results that income did not have amarked role on the nutritional status of elderly with special reference ofanaemia.

Table 3.depicts the meanfasting blood glucose level (g/dl) of the selected men variedfrom 70 to 198 with mean values of 112.08±40.89 g/dl. On the other hand, inthe elderly women they were found to be ranging from 70 to 134 with meanvalues of92.13±16.48 g/dl. Results indicated that difference in the fasting blood glucose level in the men and women was notsignificant statistically.

In nutshell, it can be said that mean value of fasting blood glucose was found to be relatively high in elderly men as compared to that in the elderly women. Even 80 per cent of elderly women were having normal level of fasting blood glucose level.

Mean values of lipid profile of the selected elderly of differentincome groups are given in Table4.The mean values of serum cholesterol was high (188.68±41.94) in elderly of high income group as compared to low(176.4±20.94) and middle (183.2±30.59) income groups. HDL values werefound to be approximately same in all three income groups. It was also foundthat the serum LDL values were high (127.3±35.89) in high income groupthan that of other two income groups. In case of VLDL the mean values of the selected elderly of lowincome group was high (26.57±15.88) than that of middle (22.52±6.97) and high income (23.47±2.66) groups. Triglyceride values of the selected elderlywere also found to be higher among elderly in high income group.

On the whole, it can be concluded that the sex of elderly didnot show a significant association in lipid profile of elderly. Results alsoindicated that family income did not play a role in causing hypercholesterolemia or hypertriglyceridemia among the selected elderly.

The mean values of lipid profile in the serum of the selectedelderly men and women are presented in Table 5. Serum cholesterol values (mg/dl) in the elderly men werebetween 124 and 251 with a mean of 182.2±34.86. On the other hand, serumcholesterol values of elderly women ranged from 131 to 252 with an averagevalue of 183.32±29.19. Serum cholesterol level of elderly men and womendid not differ markedly. In case of HDL mean value of elderly men (41.28±3.69) andwomen (41.18±2.58) found to be almost same. All the selected elderly foundto have HDL values within the normal HDL range. The mean value of LDLwas relatively high in elderly women (120.39 ± 21.89) as compared to that inthe elderly men (115.56±36.09). The VLDL content in the men was higher than that in thewomen. VLDL (mg/dl) of the elderly men ranged from 14 to 68.8 with amean value of 25.99±13.17 while in the women they ranged from 13 to14with an average value of 22.38±8.90. Statistically the difference in theVLDL content between men and women was notsignificant.

The per cent of elderly men having normal and hightriglyceride values were 60 and 40 whereas in the elderly women 53.3 percent having normal triglyceride value and 46.7 per cent were having hightriglyceride value. Mean values of serum triglyceride in the men and womenwere 171.08±83.53 and 168.28±56.74 respectively.

The categorization of elderly based on lipid profile values are given in Table 6. More than 75 per cent elderly men and women had normallevel of cholesterol and the remaining 23 per cent had higher values of serumcholesterol than normal. On the other hand, HDL level all the selectedelderly men and women was found to be almost same. Majority (86.6%) ofelderly men and (93.3%) women had normal level of LDL. Maximum (86)per cent of elderly men and women had normal level of VLDL and theremaining 14 per cent had VLDL above normal level. About 57 per cent ofelderly men and women had normal triglyceride level and the remaining 43per cent elderly

Table 1: Haemoglobin content of the selected elderly men and women of different income groups

Sex	Number of elderly	Range (g/dl)	Mean value of haemoglobin (g/dl) content among the selected elderly Mean ± SD	'Z' Value
Men	15	8-15.2	11.04 ± 1.75	
Women	15	7-12	9.68 ± 1.17	0.53^{NS}

NS – Non significant

Table 2: Prevalence of varying degrees of anaemia among selected elderly

Degrees of anaemia	Percent of haemoglobin (g/dl) content among the selected elderly of different income group Low income	Middle income	High income	'Z' Value a vs b	bvs c	a vs c
	a N=10	b N=10	c N=10			
Normal (>12)	2(20)	1 (10)	1 (10)	4.08**	0	4.08**
Mild amaemia (10 - 12)	4(40)	1 (10)	5(50)	4.07**	6.32**	1.58**
Moderate anemia (7-10)	4(40)	8(80)	4(40)	2.66**	2.66**	0

Figures in parenthesis indicate percentage
** - significant at 1 per cent level ,NS – Non significant

Table 3: Mean fasting blood glucose content of the selected elderly

Sex	Number of elderly	Range (mg/dl)	Mean value of fasting blood glucose (mg/dl) content of selected elderly Mean ± SD	'Z' Value
Men	15	70-198	112.08 ± 40.89	0.75^{NS}
Women	15	70-134	92.13 ± 16.48	

NS – Non significant

Table 4: Mean value of lipid profile of the selected elderly of different income groups

Parameters	Mean values with SD of lipid profile the selected elderly of different income groups Low income N=10 Mean ± SD	Middle income N=10 Mean ± SD	High income N=10 Mean ± SD	'Z' Value a vs b	bvs c	a vs c
Total cholesterol (mg/dl)	176.4 ± 20.94	183.2 ± 30.59	188.68± 41.94	0.14^{NS}	0.11 ^{NS}	0.26 ^{NS}
HDL (mg/dl)	41.85 ± 3.52	41.78 ± 2.50	40.06 ± 3.26	0.006 ^{NS}	0.16 ^{NS}	0.17 ^{NS}
LDL (mg/dl)	107.77 ± 27.48	118.86 ± 23.12	127.3 ± 35.89	0.38 ^{NS}	0.26 ^{NS}	0.64 ^{NS}
VLDL (mg/dl)	26.57 ± 15.88	22.52 ± 6.97	23.47 ± 2.66	0.65 ^{NS}	0.16 ^{NS}	0.48 ^{NS}
Triglycerides (mg/dl)	177.83 ± 69.05	149.1 ± 73.84	182.1 ± 70.23	0.68 ^{NS}	0.77 ^{NS}	0.09 ^{NS}

NS – Non significant

Table 5: Mean values of Lipid profile of the selected elderly

Parameters	Mean values of lipid profile of the selected elderly Men N=15 Mean ± SD	Women N=15 Mean ± SD	'Z' Value
Total cholesterol(mg/dl)	182.2 ± 34.86 (124-251)	183.32 ± 29.19 (131-252)	0.02^{NS}

HDL (mg/dl)	41.28 ± 3.69 (37-47.9)	41.18 ± 2.58 (36.6-45)	0.009 NS
LDL (mg/dl)	115.56 ± 36.09 (74-186)	120.39 ± 21.89 (80-135)	0.15 NS
VLDL (mg/dl)	25.99 ± 13.17 (14-68.8)	22.38 ± 8.90 (13-44)	0.58 NS
Triglycerides (mg/dl)	171.08 ± 83.53 (80-344)	168.28 ± 56.74 (109-338)	0.06 NS

Figures in parenthesis indicate range
NS – Non significant

Table 6: Categorization of elderly based on lipid profile values

Parameters	Normal range (mg/dl)	Per cent of the selected elderly into different category according to lipid profile			
		Normal range		Above normal Range	
		Men	Women	Men	Women
Total Cholesterol (mg/dl)	130-200	11	12	4	3
HDL (mg/dl)	35-55	15	15	0	0
LDL (mg/dl)	60-165	13	14	2	1
VLDL (mg/dl)	12-35	13	13	2	2
Triglycerides (mg/dl)	50-150	9	8	6	7

men and women had triglyceride above normal level. From the above results, it is evident that a relatively high percent of the selected elderly found to have normal values of lipid profile.

Conclusion

It can be said that mean values of the blood haemoglobin content andfasting blood glucose of elderly men were higher than that of women but it was not significant statistically. Majority of the elderly were found to be suffering from varying degrees of anaemia.On the other hand, the values of serum cholesterol LDL and triglyceride were found to be higher among elderly belonging to high income group while mean value of VLDL was high in low income group than other two income groups.However special attention should be paid in providing properhealthcare facilities to elderly to have overall wellbeing of elderly.

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Review Article

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A Review on Composition, Processed Products and Medicinal Uses of Papaya (*Carica Papaya L.*)

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Abstract

Papaya is a very popular fruit grown in tropical countries and belongs to the family of *Carcicaceae.* Nutritionally papaya is a rich source of carotenoids and also provides fair amounts of B complex vitamins, ascorbic acid and minerals. Papaya can be processed to obtain many preserved products such as candy, jams and jellies. It also can be converted to beverages such as ready-to-drink beverages and nectar. Dried and canned papaya products are also available. By-products of papaya such as pectin and papain are useful for the food industry. Papaya is also prized for its medicinal properties, which have been documented by many researches. The present review focuses on the salient features of nutritional composition, processed products, and medicinal uses of papaya.

Keywords: Production; Nutritional Composition; Flavor Components; Preserved Products; By Products.

Introduction

Papaya (*Carica papaya* L) is a rapid growing hollow stemmed and short lived perennial tree, belonging to the family *Carcicaceae* which is usually propagated from seeds. Because of open pollination, papaya is a notoriously difficult crop to maintain as a pure or tree cultivar. This family includes 4 genera and about 20 species of *carica* native to tropical and subtropical areas of the world (Sidhu, 2006). It may be male, female, or hermaphrodite, the fruits from female trees are round whereas fruits from hermaphrodite trees are elongated (Figure 1a) (Bruce and Peter, 2008). The fruit is melon-like, oval to nearly round, somewhat pyriform, or elongated club-shaped, 15-50 cm long and 10-20 cm thick and weighing up to 9 to 10kg. Semi wild (naturalized) plants bear small fruits 2.5-15 cm in length. The skin of the fruit is waxy and thin but fairly tough. When the fruit ripens it develops a light- or deep- yellow-orange coloured skin (Figure 1b), while the thick wall of succulent flesh becomes aromatic, yellow orange or various shades of salmon or red. The ripened fruit is juicy, sweetish and develops a characteristic papaya flavor which resembles the flavor like a cantaloupe. Mature fruits contain numerous grey-black ovoid seeds (**Figure 1c)** attached lightly to the flesh by soft, white, fibrous tissue (Morton, 1987).

(a) Papaya Tree (b) Papaya Fruit (c) Papaya Seeds

Fig. 1: Papaya Fruit and Seeds

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The fruit is a popular fruit grown more prominently in recent years, the volume of production being next to fruits such as mango, banana, citrus and pineapple at the global level. Even in India, the fruit is more common with a number of varieties. Some of the common varieties of papaya throughout the world are Coorg Honey Dew, Pusa Dwarf, Pusa Giant, Pusa Majesty, Pusa Delicious, Co.1, Co.2, Co.3, Co.5, Washington, Solo, Ranchi, IIHR39, IIHR54, Taiwan-785, Taiwan-786, Solo, Solo Sunrise, Solo Sunset, Red Amazon, Hortus Gold, Betty and Improved Peterson (National Horticulture Board, 2012). The fruit is given different names in various localities throughout the world as given in **Table 1**. Papaya is considered as one of the important fruit because it is rich source of antioxidants, phytochemicals, nutrients such as; carotenes, vitamin C, and flavonoids, the B vitamins including folate and panthothenic acid, minerals such as potassium and magnesium, and dietary fiber (Murcia *et al*., 2001; Leong and Shui, 2002, Gopalan *et al.,* 2004). In addition, papaya is a source of digestive enzyme papain, which is used as an industrial ingredient in brewing, meat tenderizing, pharmaceuticals, beauty products, and cosmetics. The fruit is mostly consumed fresh but the immature fruit is also cooked or used in fruit salads, preserves, sauces and pies. The fruit is characterized for its active pectinolytic enzymes during ripening. A number of products are prepared by drying, canning, pickling and processing the raw fruit latex. Pureed papaya is a good source of â-carotene (Ncube *et al*, 2001). Brazil, Nigeria, India, Mexico, Indonesia, China and Thailand are leading producers of papaya. However other countries such as USA, Taiwan, Puerto Rico, Peru, Bangladesh and Australia are also producing sizeable quantity of this fruit (FAO, 2001). The world production of papaya is given in **Table 2.** Papaya is produced in about 60 countries, with the bulk of production occurring in developing economies. Global papaya production in 2012 was estimated at an annual rate of 3.85 % between 2004 & 2012. India is the leading papaya producer, with a 41.56% share of the world production during 2010-2012 and the total production during 2014 (APEDA) was 5,639,310 tonnes, followed by Brazil (12.25%) and Indonesia (7.30%). Other important papaya producing countries and their share of global production include Nigeria (6.79%), Mexico (6.18%), Ethiopia (2.34%), Democratic Republic of the Congo (2.12%), Colombia (2.08%), Thailand (1.95%), and Guatemala (1.85%) (FOSTAT, 2012a, b). This review article comprises of physiology and ripening of papaya, chemical composition, different products prepared by papaya and the health benefits of papaya.

Physiology and Ripening

Papaya trees are very fast growing, prolific fruit bearers and the first fruit is ready in 10-14 months from the time the plants are transplanted into the orchard (Sommer, 1985). In India, the fruit takes about 135-155 days from pollination to fruit maturity (Selvaraj *et al*, 1982a, b). The weight and length of a fruit shows a typical double sigmoid type of growth curve (Selvaraj *et al*, 1982a, b; Ghanta *et al*, 1994; Ong, 1983). Change of latex colour from white to watery, is another index of maturity of papaya fruit (Akamine and Goo, 1973).

Some researchers report that, application of micronutrients during fruit growth and ripening influence the fruit quality and increase the production of papaya fruit. Chattopadhyay and Gogoi (1992) carried out a study on the effect of treating plant with micronutrients such as boron, zinc, copper, iron and manganese on the composition of the fruit. The application of boron (40ppm) increased total sugars (7.69% versus 6.6%) and ascorbic acid (65.63 versus 60.84 mg / 100g pulp). Treatment with boron, copper and zinc (all 40 ppm) reduced titrable acidity (TA), and increased carotene content was higher (2.07-2.33 versus 2.01 mg / 100g). The researchers concluded that a combined foliar application of these micronutrients (40 ppm of each) will result in good quality papaya fruits. Lavania and Jain (1995) reported that the yield and quality of papaya fruits are greatly influenced by nitrogen, phosphorus and potassium (NPK) fertilizer application. They reported that the application of nitrogen (200g), phosphorous (50g) and potassium (100g), per tree was found to be the most effective dose for increasing fruit yield and quality parameters such as ascorbic acid, total soluble solids (TSS) and sugar contents of mature papaya fruits. Yunxia *et al.*, (1995) carried out a similar study on the ripening process of the "Sunset" papaya (*Carica papaya* L) fruit with the treatment of calcium. The researchers reported that the higher concentration of calcium in mesocarp was associated with slower fruit softening rate when compared with a lower calcium concentration. Kavitha *et al.,* (2000 a, b) reported that application of boron and zinc affected the biochemical and quality characters of papaya. The two minerals treated samples produced higher levels of TSS, total sugars, reducing sugars and non reducing sugars. The TA and ascorbic acid in the mineral treated fruits averaged approximately 0.29% and 47.1mg/g respectively.

Paull and Chen (1990) studied the effect of heat processing on the softening process of the papaya at various stages of maturity and harvest date. Mesocarp softening during papaya ripening was impaired by heating at 42ÚC for 30 mins followed by 49ÚC for 70 mins. The fruit samples which were subjected to heat processing failed to be softer and the researchers observed that the disruption of the softening process varied with the stage of maturity and harvest date. The treated fruits had the highest ethylene production than in the non treated fruits. Camara *et al.,* (1993) stated that the softness to touch is another indicator used as the ripening index. Among the physicochemical determinants, pH and TSS (° Brix) are very good indicators of ripening of papaya fruit. Calegario *et al.,* (1997) compared the physical methods; reflectance measurement, delayed light emission intensity, and body transmission spectroscopy and subjective methods; change in skin colour to evaluate the ripening stage of the papaya fruit and reported that the subjective method is more useful than the physical methods.

Bron and Jacomino (1996) investigated about the effect of different maturity stages at harvest on the ripening physiology and quality of 'Golden' papaya. Papayas were harvested at four different maturity stages (Stage 0: totally green; Stage 1: up to 15% of yellow skin; Stage 2: 16-25% of yellow skin; and Stage 3: 26-50% of yellow skin) and evaluated during ripening at 23ºC. Physical and physico-chemical (skin color, pulp firmness, soluble solids, titrable acidity, and ascorbic acid), physiological (respiratory activity and ethylene production), and sensorial (flavor, odor, firmness, and appearance) characteristics were evaluated. The authors reported that the fruit harvested at stages 0, 1, 2 and 3 reached the edible condition after 7, 6, 4, and 3 days respectively. There was an increase in ascorbic acid concentration (20-30%) during ripening, skin hue angle and titrable acidity were reduced and soluble solids did not alter. The fruits which were harvested at stages 2 and 3 had superior scores for sensorial evaluation, mainly for flavor and appearance and the authors concluded that harvest at different maturity stages altered fruit postharvest physiology. Brishti *et al.,* (2012) studied the effect of Bio preservatives on storage life of papaya. In this experiment the effect on post-harvest preservation of papaya (*Carica papaya* L.) fruit coated with either Aloe gel (AG; 100%) or papaya leaf extract with Aloe gel (PLEAG; 1:1) was studied. To evaluate the role of coating on ripening behaviour and quality of papaya, the uncoated and coated fruits were stored and ripened at room temperature (25ºC - 29ºC) and 82-84% relative humidity. Physico-chemical properties were analyzed at 4 day intervals during the storage period. The incidence of disease attack was also visually observed. The overall results showed the superiority of AG and PLEAG coating in lengthening the shelf-life of papaya fruit compared to controls which showed significant decay from 6th day onward and complete decay within 12 days of storage. The AG and PLEAG coated fruits maintained their shelf life for 12 days and decayed at 16th day. The coated fruits also maintained their colour, flavour and firmness up to 12 days of storage. An increase in ascorbic acid content (120.2 mg / 100 g) was also found in coated fruits in contrast to the control (59 mg / 100 g). Only 27% disease incidence was observed in AG and 13% in PLEAG coated fruits as compared to control (100%) during the storage period. The results of this study showed that both AG and PLEAG coatings have excellent potential to be used on fresh produce to maintain quality and extend shelf-life.

Chemical Composition

The chemical composition of papaya, viz, proximate composition – moisture, protein, fat, total ash, vitamins – fat soluble: total carotenoids, water soluble: thiamine, riboflavin, niacin, vitamin C, minerals – iron, sodium, phosphorus, potassium, magnesium and calcium; in different parts of the fruit is compiled in **Table 3** and flavor components in **Table 4** as reported by some of the researchers. As observed, it is noteworthy to mention that papaya is a wholesome fruit rich in sugar and vitamins C, A, B_1 and B_2. Among the carbohydrates, sugar is the major constituents of papaya fruits but amounts vary considerably depending upon the cultivar and agronomic condition. Indian cultivars have higher sugar content (10 – 10.2% TSS) than the papaya cultivars grown in the United States (5.6 – 7.1%) (Pal and Subramanian, 1980; Madhav Rao, 1974). Papaya is second only to mango as a source of â-carotene, a precursor of vitamin A. The researchers studied the influence of various agronomic practices and planting time on changes in the physicochemical quality parameters of papaya fruit, such as mean fruit weight, pulp, yield, pulp-peel ratio, TSS as brix, vitamin C and total carotenoids. They reported that, September planting produced heavier mean fruit weight (2.30 kg), maximum TSS (11.2°Brix), vitamin C (74.55 mg / 100g) and total carotenoids (1152.50 mg / 100g), higher pulp – peel ratio than that of the fruits harvested from other months of planting. Selvaraj *et al*, (1982a, b) and Birth *et al*, (1984), observed that the change in outer color of the skin of fruit is an indicator of ripeness, and this change is mainly due to an increase in the carotene content and decrease in chlorophyll. The authors reported that, the total carotenoids contents increased manyfolds from the mature green stage to nearly about 4mg / 100gm at the fully ripe stage of maturity. Papaya fruits are also good source of many minerals (potassium, phosphorus and magnesium) in human diet. The papaya fruit belongs to the group of low acid content fruit and the pH of pulp ranges from 5.5 to 5.9. Citric acid and malic acid are the major acids with smaller quantities of ascorbic acid and á-ketoglutaric acid (Chan *et al.,* 1971, 1973). The major enzymes present in papaya are invertase, papain esterase, myrosinase and acid phosphates, which play important role in the quality and stability of processed products made from papaya (Jagtiani *et al*, 1988).

The hydrolytic change of protopectin to pectin during the ripening of the fruit reduces firmness or softens the fruit. During the ripening stage, the enzymatic demethylation and depolymerization of protopectin leads to the formation of low molecular weight compounds with less methoxyl group which are insufficient to maintain the firmness and thereby it reduces structural firmness of the fruit (Kertesz, 1951). The author reported that the enzymes such as polygalacturonase and pectin methyl esterase play an important role for the textural changes of the fruit. The chemical composition of the pectin is influenced by the variety of fruit, the growing condition and the state of development at the time of harvest (Lassoudiere, 1969a, b). Loss of firmness is not uniform in papaya fruit as some time the fruit become soft before the complete development of total soluble solids (Pelag, 1974). Ali *et al*., (1998), reported that â-galactosidase is an important enzyme present in papaya which has the ability to depolymerize pectin and hemicelluloses, which helps in softening of the fruit. Various careteniods such as â-carotene, lycopene, â-cryptoxanthin and â-zeacarotene are present in varying amount in papaya (Chan, 1983; Bhaskarachary *et al*, 1995; Wilberg and Rodriguez, 1995; Cano *et al.*, 1996; Irwig *et al*, 2002; Sugiura *et al*, 2002). A study conducted by Selvaraj *et al*, (1982a, b), showed increase in carotenoids content (as â-carotene) by five to ten folds in yellow fleshed cultivars. During ripening the color of papaya flesh turns yellow or reddish from green unripe fruit. The major difference between yellow and red fleshed cultivars is the total absence of lycopene in the yellow fleshed papaya. Carotenoids, which are relatively heat stable, showed higher retention than anthocyanins after blanching and drying in papaya fruit. Pretreatment of papaya fruits with sodium metabisulphite, prevented the oxidation of carotenoids but caused bleaching of anthocyanins while blanching (Sian and Soleha, 1991).

Table 1: Common names of Papaya

Sl.No	Place	Common names
1.	Africa, Australia, and Jamaica	Paw-paw, papayer and papaw
2.	Arabic	Fafay, babaya
3.	Argentina	Maman
4.	Bali	Gedang castela, Spanish Musa
5.	Burmese	Thimbaw
6.	Creole	Papayer, papaye
7.	Cuba	Fruta bomba
8.	English	Bisexual pawpaw, pawpaw tree, melon tree, papaya
9.	Europe	Tree melon
10.	Filipino	Papaya, lapaya, kapaya
11.	French	Papaya, papayer, figuier des Îles
12.	German	Papaya, melonenbraum
13.	India	Pappaiya (Bengali), papeeta (Hindi), papaya (English) and pappali or pappayi (Tamil)
14.	Indonesia	Dangandangan, gedang, papaya
15.	Khmer	Lhong, doeum lahong
16.	Lao	Sino-Tibetan, houng
17.	Luganda	Papaali
18.	Malaysia, Singapore	Betik
19.	Mexico, Panama	Olocoton
20.	Philippines	Kapaya, kepaya, lapaya, tapayas and papyas
21.	Sinhala	Pepol
22.	Spanish-speaking countries	Melon zapote, payaya (fruit), papayo or papayero (the plant), fruta bomba, mamón or mamona, figuera del monte, papaita, lechosa
23.	Swahili	Mpapai
24.	Thai	Ma kuai thet, malakor, loko
25.	Thailand	Malakaw, lawkaw, teng ton
26.	Tigrigna	Papayo
27.	USA	Pawpaw, paw paw, papaw, poor man's banana, or hoosier banana
28.	Venezuela	Lechosa
29.	Vietnamese	Du du
30.	Worldwide	Papaya

Source: Silva *et al.,* (2007); Saran and Chaudhary (2013); Roshan *et al.,* (2014)

Table 2: Global Papaya Production (in metric tonnes)

Country	Production
India*	5,639,310
Brazil	1,517,696
Indonesia	906,312
Nigeria	775,000
Mexico	742,017
Ethiopia	308,654
Democratic Republic of Congo	295,770
Colombia	283,078
Thailand	271,584
Guatemala	201,000
Other	1,889,758
TOTAL	**12,413,031**

Source: FAOSTAT (2012 a, b)
* APEDA (2014)

Table 3: Chemical Composition of papaya (per 100g)

Reference	Part of the plant studied	Energy (Kcals.)	Moisture (%)	Carbohydrate (%)	Protein (%)	Fat (%)	Ash (%)
Das and Siddappa, 1955	Pulp	-	88.9	-	0.5	-	0.57
Fredrich and Nichols, 1975	Fruit flesh	30	-	10	0.6	0.1	-
Gopalan *et al.*, 2004	Whole fruit	32	90.8	7.2	0.6	0.1	-
Puwastien *et al.*, 2000	Ripe papaya	-	89.1	9.5	0.9	0.1	0.51
Puwastien *et al.*, 2000	Green papaya	-	92.6	6.0	0.8	0.1	0.50
		Total carotenoids (µg)		**Thiamine (µg)**	**Riboflavin (µg)**	**Niacin (mg)**	**Vitamin C (mg)**
Das and Siddappa, 1955	Pulp	927		40	250	0.20	42.90
Singh and Singh, 1998	Whole fruit	1152		-	-	-	74.55
Gopalan *et al.*, 2004	Whole fruit	666		40	250	0.20	57.00
Munsell, 1950	Whole fruit	-		25	29	0.24	-
Asenjo *et al.*, 1950	Whole fruit	-		30	38	0.40	-
Puwastien *et al.*, 2000	Ripe papaya	7807		31	31	0.31	62.57
Puwastien *et al.*, 2000	Green papaya	0		40	192	0.29	29.00
		Iron (mg)	**Sodium (mg)**	**Potassium (mg)**	**Phosphorus (mg)**	**Calcium (mg)**	**Magnesium (mg)**
Gopalan *et al.*, 2004	Whole fruit	0.50	6.0	69	13.0	17.0	-
Hardisson *et al*, 2001	Whole fruit	-	120.0	210	10.0	30.0	20
Munsell, 1950	Whole fruit-Variety 1	0.25	110.0	-	1.8	18.3	-
	Whole fruit-Variety 2	0.42	97.0	-	15.5	17.5	-
Puwastien *et al.*, 2000	Ripe papaya	1.41	14.1	137	NR	16.2	25
Puwastien *et al.*, 2000	Green papaya	0.60	21.0	203	NR	31.9	47

***NR-Not reported**

Table 4: Flavour Components of papaya

Reference	Part of the plant studied	Flavour components
Flath and Forrey, 1977	Whole fruit	Linalool, β-ionone
Macleod and Pieris, 1983	Whole fruit	Methyl butanoate
Mohammed *et al*., 2001	Whole fruit	Linalool, benzaldehyde, benzenemethanol, cyclohexane and hexanoic acid
Sheikh and Krishnamurthy, 2013	Fruit	Linalool, benzylisothyocynate, cis and trans 2,6-dimethyl 3,6 epoxy-7 octen-2-ol,Alkaloid,α carpine, benzyl-β-D gucoside,2-phenyl ehyle-β-D gucoside,4-hydroxyphenyl-2-ehyle-β-D gucoside
Sheikh and Krishnamurthy, 2013	Juice	N-butyric, n-hexanoic and n-octanoic acid, lipid, myristic, palmitic, stearic, linoleic, linolenic and cis-vasanic and oleic acid

Papaya Based Products

As the papaya fruit grows faster with higher yields and as it has various varieties which are diverse in range, this fruit can be used for development of economically viable products on commercial scale, with ample scope for blending with other fruits. Because of the mild flavor of the fruit, the products can be supplemented with other strong flavors, to obtain tailor made sensorial products. Besides consumption as a fresh fruit, a number of processed food products developed using papaya are used in the form of puree (Brekke *et al*., 1972; Martin *et al*., 1972; Flath and Forrey, 1977; Nath and Ranganna, 1981), jam (Parsi, 1976, Teangpook and Poasantong, 2013), jelly (Yi-zhuo *et al*., 2013; Mie, 2013), pickle (Su and Liu, 2006; Nurul and Asmah, 2012), candied fruit (Chan and Caveletto, 1978; Cherian and Cheriyan, 2003; Ahmad *et al*., 2005; Jadhav *et al*., 2012), mixed beverages (Rodriguez and George, 1971; Martin *et al*., 1972; Chan *et al*., 1975; Salomon *et al*., 1977; Kalra *et al.,* 1991; Sheeja and Prema, 1995; Mostafa *et al.,* 1997; Ukwuru and Adama, 2003; Saravana and Manimegalai, 2001; Boghani *et al.,* 2012; Yadav *et al*., 2013), canned slices / chunks (Lynch *et al*., 1959; Nath and Ranganna, 1981; Dos – Amagalhaes *et al*., 1990), concentrate (Siddappa and Lal, 1964; Ponting *et al*., 1966; Chan and Caveletto, 1978; Mehta and Tomar, 1980a, b; Arya *et al*., 1983; Aruna *et al.,* 1999; Barbaste and Badrie, 2000; Kaleemullah *et al.,* 2002; Mendoza and Schmalko, 2002; Moyano *et al*., 2002; Kandasamy and Varadharaju, 2014) on a commercial scale. The functional components of the papaya such as pectin content of the fruit aids in jam preparation and easy setting. The biochemical constituents of the fruit related to health benefits such as reducing cholesterol and the provision for development of wide spectrum of processed products dictate the scientific merit of the fruit, with national and international strategies for the future. Varieties of papaya products developed by research with low sweetness have proved its importance in reducing the blood sugar levels. The mature fruit, at its various stages of ripening, can also be processed to give several products and a few are mentioned below in this review.

Papaya Candy

Papaya candies are fruit prepared by using high percentage of sugar. Papaya and sugar are the main raw materials. The processing of papaya candy according to Kumar (1952) is as given in Figure 2.

Fully mature but unripe fruit is hand peeled, deseeded, and cut into 0.5–1.0 cm cubes.

⇓

These cubes are soaked in 4% brine solution for 2 weeks, taken out and leached in running tap water to remove the salty taste.

⇓

The fruit is boiled in 25^{o} Brix syrup for a few minutes and then allowed to stand overnight.

⇓

The sugar content of syrup is increased by 10% by boiling the mixture of fruit / syrup and allowed to stand overnight.

⇓

This process is repeated for 5 days until the syrup concentration reaches between 70 and 75^{o} Brix after standing.

⇓

Other fruit essences such as orange, pineapple, raspberry, and strawberry are added to the syrup and allowed to stand overnight.

⇓

A translucent candied papaya is obtained at this stage, which can be rolled in powder sugar to prevent stickiness.

Fig. 2: Processing of Papaya Candy

Some of research studies reported on the processing of papaya leather / candy are as follows. Chan and Caveletto (1978) studied the effect of (i) drying temperature (77°C, 84°C or 94°C), (ii) storage times (1, 2 or 3 months), (iii) storage temperature (18°C, 24°C or 38°C) and (iv) sulphur dioxide (SO_2) on the quality attributes viz (a) drying rate, (b) sensory analysis – colour, flavor, off flavor of papaya leather. The researchers concluded that, drying rate was decreased when high SO_2 levels were used. The colour of the leather was dependent on drying and storage temperature, and the addition of SO_2 protected against darkening at high drying and storage temperature respectively. Cherian and Cheriyan (2003) carried out the study on sensory acceptability of papaya leather by developing 2 different products viz, papaya leather and papaya+mango (60:40) blended leather and compared the two leathers with a control plain mango leather. Ahmad et al., (2005) developed a fruit bar from blend of ripe papaya pulp + tomato pulp (75:25). Seven different fruit bars were developed with the combination of the three hydrocolloids, which were added at different percentages. It was found that seven different samples of fruit bar had moisture contents of 20.9–22.1% and total soluble solids 78.1–78.8°Brix while pH, browning index, and vitamin C contents were in the following ranges, 4.3–4.50, 0.137–0.150 (OD), and 40.5–41.4 mg/100 g respectively. Jadhav et al., (2012) prepared toffee by blending noni-pulp with papaya pulp at a ratio of (i)100:0, (ii) 95:5, (iii) 93:7 and (iv) 90:10 and studied the effect of varying pulp concentration of fruit pulp on sensory quality of noni (*Morinda citrifolia* L). Toffee comprising 90% noni pulp with 10% of papaya pulp and 93% noni pulp and 7% guava pulp had higher overall sensory acceptability such as appearance, colour, flavor, consistency.

Papaya Jam

Jams are fruit preserves, which are 45 parts prepared fruit with 55 parts of sugar concentrate to 65% or higher solids, resulting in semi solid product. The processing method for the preparation of papaya jam according to Lal and Das (1956) is given in Figure 3.

Cooked slices are mashed, mixed with equal weight of sugar, and the mixture is cooked.

⇩

Citric acid at the rate of 5 g / kg of pulp is added to improve the sugar–acid ratio and it also helps in the production of inverted sugars, which prevent sugar crystallization in jam during storage.

⇩

Cooking of fruit pulp / sugar mixture is continued until it attains a thick consistency, which usually corresponds to a TSS of 65–68° Brix.

⇩

Jam is filled hot into clean, dry, and sterilized glass jars, sealed airtight and cooled.

Fig. 3: Processing Method of Papaya Jam

Teangpook and Poasantong, (2013) developed low sucrose papaya jam from ripe papaya pulp and green lime juice and studied the storage stability of the jam. The developed jam was comprised of papaya (32%), lime juice (8%), low ester pectin (0.55%), konjac flour (0.5%), glucose syrup (9%), salt (0.03%) and calcium lactate (0.01%) and consisted of 52.10% moisture, 45.61% total carbohydrate, 0% fat and 1.52% dietary fiber. It contained 36.46% sucrose in comparison with control jam which had sucrose concentration of 55%, 46° Brix TSS and a pH of 3.22. The average sensory evaluation score was moderate preference and 79.31% of consumers liked it.

Papaya Jelly

Fruit jelly is preserved fruit product with characteristic texture and body. The steps involved in jelly making is same as that for jams, but the cut fruits are boiled in enough water and citric acid is added to extract pectin, which is then decanted and heated with sugar until it forms sheets or flakes when let down from a spoon. It is then set at cold temperature. Papaya jelly was optimized and developed by Yi-zhuo *et al.,* (2013) through single factor experiments and orthogonal tests. The results showed that the best formula of papaya jelly contained a ratio of sodium alginate, agar and xanthan gum of 6:5:4 (3.0 g in total), 40g of papaya, 0.2g citric acid and 16g sugar. The papaya jelly was homogeneous smooth and had a good flavor. Investigation on the best processing technology for production of health jelly with papaya was carried out by Mei (2013). Results showed that the optimal mixture was gum - 1.0%, sugar - 20%, papaya juice - 30% and citric acid - 0.25%. The product had the aroma and colour of papaya, a good acidic and sweet flavor, a uniform texture and a smooth taste.

Papaya Beverages

Juice or nectar is obtained by blending the thin pulp of the fruit with sugar and citric acid. The finished product has 15-20° brix and mild acid taste. The method for the preparation of papaya juice and nectar according to Payumo *et al*., (1968) is given in Figure 4.

Papaya pulp is mixed with sugar (1.5-2.0kg / kg pulp).

⇩

Citric acid (12.5-17.5g / kg pulp), color and flavour are added.

⇩

Nectar is filtered and heated to 85-88°C.

⇩

Filled in plain or lacquered cans and cooled in running water about 38°C.

Fig. 4: Processing Method of Papaya Nectar

Rodriguez and George (1971) developed a good quality canned papaya beverage from the pulp of peeled and unpeeled fruit. To enhance the flavor of the beverage, 0.4% of sliced, ripe Indian lime was added before pasteurization. The beverage was adjusted to 15° brix and pH of 3.7 and pasteurized at 88°C and canned. The product was excellent organoleptically even after 1 year of the storage. Chan *et al.,* (1975) studied changes in ascorbic acid, carotenoid and sensory quality of papaya puree at different stages of processing. About 5.5% ascorbic acid was destroyed during pulping in preparation of puree and 14% more was lost during vacuum concentration. There was no change in quality, flavor or aroma seen with alteration of the concentration. Salomon *et al.,* (1977) studied the blending of papaya / passion fruit nectar. The results showed that the 82.5:17.5 and 87.5:12.5 blends were preferred to the 75:25 blends. Kalra *et al.,* (1991) evaluated the quality of mango – papaya blended beverage. Mango and papaya pulps were blended in ratio 1:0, 1:1, 2:1, 3:1 and 0:1 and these pulps were stored for 1 year. The stored pulp contained 15% pulp, 20% total soluble solids and 0.3% acidity, and could be preserved for 1 yr in glass bottle under ambient conditions. The study indicated that 25-33% papaya pulp could be incorporated in blended beverage without affecting the quality and acceptability of the beverage.

Formulation of different types of papaya juice blends and nectars have been reported by different authors. Mostafa *et al.,* (1997) developed two different fruit nectars from (i) papaya pulp and (ii) papaya and mango pulps. The two nectars contained, total pulp concentration of about 20, 30 or 40%, TSS - 15% and acidity as citric acid - 0.55%. Mango pulp was added at 0, 15, 25, 37.5 or 50% of total pulp content. A blend of 15% papaya + 15% mango was rated excellent and it was characterized by higher acceptability. Ukwuru and Adama (2003) prepared beverages by blending soya flour (SF) and papaya pulp flour (PF) in the ratio of (i) 100:0, (ii) 70:30, (iii) 50:50, (iv) 30:70 and (v) 0:100, and fortified the above beverages with vitamin C. Storage stability of a whey based papaya fruit juice ready to serve (RTS) beverage was studied by Saravana and Manimegalai (2005). The beverage was prepared by blending 10% papaya juice with whey. In another study, the authors formulated mango-papaya blended squash by mixing them in proportions of 50:50, 75:25 and 25:75 (Saravana and Manimegalai, 2001). Boghani *et al.,* (2012) developed a blended papaya and aloe vera ready-to-serve beverage in concentration of 90% and 10% respectively. Blended RTS beverages were prepared using 12% TSS, 0.3% acidity and 10% blended juices in blending ratio of 90% papaya juice + 10% *Aloe vera* juice. Optimization studies on the development of blended fruit nectar, based on papaya and bottle gourd were studied by Yadav *et al*., (2013). The nectar was optimized with the ingredient composition (%) of papaya: bottle gourd juice (2.47:1), sugar (20.95) and citric acid (0.30). The nectar had a pH of 3.99, acidity 0.35%, TSS of 20.80 with hedonic scale sensory ratings of 7.43 and 7.18 for flavor and taste respectively.

Fermented Papaya Products

Wen-Jun and Hong (2008) studied the brewing technology of papaya and jujube to make healthy wine. A method was described for preparation of wine by fermentation of papaya, jujubes, powdered Eucommia extract and honey for 48 hours at 30-34° C. Lee *et al.,* (2011) studied the impact of amino acid addition on aroma compounds in papaya wine fermented with *Williopsis mrakii.* The study suggested that papaya juice fermentation with *W.Saturnus mrakii* in conjunction with the addition of selected amino acid (L-leucine, L-isoleucine, L-valine and L-phenylalanine) can be an effective way to modulate the aroma of papaya wine.

Papaya Pickle

Raw papaya can be used for making salted pickles by brine curing and adding spiced vinegar in the traditional way. Su and Liu (2006) studied the processing technique of papaya pickle preparation with the addition of spices (including garlic, hot pepper and ginger). Nurul and Asmah (2012) developed a papaya pickle and compared the pickle with the fresh papaya for its total phenol (TPC), total flavonoid (TFC), â- carotene, lycopene, ascorbic acid contents and antioxidant activity. With the process of pickling the researchers found that there was a significant decrease in the above mentioned parameters in comparison with the fresh papaya.

Papaya Pulp

Papaya puree is the major semi processed product that finds use in juices, nectars, fruit cocktails, jams, jellies, and fruit leather. Earlier the processing of papaya into puree was difficult, mainly due to product gelation and off-flavour development. The development of undesirable odours, due to the presence of butyric, hexanoic and octanoic acids and their methyl esters was observed in puree prepared by commercial methods. Therefore, few studies have been carried out to rectify this problem by modifying the processing technologies and a few are discussed below. Brekke *et al.,* (1972) reported the composition of Hawaii varieties of papaya puree as total soluble solids – 11.5 to 13.5%; total acid (after acidification) – 1.05 to 1.10; ascorbic acid – 50 to 90mg%; carotenoids – 3.5 to 3.9mg%; and moisture – 84 to 88%. The authors reported that the technology in the processing included preliminary steaming, the use of crusher scrapper device and acidification. In addition to the above study, Chan *et al.*, (1973) also reported that acidification and heat inactivation of enzymes prevented the development of the above mentioned unpleasant flavours and odours in the papaya puree. Chan *et al*., (1975) reported that, during the process of making a puree and a concentrate from papaya, small but statistically significant losses in vitamin C had occurred. Microwave treatment of papaya puree produced a small change in qualitative and quantitative composition of carotenoid pigments, without significant alterations to the original colour of the fruit puree (de Ancos *et al*., 1999). Parker *et al.,* (2010) developed optimized papaya pulp nectar using a combination of irradiation and mild heat treatment.

Canned Papaya Products

Canned papaya chunks or slices are some of the popular ingredients employed for the preparation of fruits salads. Although fully ripe, soft papaya fruits are ideal for fresh consumption, but they are not suitable for canning purpose. For canning only the green mature or semi ripe papaya fruits are used. Lynch *et al.,* (1959) described a canning procedure for papaya chunks. Nath and Ranganna (1981) recommended thermal processing of 3-cm papaya cubes in cans (hot filled with syrup at pH 3.8) at 100^{0}C for 16.2 mins to achieve F-value of 1.33 or D-value of 2.5 during the canning process. For the establishment of required thermal processing time for canned papaya puree, the use of destruction studies with *Clostridium pasteurianum* was conducted by Dos-Amangalhaes *et al.*, (1996). Higher temperature was used for the inactivation of the polyesterase enzyme.

Dried Papaya Products

A number of low-moisture products such as fruit leather, powder, toffees, chunks, rolls, and slices have been prepared from papaya puree, which finds their place in food commodity market. Siddappa and Lal (1964) patented a process for drying mixtures of papaya juices, previously concentrated, with sugar and other additives. A procedure for the dehydration of ripe papaya slices after steeping in 70° brix syrup containing 1000 ppm of SO_2 was standardized to give the best quality product by Mehta and Tomar (1980 a, b). Ponting *et al*., (1966) reported that pulp can also be dried after adding 5–7.5% sugar, 0.5% citric acid, and 0.3% potassium metasulphite. This mixture is spread on greased trays in 1 cm thickness layer and dried in cabinet drier at 55–60^{0}C. The dried product developed a leathery consistency; which was rolled and cut into desirable sizes. This fruit leather had a shelf life of about 8 months when stored at 24–30°C. Chan and Caveletto (1978) developed papaya toffee similar to fruit leather from puree. Papaya fruit bars when stored at room temperature for 9 months retained 54%, 46%, and 43% of total carotenes, â-carotene, and vitamin C, respectively, and were judged to have superior texture and aroma with fewer physicochemical changes (Aruna *et al*., 1999). For cheese product containing fruit blends, optimal ratio of papaya puree to pineapple puree was 2:1 with 2% pectin and processed to 77–80° Brix (Barbaste and Badrie, 2000). Sensory analysis indicated a significant preference for the blended fruit cheese. Shelf life of these products at 4–5°C was around 8 weeks. Kandasamy and Varadharaju (2014) carried out the experiment to find out the effect of drying air temperatures (60, 65 and 70°C), foaming agents (methyl cellulose, glycerol-mono-stearate and egg white) and foam thickness (2, 4, 6 and 8 mm) on biochemical qualities of foam and non-foam dried papaya powder. It was observed that there was significant (p d" 0.05) variations in ascorbic acid and â-carotene content with temperatures, foaming agents and foam thickness.

Freeze Drying

Most of the dried products prepared from papaya fruit suffer from undesirable darkening effects. To overcome these defects, less severe treatments have been tried. Freeze-drying is one such method that produced good results to reach a moisture content of as low as 3% in the finished papaya powder. Storage of freeze-dried powder in glass jars did not show significant adverse effects on the quality or composition of finished products after 3 months (Salazar, 1968). Carotenoids were found to be most stable in freeze-dried powder at water activity of 0.33 (6–7% moisture content) and the researchers recommended freeze drying for the storage of papaya (Arya *et al.,* 1983). A combination of osmotic dehydration and freezing was investigated for the preservation of papaya slices (Moyano *et al*., 2002). Two models have been developed by Mendoza and Schmalko (2002) to predict the contents of moisture and sugar during osmotic drying of papaya slices. The osmotic (60° brix, 60°C) and air-drying (60°C) methods were used for drying papaya slices.

Papaya Preserves

Papaya preserves are developed by washing, peeling, deseeding papaya and then cutting into pieces; the pieces are soaked for 1-2 days in solution containing sulfite and calcium chloride. The treated pieces are blanched in water (90ÚC), cooled, and then submerged in 30Ú Brix sucrose syrup. More sucrose is added to the syrup gradually until its concentration reaches 45Ú Brix. The syrup-infiltrated fruit are dipped into boiling water to wash off the sugar on their surface, taken out, and then dried in hot air oven, until the water activity drops to 0.75 or lower (Chen *et al.,* 2005).

Minimally Processed Products

Minimal processing is based on a combination of mild heat treatment (blanching), a_w reduction, pH reduction, and addition of potassium sorbate and sodium metabisulphite. This process is also known as the hurdle technology and has been used for the preservation of fruit slices. Papaya chunks treated with increasing levels of preservatives up to 680ppm of metabisulphite and 826ppm of sodium benzoate exhibited good storage stability up to 90 days at 2°C and ambient temperature (Vijayanand *et al*., 2001). O'Connor-Shaw *et al.,* (1994) studied the shelf life of minimally processed (peeled, deseeded, and diced) honeydew melon, kiwifruit, papaya, pineapple, and cantaloupe by storing the fruits at 4°C and comparing it with the fruits which were stored at more than 4°C. Minimal processing helped to store the fruits for longer duration, where as the control fruits stored at >4°C and without any processing technology showed greater rate of spoilage. Lopez-Malo *et al*., (1994) produced shelf-stable high-moisture minimally processed papaya slices. The moisture and soluble solids contents, pH, and a_w remained almost constant in treated papaya slices during storage. Minimally processed papaya slices had good acceptability even after 5 months of storage at 25°C. The use of vacuum osmotic dehydration (VOD) techniques for the production of high moisture minimally processed papaya has also been reported by Tapia *et al*., (1999). It was possible to obtain minimally processed papaya (a_w 0.98, pH 3.5) by applying (i) vacuum osmotic drying for just 10 min when sucrose syrup contained 7.5% citric acid, or (ii) by applying pulsed VOD treatment (vacuum pulses for less than 15 min followed by osmotic drying for less than 45 min) when the citric acid concentration in sugar syrup was 2.5% or 5%..

By-Products from Papaya

Papain

Papain is the major by-product from dried latex derived from papaya fruit, which contains a protein hydrolyzing enzyme. This enzyme has a number of specific technological applications such as in food, meat tenderization, beverages, and animal feeds; pharmaceutical industry; textile industry and detergents; paper and adhesives; medical applications; sewage and effluent treatment; and research and analytical chemistry (Flynn, 1975; Sanchez- Brambila *et al.,* 2002; Kaul *et al.,* 2002). Among the food applications, the use of papain in chill haze removal during beer clarification as well as in the tenderization of meat has shown a steady increase over the past years. There is also a belief in some countries of Asia that eating papaya by pregnant ladies results in abortion (Adebiyia *et al*., 2002). Based on rat feeding studies, the authors suggested that normal consumption of ripe papaya during pregnancy may not pose any significant risk but unripe or semi ripe papaya may be unsafe in pregnancy, as the high concentration of latex produces marked uterine contractions. Papaya cultivars differ in papain yield, Red Panama

(Lassoudiere, 1969a, b; Foyet, 1972), CO6 (Balmohan *et al*., 1992), CO2 (Wagh *et al*., 1992), and the line CP1512, CP1513, CP4 (Auxcilia and Sathiamoorthy, 1995), and CP5911 (Kanan and Muthuswamy, 1992) are shown to be high yielding. Other factors affecting the papain yield from papaya plants are fruit shape (Lassoudiere,1969a, b), stage of maturity (Singh and Tripathi, 1957; Bhalekar *et al*.,1992), season of tapping (Reddy and Kohli, 1992), tapping time of the day (Lassoudiere, 1969 a, b; Foyet, 1972), pattern of tapping (Madrigal *et al*., 1980), and frequency of tapping (Bhutani *et al*., 1963). Muthukrishnan and Irulappan (1985) have described the procedure for the collection of latex as well as crude papain manufacturing process using simple equipment. The yield of crude papain powder obtained from raw green papaya is reported to be usually around 0.025% (Nanjundaswamy and Mahadeviah, 1993).

Pectin

To make papaya cultivation and papain industry viable, the profitable use of promising fruit is essential. The green fruits, whether scarred or not, are rich source of pectin (10% pectin on dry basis), which can be extracted for use in food industry (Das *et al*., 1954; Varinesingh and Mohammed-Maraj, 1989). Peel is shown to be higher in pectin content than the papaya pulp, and pectin content increases at a higher rate with fruit maturity up to a stage (Paul *et al.,* 1998). The integrated processing of papaya fruits for the production of papain and pectin has been found to be economical (Nanjundaswamy and Mahadeviah, 1993). The process as described by the above authors reported that, it gave a papain yield of 0.25% and a pectin (jelly grade 200) yield of 1% on fresh fruit basis. The variety of the fruit, the growing conditions, and the stage of maturity of fruit are all known to influence the chemical composition of pectin (Lassoudiere, 1969a, b).

Medicinal Values, Traditional usage and Scientific Studies

Since ancient times, humans worldwide have used papaya to alleviate effects of ailments (Table 5). Thousands of plant species are used for medication in modern and traditional medicine systems and most of the world populations use them to cure acute and chronic health problems. Some of the work carried out on the scientific studies in human and animal models is compiled in Table 5 which shows that papaya is a promising fruit which helps to reduce many health disorders. The different parts of the plant such as latex is used as anthelmintic, relieves dyspepsia, cure diarrhoea, pain of burns and topical use, bleeding haemorrhoids, stomachic, whooping cough. Ripe fruits can be used as stomachic, digestive, carminative, diuretic, dysentery and chronic diarrhoea, expectorant, sedative and tonic relieves obesity, bleeding piles, wounds of the urinary tract, ringworm and skin disease psoriasis. Unripe fruits are used as diuretic, laxative, dried fruit reduces enlarged spleen and liver, used in snake bite to remove poison, abortificient and anti implantation activity, anti bacterial activity. Seeds can be used as carminative, emmenagogue, vermifuge, abortificient, counterirritant, as paste in ringworm disease, psoriasis, antifertility agent in males and seed juice helps in bleeding piles and in large liver and spleen. Root can be used as abortificient, diuretic, in checking irregular bleeding from uterus and anti fungal activity, piles. Young leaves used as vegetables in curing jaundice, urinary complains, urinary tract infection and gonorrhea, dressing wounds, anti bacterial activity, vermifuge in colic, fever, beriberi, abortion, asthma. Flowers have emmengogue, jaundice, febrifuge and pectoral properties. And stem bark has jaundice, antifungal activity and antihelmantic activity.

Table 5: Some of the salient works carried out by researchers on Papaya

Scientific study or activity	Part of the plant used	Report/findings	References
Anticancer activity	Papaya seed	Highly effective in inhibition of super oxide generation and inducing apoptosis in acute promyelocytic leukemia cell line HL-60 and the activity was mainly contributed by benzyl isothiocyanate	Nakamura *et al*., 2007.
	Papaya fruit extract	The benzyl isotiocyanate induced cytotoxic effect in proliferating human colon CCD-18Co cells to the quiscient state	Miyoshi *et al*., 2007
	Papaya flesh	The aqueous extract of papaya flesh treated with breast cancer cell line MCF7 revealed significant inhibition of cell proliferation	García *et al*., 2009
	Papaya leaves	Aqueous extract of papaya leaves shown to possess anticancer activity and inhibition of cell proliferation in a variety of cancer cell lines	Morimoto *et al*., 2006.
	Papaya leaves	The aqueous extract demonstrated antitumor activity and immunomodulatory activity in tumor cell lines and it proved upregulation of immunomodulatory genes by microarray studies	Otsuki *et al*., 2010
	Aerial part	Showed that petroleum extract has significant anticancer effect on MCF7 (breast) cancer cells. *C. papaya* could be a natural source of anticancer compounds with anti proliferative and/or apoptotic properties and as well, due to its anticancer pharmacological effect	Khaled *et al*., 2013

	Flesh	The effects of papaya flesh extracts on the viability of breast cancer cell line MCF-7 were examined concurrently with extracts from other fruits. In these studies, the authors also evaluated antioxidants such as β-carotene, polyphenols, and flavonoids in the fruits to focus on the contribution of these antioxidants in the inhibition of proliferation	Garcia *et al*., 2009; Jayakumar and *et al*., 2011
Anti-inflammatory activity	Papaya leaves	The C.papaya leaf extract was examined in rats using edema, granuloma and arthritis models. The extract showed significant reduction in paw edema, granuloma formation and reduced inflammation in rats and proved its anti-inflammatory activity	Owoyele *et al*., 2008
	Papaya fruit	Intake of papaya fruits in healthy individuals alleviated anti-inflammatory response mediated through regulatory T-cells (Tregs) .	Abdullah *et al*., 2011
Treatment for dengue fever	Leaves	Aqueous extract of C.papaya leaves administered to a patient affected with dengue fever twice daily for 5 consecutive days exhibited elevated platelet count from 55x10^{3}/µl to 168x10^{3}/µl.	Ahmad *et al*., 2011
	C.papaya extract	Evidenced to increase in platelet and RBC count without any acute toxicity after oral administration	Dharmarathna *et al.,* 2013
	Leaves	Supplementation of juice recorded significance increase of platelet count in randomized controlled trial conducted on patients with dengue fever and dengue hemorrhagic fever	Subenthiran et al., 2013
Antidiabetic activity	Leaves	The aqueous extract significantly reduced plasma blood glucose level and serum lipid profile in diabetic rats	Juárez *et al*., 2012; Maniyar and Bhixavatimath, 2012
	Leaves	The ethanolic extract demonstrated significant reduction in blood glucose level and regeneration of the beta cells of pancreas in diabetic mice	Sasidharan *et al.,* 2011
	Unripe papaya fruit	Aqueous extract significantly inhibited the key enzymes α-amylase and α-glucosidase involved in type 2 diabetes and also inhibited the lipid peroxidation in rat pancreatic cells studied in vitro	Oboh *et al.,* 2014
Wound healing activity	Fruits and seeds	Extracts were evaluated for wound healing activity using wound excision model. Diabetic rats showed significant reduction in the wound area compared to untreated diabetic control. It also showed increased granulation, elevated hydroxyproline content and deposition of collagen in the wound area	Nayak *et al.,* 2007; Nayak *et al.,* 2012
	Papaya latex	Used for treatment of burns demonstrated significant increase in hydroxyproline content as well as wound contraction in swiss albino mice	Gurung and Skalko-Basnet, 2009
	Fruit	Diabetic mice supplemented with fermented papaya preparation (FPP) showed effective recruitment of monocytes and proangiogenic response by the macrophages at the wound site resulting in wound closure	Collard and Roy, 2010
Antifertility effects	Seeds	Shown to have antifertility properties in male albino rats and reduced the cauda epidymal and testicular sperm counts	Lohiya and Goyal, 1992
	Seed	Male Wistar rats treated orally with papaya seed extract (200mg/kg) demonstrated hypertrophy of pituitary gonadotrophs and gradual degeneration of germ cells, sertoli cells and leydig cells of testis thereby drastically affecting the male reproductive functions	Udoh *et al*., 2005
	Seed	The aqueous extract administered to male Sprague-Dawley rats suppressed the steroidogenic enzymes in the testis and reversible changes occurred when the extract was withdrawn after 30-45 days of treatment	Uche-Nwachi *et al*., 2011
Antifungal activity	Latex	The latex of papaya and Fluconazole has synergistic action on the inhibition of *Candida albicans* growth and synergistic effect resulted in	Giordani *et al*., 1997
Antifungal activity	Latex	The latex of papaya and Fluconazole has synergistic action on the inhibition of *Candida albicans* growth and synergistic effect resulted in partial cell wall degradation.	Giordani *et al*., 1997
Antimalarial Activity	Rind of the raw papaya fruit	The petroleum ether extract exhibited significant antimalarial activity.	Bhat and Surolia., 2001
Anti-helmenthic activity	Latex	The latex of papaya has anthelmintic efficacy against *Heligmosomoides polygyrus* in experimentally infected mice, which suggests its potential role as an anthelmintic against potent intestinal nematodes of mammalian hosts	Satrija *et al*., 1995
Antimicrobial activity	Seed and pulp	Shown to be bacteriostatic against several enteropathogens such as *Bacillus subtilis, Enterobacter cloacae, Escherichia coli, Salmonella typhi, Staphylococcus aureus, Proteus vulgaris, Pseudomonas aeruginosa* and *Klebsiella pneumoniae* by the agar cup plate method	Osato *et al.,* 1993
	Ripe and	Purified extracts produces very significant antibacterial activity on *S.*	Emeruwa, 1982.

	unripe fruits	*aureus, Bacillus cereus, E. coli, P. aeruginosa* and *Shigella flexneri*	
Anti-amoebic activity	Seeds	The cold macerated aqueous extract of matured papaya seeds has shown anti-amoebic activity against *Entamoeba histolytica*	Tona *et al,* 1998
Immuno-modulatory activity	Fruit	Fermented papaya preparation exerts both immunomodulatory and antioxidant activity in the macrophage cell line RAW 264 and it is a macrophage activator, which augments nitric oxide synthesis and TNF-alpha secretion independently of lipopolysaccharides	Rimbach *et al*., 2000
	Fruit	The antioxidant cocktail derived from fermentation of unpolished rice, papaya and sea weeds with effective microorganisms of lactic acid bacteria, yeast and photosynthetic bacteria has shown inhibition of lipid peroxidation in vivo, a point dependent on the concentrations of bioactive flavonoids	Aruoma *et al*., 2002
Antisickling activity	Fruit	The extract was found to have the highest antisickling properties with 93% inhibitory and 84% reversal activities.	Oduala *et al*., 2006
Nephro-protective activity	Seeds	The aqueous seed extract of *Carica papaya* Linn. has been evaluated by carbon tetrachloride induced renal injury in wistar rats as a dose and time-dependent study. The study showed that *Carica papaya* Extract has nephroprotective effect on Carbon tetra chloride renal injured rats, an effect which could be mediated by any of the phytocomponents present in it via either antioxidant and / or free radical scavenging mechanism	Debnath *et al*., 2010

Summary

Carica papaya is considered as one of the important fruits because of its nutritional, medicinal and neutraceutical properties. Papaya is an excellent source of nutrients such as; carotenes, vitamin C, and flavonoids, the B vitamins including folate and panthothenic acid, minerals such as potassium and magnesium and dietary fiber and phytochemicals. Besides consumption as a fresh fruit, a number of processed products developed using papaya are used in the form of puree, jam, jelly, pickle, candied fruit, blended beverages, canned slices / chunks, concentrate, fermented juices, dried products, minimally processed products and by products on a commercial scale. The functional components of the papaya such as pectin content of the fruit aids in preparation of many processed products such as jams, jellies. Similarly nutritional components of papaya help in developing blended beverages, which has many health benefits. Papaya contains several unique protein-digesting enzymes including *papain* and *chymopapain*. These enzymes have been shown to help lower inflammation and to improve healing from burns. The enzyme papain is a digestive enzyme that helps in natural digestion. The biochemical constituents of the fruit related to health benefits such as reducing cholesterol and the provision for development of wide spectrum of processed products dictate the scientific merit of the fruit, with national and international strategies for the future. Varieties of papaya products developed by research with low sweetness has proved its importance in reducing the blood sugar levels and the phytochemical constituents of the fruit has shown its functional role as anti caner, anti inflammatory and anti microbial fruit. The bioavailability of carotenoids from papaya is higher than that of other fruits and vegetables which can help in reducing the incidence of vitamin A deficiencies.

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Role of Diet as a Mediator between Exercise and Pain- a Friend or a Foe?

Kumar Senthil P.*, Adhikari Prabha, Jeganathan***, RaoManisha******

Abstract

This short communication explores the intervening role of dietary supplementation on the inter-relationship between exercise and pain. There were two studies on caffeine, three studies on ginger, one study on fluid intake, one study on magnesium, and one study on herbal supplement ephedra. Existing evidence points out the apparently beneficial role of caffeine and oral magnesium supplements, inconsistent role of ginger, and potentially harmful role of herbal supplement ephedra and reconstituted fruit juices with high carbohydrate content on muscle performance and exercise-induced muscle pain.This article highlighted the role of dietary supplements in mediating the interaction between exercising and pain, which is important for clinicians ad researchers using nutritional and diet interventions as adjunct to exercise therapy for people with primary complaints of pain.

Keywords: Exercise Dietetics; Nutiritonal Physiology; Analgesic Diet; Nutritional Analgesia.

This short communication explores the intervening role of dietary supplementation on the inter-relationship between exercise and pain.

Caffeine

Astorinoet al[1]assessed the effect of caffeine on rating of perceived exertion (RPE) and pain perception in 10 active women who completed an 8.2km "all out" time trial on each of 3days separated by at least 48h.Following the initial phase, the participants randomly ingested anhydrous caffeine and glucose (each 6mg/kg bw+each 6mg/kg bw glucose) or placebo (each 6mg/kg bw of glucose) 1h pre-exercise. Despite not altering (P>0.05) RPE, HR, or leg pain, Caffeine improved cycling performance and power output, but not RPE, HOUR or leg pain.

Motl et al[2] examined the effect of ingesting a large dose of caffeine on perceptions of leg muscle pain during moderate intensity cycling exercise in 16 college-aged males who ingested either caffeine (10 mg x kg(-1) body weight) or placebo and 1 hour later completed 30 minutes of moderate intensity cycling exercise (60% VO(2peak)). Leg muscle pain ratings were found to be significantly and moderately reduced after a high dose of caffeine.

Ginger (Zingiberofficinale)

Black et al[3]examined the effects of 11 days of raw (study 1) and heat-treated (study 2) ginger supplementation on muscle painin 34 and 40 volunteers, respectively. Participants performed 18 eccentric actions of the elbow flexors to induce pain and inflammation. This study demonstrated that daily consumption of raw and heat-treated ginger resulted in moderate-to-large reductions in muscle pain following exercise-induced muscle injury.

Black and O'Connor[4] examined the acute effects of ginger on muscle pain, inflammation and dysfunction induced by eccentric exercise in 27 participants who performed 24 eccentric actions of the non-dominant elbow flexors. Participants who consumed ginger 24 h after exercise was reported to have reduced arm pain the following day and 48 h

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after exercise. The study concluded that ginger did not attenuate eccentric exercise-induced muscle pain, inflammation or dysfunction 45 min after ingestion, with minimal beneficial effect on the day-to-day progression of muscle pain.

Black and Oconnor[5] studied the effects of an oral dose of ginger on quadriceps muscle pain, rating of perceived exertion (RPE), and recovery of oxygen consumptionduring and after moderate-intensity cycling exercise in 25 college-age participants who ingested a 2-g dose of ginger or placebo in a double-blind, crossover design and 30 min later completed 30 min of cycling at 60% of VO2peak. Compared with placebo, ginger had no clinically meaningful or statistically significant effect on perceptions of muscle pain, RPE, work rate, HR, or VO2 during exercise.

Fluid Intake

Morton et al[6]investigated the effect of ingested fluid composition on the experience of exercise-related transient abdominal pain (ETAP) in 40 subjects, who completed 4 treadmill exercise trials: a no-fluid trial and flavored water (FW, no carbohydrate, osmolality = 48 mosmol / L, pH = 3.3), sports drink (SD, freshly mixed Gatorade, 6% total carbohydrate, 295 mosmol / L, pH = 3.3), and reconstituted fruit juice (FJ, BERRI trade mark orange, 10.4 % total carbohydrate, 489 mosmol / L, pH= 3.2) trials. The study results indicated that in order to avoid ETAP, susceptible individuals should refrain from consuming reconstituted fruit juices and beverages similarly high in carbohydrate content and osmolality, shortly before and during exercise.

Magnesium

Shechteret al[7] examined the impact of oral magnesium on clinical outcomes, such as exercise-induced chest pain, exercise tolerance, and quality of life in 187 patients with CAD who were randomized to receive either oral magnesium 15 mmol twice daily or placebo for 6 months. Magnesium treatment significantly increased exercise duration time and lessened exercise-induced chest pain, with improvements in Quality-of-life.

Herbal Supplement Ephedra

Stahl et al[8]reported a rare case of severe rhabdomyolysis provoked by ingestion of a performance-enhancer herbal supplement containing ephedrain a healthy 21-year-old Army soldier who complained of "complete muscle failure" after collapsing at the end of Army Physical Fitness Test.

There were two studies on caffeine, three studies on ginger, one study on fluid intake, one study on magnesium, and one study on herbal supplement ephedra. Existing evidence points out the apparently beneficial role of caffeine and oral magnesium supplements, inconsistent role of ginger, and potentially harmful role of herbal supplement ephedra and reconstituted fruit juices with high carbohydrate content on muscle performance and exercise-induced muscle pain. This article highlighted the role of dietary supplements in mediating the interaction between exercising and pain, which is important for clinicians ad researchers using nutritional and diet interventions as adjunct to exercise therapy for people with primary complaints of pain.

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