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Journal of Practical Biochemistry and Biophysics	Semiannual	7000	6500	547	508
Journal of Psychiatric Nursing	Triannual	5500	5000	430	391
Journal of Social Welfare and Management	Triannual	7500	7000	586	547
New Indian Journal of Surgery	Bi-monthly	8000	7500	625	586
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Fast Food Consumption Pattern and Risk of Development of Obesity among Young Individuals: A Population Based Study

Bindiya Satish[1], Damodara Gowda K.M.[2]

Abstract

Introduction: Overweight and obesity have also been reported to be associated with a variety of lifestyle factors, among which eating pattern and eating behaviour have long been identified as a factor. Pattern of consumption of fast foods and their perception of this practice as a risk factor for obesity among university undergraduates have not been fully explored. Hence, this study was designed to assess fast food consumption pattern and the perception of it as a risk factor for obesity among undergraduates. *Materials and Methods:* This is a questionnaire-based study, which contained 48 questions relating to the socio-demographic characteristics; knowledge about fastfoods and pattern of its consumption and eating behavior, was used for the survey. A total of 250 subjects who gave a history of fast food consumption for a minimum period of one year belong to the age group of 18 to 30 years were recruited. *Results:* The association between fast food consumption and the development of obesity was negatively correlated in undergraduate university students. The snack after dinner was also found to be negatively correlated (p=0.028) with the fast food consumption and the development of obesity. *Conclusion:* This study showed the level ofawareness of fast food consumption among the undergraduates and its riskfor developing obesity. Therefore, this study emphasizes the promotion of healthy dietary intake and food choices while highlighting the harmful effects of excessiveconsumption of fast foods.

Keywords: Fast Food Consumption; Obesity; University Undergraduates.

Introduction

Obesity is a major risk factor for chronic diseases, and it also plays a central role in both insulin resistance and metabolic syndrome, like hyper-insulinemia, hypertension, and type-II diabetes mellitus [1]. Overweight and obesity have also been reported to be associated with a variety of lifestyle factors [2,3], among which eating pattern and eating behaviour have long been identified as a factor.

Several studies have reported an association between eating speed and overweight [4], and eating until full, which refers to consuming a large quantity of foodin one meal [5], has been reported to be associated with overweight. Maruyama et al. reported that both eating quickly and eating until full are associated with overweight among adults, and the combination of the two may have a substantial effect on overweight [5].

Eating pattern includes increased consumption of energy dense, nutrient poor foods that are high in fat, sugar and salt. Adding on to it is the reduced physical activity of children and adolescents [6]. Often overall nutrient intake adequacy improves with an increasing variety of foods, but the movement towards more fats, salt, sugars and refined foods quickly moves beyond the optimal state to one in which diets contribute to rapidly exhalating rates of obesity and chronic diseases [7]. Studies have shown that rural dwellers diets are low in fat and sugar but high in carbohydrates and fibre [8], while their urban counterparts show high fat and low fibre and carbohydrate intake [9] which is typical of a western diet. Epidemiological data from developing and developed countries concluded that with the westernization of diet, many chronic diseases would emerge first as obesity [8, followed by diabetes and cardiovascular changes.

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The increase in these diseases has been associated with increased urbanization and lifestyle changes [9]. The dietary changes from traditional high fibre diets towards foreign fast food diets have contributed to the increase in the incidence of diet related non-communicable diseases. The concept of fast food eating has expanded into food sales in schools and colleges. For many students the day is not complete without observing the ''daily ritual'' of visiting a fastfood joint and most of the fast food restaurants have began to open centres within and very close to schools and especially university campuses [10].

Consumption of fast foods has gradually become a common lifestyle especially in urban areas andamong young people in spite of the associated adverse health consequences. University undergraduates pattern of consumption of fast foods and their perception of this practice as a risk factor for obesity have not been fully explored. Hence, this study was designed to assess fast foodconsumption pattern and the perception of it as a risk factor for obesity among undergraduates.

Materials and Methods

This cross sectional descriptive study conducted in 250 subjects who gave ahistory of fast food consumption for a minimum period of one year were included in the study. Subjects belonged to the student community of medical, dental and paramedical courses of Nitte (Deemed to be) University. This is aquestionnaire-based study, which contained 48 questions relating to the socio-demographic characteristics; knowledge about fast foods and pattern of its consumption and eating behavior, was used for the survey. The age group of the subjects was 18 to 30 years.

Statistical Analysis

Thedata were presented as counts and percentages if categorical or as means and standard deviations if continuous. Chi square test and Fischer's exact test was used to find the association between fast food consumption and the awareness of disease that will affect from consumption of fast food. A 'p' value of less than 0.05 was considered the level of significance.

Results

Our results provide some of the first evidence to show the relationship between eating behaviour, fast food consumption pattern and development of obesity among young undergraduate medical students. The Table 1 explains the demographic characteristics of the participants. The age of the participants of the present study ranged between 18-30 years (94% is below 20 years). Majority were males (55.6%). The birth weight of majority of the participants was between 2500g to 3500g. The parents of most of the participants (44.7%) were professionals without having obesity in any of the parents (Table 1).

Table 1: Demographic characteristics of the participants

Variables	Frequency	Percentage
Age (years)		
<20	142	94
20-25	7	4.6
26-30	2	1.3
Gender		
Male	84	55.6
Female	66	44.4
Birthweight (g)		
<2500	18	11.9
2500-2999	50	33.1
3000-3499	44	29.1
3500-3999	20	13.2
4000+	12	7.9
Parents Occupation		
Self Employed	39	25.8
Employed	40	26.5
Professional	67	44.4
Retired	2	1.3
Clergy	1	0.7
No Response	1	0.7
Parents Obesity		
None	106	70.2
Father Only	19	12.6
Mother Only	19	12.6
Father and Mother	7	4.6

1. Association between fast food consumption and the awareness of disease that will affect from consumption of fast food.

Chi square test and Fischer's exact test was used to find the association between fast food consumption and the awareness of disease that will affect from consumption of fast food. It showed that, the fast food consumption between 2PM and 6 PM and between 6PM and 10 PM was significantly high (p=0.031 respectively) though the pupil is aware of disease caused due to fast food consumption (Table 2). In the same way, the reasons for eating at fast food was significantly correlated (p=0.023) with the awareness of disease caused due to fast food consumption. The reasons may be advertisement or enjoyment or the taste or the lack of cooking skill, the limited time, the cost/price, the variety of menu or eating with friend/ family (Table 2).

Table 2: Association between fast food consumption and the awareness of disease that will affect from consumption of fast food

		Never	Certainly	Absolutely	Test statistic	P value
Skipping breakfast	yes	4	77	40	4.196 (chi square)	0.112
	no	3	14	13		
Snack after dinner	Seldom/none	3	72	46	4.699(Fischer's exact test)	0.69
	Always/often	3	19	7		
Eating speed	fast	1	22	12	4.171(Fischer's exact test)	0.353
	medium	3	58	33		
	slow	3	11	8		
Eating until full	yes	4	46	27	0.178(Fischer's exact test)	1.000
	no	3	45	26		
Number of times in a week you consume fast-food	0 times	1	11	4	7.125(Fischer's exact test)	0.246
	1-2 times	3	59	35		
	3-4 times	2	18	8		
	5 times or more	1	3	6		
When do u typically eat at fast-food	breakfast	0	1	2	6.466(Fischer's exact test)	0.353
	Lunch	2	13	6		
	dinner	1	47	27		
	snack	4	30	18		
What time of day do you eat fast food	Before 11AM	2	1	2	18.117(Fischer's exact test)	**0.031***
	Between 11AM and 2 PM	1	6	2		
	Between 2PM and 6 PM	1	35	17		
	Between 6PM and 10 PM	4	48	30		
	After 10 PM	1	1	2		
Reasons for eating at fast food	Advertisement	2	3	1	20.810(Fischer's exact test)	**0.023***
	Enjoy the taste	2	60	40		
	Lack of cooking skill	2	5	1		
	Limited time	1	5	3		
	Cost/price	0	1	1		
	Variety of menu	0	2	3		
	Eat with friend/family	0	15	4		
Taking fast food depends on emotional factors	Strongly agree	2	17	11	4.030(Fischer's exact test)	0.674
	agree	3	34	15		
	neutral	2	29	15		
	disagree	0	11	11		

2. Association between fast food consumption and the development of obesity.

Chi square test and Fischer's exact test was used to find the association between fast food consumption and the development of obesity. It showed that, the snack after dinner was found to be negatively correlated (p=0.028) with the fast food consumption and the development of obesity (Table 3).

Skipping breakfast, snack after dinner, eating speed, number of times in a week he/she consume fast-food, time of the day he/she eat fast-food, reasons for eating at fast-food, taking fast-food depends on emotional factors etc. did not show any correlation with the awareness of disease caused due to fast food consumption and the development of obesity.The preference of fast food to home meal and the probable causes for the fast food consumption was analysed and shown in the Table 4. This showed that the branding of the fast food, prices of the fast food, taste of the fast food is the main reason for preferring the fast food over homemade food.

The type of fast food consumption by the participants was described in the (Table 5). This showed that majority consume burgers than biriyani

Table 3: Association between fast food consumption and the development of obesity

		Yes	No	Test statistic	P value
Skipping breakfast	Yes	113	5	0.313(Chi square test)	0.433
	no	28	2		
Snack after dinner	Seldom/none	115	3	6.497(Chi square test)	0.028*
	Always/often	25	4		
Eating speed	fast	34	1	1.531(Fischer's exact test)	0.531
	Medium	88	4		
	slow	19	2		
Eating until full	yes	74	2	0.25(Fischer's exact test)	0.266
	no	67	5		
No. of times in a week u consume fastfood	0 times	16	0	5.259(Fischer's exact test)	0.108
	1-2 times	92	3		
	3-4 times	23	4		
	5 times or more	10	0		
When do u typically eat at fast food restaurants	breakfast	2	1	6.250(Fischer's exact test)	0.078
	lunch	18	2		
	dinner	71	2		
	snack	50	2		
What time of the day u eat fastfood	Before 11AM	3	1	7.394(Fischer's exact test)	0.242
	Btwn 11AM and 2PM	8	0		
	Btwn 2PM and 6PM	48	4		
	Btwn 6PM and 10PM	78	2		
	After 10PM	2	0		
Reasons for eating at fastfood	Advertisement	6	0	7.189(Fischer's exact test)	0.250
	Enjoy the taste	96	4		
	Lack of cooking skill	7	1		
	Limited time	8	1		
	Cost/price	2	0		
	Variety of menu	4	1		
	Eat with friend /family	18	0		
Taking fastfood depends on emotional factors	Strongly agree	29	1	1.710(Fischer's exact test)	0.669
	agree	47	4		
	neutral	42	2		
	disagree	22	0		

Table 4: Details of the causes for fast food consumption

	Frequency	Percentage
Preference of fast food to home meal		
Yes	65	43.0
No	86	57.0
Reasons for preference of fast food to home meal		
Readily available without stress	40	26.5
More delicious and nutritious	41	27.2
Weight control	8	5.3
No response	59	39.1
Does branding affect the chosen fast food		
Strongly Agree	36	23.8
Agree	68	45.0
Neutral	46	30.5
Disagree	1	0.7
Strongly Disagree		
Fast food prices are influencing the chosen fast food		
Strongly Agree	20	13.2
Agree	63	41.7
Neutral	56	37.1
Disagree	9	6.0
Strongly Disagree	2	1.3
Reasons for choosing to eat at fast food		
Advertisement	6	4
Enjoy the taste	102	67.5
Lack of cooking skill	8	5.3
Limited time	9	6
Cost/Price	2	1.3

Cost/Price	2	1.3
Variety of menu	5	3.3
Eat with friend/ family	19	12.6
Ice cream	1	0.7
KFC	1	0.7
McDonalds	6	4.0

Table 5: Analysis of the type of food consumption by the participants

	Frequency	Percentage
What do you usually eat at fast food restaurant		
Burger	45	29.8
Fries	17	11.3
Pizza	27	17.9
Fried Chicken	24	15.9
Sandwich	16	10.6
Icecream	18	11.9
Others	3	2.0
Chiken Biryani	1	0.7
What beverage do you usually order with fast food meal		
No Drink	11	7.3
Mineral Water	21	13.9
Carbonated Drink	43	28.5
Carbonated Diet Soda	8	5.3
Fruity Juice	33	21.9
Milk And Shake	28	18.5
Lemonade	4	2.6
Tea/Coffee	2	1.3
Others	1	0.7

Table 6: Details of the time of fast food consumption by the participants

	Frequency	Percentage
Number of times a week you can consume fast food		
0 times	16	10.6
1-2 times	97	64.2
3-4 times	28	18.5
5 times or more	10	6.6
What do you typically eat at fast food restaurant		
breakfast	3	2
lunch	21	13.9
dinner	75	49.7
snack	52	34.4
What time of day do you eat fast food		
Before 11am	4	2.6
Before 11am and 2pm	8	5.3
Between 2pm and 6pm	53	35.1
Between 6pm and 10pm	82	54.3
After 10pm	2	1.3

and others along with the carbonated drinks. The time of fast food consumption by the participants was detailed in the Table 6. This indicated that majority of the participants consume fast food 1-2 times in a week preferably dinner in the fast food restraint between 6PM to 10PM.The awareness of the consequences of fast food consumption on the development of various disorders was explained in the Table 7. It showed that the 38.4% of the participants knows about the nutritional information and ingredient content in each of fast food, 40.4% of the participants knows about the high salt content, 41.7% about the cholesterol and sugar content, 78.1% knows about the development of heart diseases and 93.4% of the participants had the knowledge of development of obesity on consumption of fast food.

Table 7: Awareness of the consequences of fast food consumption

	Frequency	Percentage
Awareness about nutritional information and ingredient content in each of fast food		
Not at all	10	6.6
Rarely	41	27.2
Sometimes	58	38.4
Most of the time	32	21.2
Always	10	6.6
Respondents knowledge of the contents of fast food consumed		
High salt content	61	40.4
High sugar content	14	9.3
Saturated fats	21	13.9
High cholesterol	43	28.5
Additives	5	3.3
Low fiber content	6	4.0
Are you aware of disease that will affect from consumption of fast food		
Never	7	4.6
Certainly	91	60.3
Absolutely	53	35.1
Respondents perception of how fast foods can lead to non-communicable diseases		
Fast food contain cholesterol, sugar, salts, fats	63	41.7
Fastfoods are not cooked under healthy condition	34	22.5
Excessive consumption of fast food	24	15.9
Intake of chemicals	25	16,6
Increases the risk of developing NCDs	1	0.7
Long preservation	2	1.3
Which of the following are effects of taking fast food frequently		
Heart Disease	118	78.1
Dyslipidemia	4	2.6
Pcod	4	2.6
Sleep Apnea	11	7.3
Arthritis	4	2.6
Liver Damage	6	4
Stroke	1	0.7
Do you know taking fast food frequently can cause obesity		
Yes	141	93.4
No	7	4.6

Discussion

The current cross sectional survey attempted to investigate the relationship between eating behaviour, fast food consumption pattern and development of obesity among young individuals.

Findings of the study showed that, fast food consumption between 2PM and 6 PM and between 6PM and 10 PM was significantly high and the participants were aware of disease caused due to fast food consumption. In the same way, the reasons for eating at fast food was significantly correlated (p=0.023) with the awareness of disease caused due to fast food consumption. It was also showed that, the reasons such as advertisement or enjoyment or the taste or the lack of cooking skill, the limited time, the cost/price, the variety of menu or eating with friend/family were the significant factors for the consumption of fast food. In the past few decades, fast food (food prepared in a restaurant with limited service staff and from which the majority of meals are consumed off premises) has been implicated as one of the contributors to increased population rates of obesity [11-14]. The growth of the fast-food industry has led to an increased consumption of food prepared away from home that is high in total and saturated fat, as well as sodium, but low in dietary fibre, calcium, and iron [15].

In recent years, there has been a marked increase in the rates of obesity in countries such as India that has been attributed to unhealthy lifestyle practices associated with the introduction of Western-style fast foods that are higher in fat and refined carbohydrates [16, 17].

In a study on National Prevalence of Obesity: Changing patterns of diet, physical activity and obesity among urban, rural and slum populations in north India by Yadav and Krishanan, reported that the prevalence of central obesity in North India increased with the level of urbanization in both men and women by 8.7% and 34.5%, respectively [18]. Result of our study is not in accordance with the reports of above stated study. This indicates the development of obesity is not directly linked to fast food consumption. The genetics of parents play a major role because; both the parents of majority of the participants were not obese. This is in accordance with a population-based study from 4 distinct regions in Europe conducted by Ulf Ekelund et.al. On the association between obesity, physical activity and indicators of body fatness in 9 to 10year old European children reported that the rising prevalence of obesity in children may be due to a reduction in physical activity [19]. Our results are in line with the he Chandigarh Healthy Heart Action Project (CHHAP), which reported that more people aged 15–24 years old living in an urban area (72%) preferred Western-style fast food [20].

Conclusion

This study showed the level ofawareness of fast food consumptionamong the undergraduates and its riskfor developing obesity. Therefore, this study emphasizes the promotion ofhealthy dietary intake and food choices whilehighlighting the harmful effects of excessiveconsumption of fast foods.

References

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Nutritional Composition and Functional Properties of KMR 204 and ML 365 Varieties of Finger Millet Fractions

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Abstract

Finger millet also known, as *'ragi'* is popular millet consumed in India without dehulling. It occupies the largest area under Indian cultivation among the small millets and ranks sixth in production after wheat, rice, maize, sorghum and bajra. Millets are easy to digest as they are non-glutinous, non-acid forming and nutritious. Millets are good sources of energy, protein, minerals, vitamins, dietary fibre, fatty acids and polyphenols. The aim of the study was to find the nutritional composition and functional properties of two different varieties i.e., KMR-204 and ML-365 of finger millet fractions such as Coarse flour (CF), Medium flour (MF), Fine flour (FF) and Very fine flour (VFF). The water absorption capacity (WAC) was higher in flour with wide variation in MF and CF (1.70 – 1.79%) than VFF and FF fractions (1.38-1.55%). Higher value of WAC in MF and CF could be due to the presence of higher dietary fiber content which has the ability to hold more water. VFF and FF fractions showed higher foaming capacity than medium and coarse fractions. The protein content of MF (11.2%) and CF (11.9%) fraction was comparatively higher and nearly two times higher than first (6.4%) and second (5.7%) fraction in KMR-204. Soluble dietary fiber was higher in FF and CF and lower in VFF and MF. The content of phytic acid ranged between 5.21 – 7.11mg/100g and 2.99-6.60mg/100g in KMR-204 and ML-365 respectively, which was very low. It was inferred that medium and coarse fraction of finger millet was particularly rich in nutrients and dietary fiber.

Keywords: Nutrients; Anti-Nutrients; Water Absorption; Fat Absorption; Foaming Capacity.

Introduction

Cereal grains are the most important source of the world's food and have a significant role in the human diet throughout the world. As one of the most important drought-resistant crops, millet is widely grown in the semiarid tropics of Africa and Asia and constitutes a major source of carbohydrates and proteins for people living in these areas. In addition, because of their important contribution to national food security and potential health benefits, millet grain is now receiving increasing interest from food scientists, technologists, and nutritionists. Millet's resistance to drought is perhaps the reason for its popularity in ancient times. The four major types of millet are Pearl millet (*Pennisetum glaucum*), Foxtail millet (*Setaria italica*) Proso millet (*Panicum miliaceum*), and Finger Millet (*Eleusine coracana*) [1].

Finger millet also known, as *'ragi'* (*Eleucine coracana*) is popular millet consumed in India without dehulling. This food grain is chiefly consumed by rural population belonging to low-income groups particularly in the Southern region. It became staple food for humans 10,000 years ago before the rise of wheat and rice [2]. These grains are also beneficial for those suffering from metabolic disorders like diabetes and obesity [3]. In India, finger millet occupies the largest area under cultivation among the small millets and ranks sixth in production after wheat, rice, maize, sorghum and bajra. It is generally used in the form of the whole meal for preparation of traditional foods, such as *roti* (unleavened breads or pancake), *mudde* (dumpling) and *ambali* (thin porridge). The tiny millet grain has a dark brick red-coloured or brown seed coat, richer in polyphenols

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compared to other continental cereals such as barley, rice, maize and wheat. It is rich in calcium (0.34%), dietary fiber (18%), phytates (0.48%), protein (6%–13%) minerals (2.5 - 3.5%), and phenolics (0.3 - 3%) [4]. Moreover, it is also a rich source of thiamine, riboflavin, iron, methionine, isoleucine, leucine, phenylalanine and other essential amino acids. The abundance source of phytochemicals enhances the nutraceutical potential of finger millet, making it a power house of health benefiting anti nutrients. It has distinguished health beneficial properties, such as anti-diabetic, anti-diarrheal, antiulcer, anti-inflammatory, antitumerogenic, antiatherosclerogeni effects, antimicrobial and antioxidant properties [5]. Thus daily consumption of whole grain of finger millet and its products can protect against the risk of cardiovascular diseases, type II diabetes, and gastrointestinal cancers and other health issues [6].

Finger millet has good malting characteristics and serves as popular malt drink and weaning food for infants. The malt flour is a good source of amylases and is hence termed as ‘Amylase-rich food’. Malt flour is a substitute to maltodextrin and can be blended with milk and spray dried to prepare infant food. During germination, the amylases partially hydrolyze the starch to lower molecular weight carbohydrates such as oligo and disaccharides, and thus the malt flour has reduced water holding capacity and thus high energy density. Due to this, the refined finger millet malt flour has scope for utilization in infant foods, weaning foods and enteral foods [7].

World wide, utilization of whole grain cereals in food formulations is increasing, since they are rich sources of phytochemicals and dietary fiber which offer several health benefits [8]. There is an immense potential to process millet grains into value-added foods and beverages, further more millets, as they do not contain gluten are advisable for celiac patients [9].

In current study an attempt has been made to extract different fractions from two different cultivars varieties of finger millet and analyze its functional properties and nutritional composition using standard techniques.

Materials and Methods

Grain material

Two different popular cultivated varieties of finger millet seeds i.e., KMR-204 and ML-365 were procured from Zonal Research Station,Vishweshwaraiah Canal (VC) Farm, Mandya, Karnataka, India. The grains were sorted and cleaned to remove foreign particulate matter and dust before further processing.

Fractional separation of finger millet flour

The finger millet grains were milled into flour, (Domestic flour mill, Delux semiautomatic) later the flour was sieved through sieve no. 200 with 75 micron mesh opening wherein very fine flour (VFF)was separated followed by sieving through sieve no. 100 with 150 micron mesh opening in which fine flour (FF) got separated and at last the remaining flour were passed through sieve no. 80 having 180 micron opening, thus extracting the medium portion of the flour (MF). The residual flour was labeled as coarse fractions (CF).

Functional properties

The fractionated finger millet flourswere analyzed for functional properties using following methods. Water absorption capacity (WAC) of the flour fractions were determined following the procedure and reported as the ‘g’ of water absorbed/100g of flour [10]. The water solubility index (WSI) was measured according to the standard method and calculated from the weight ratio of dissolved solids in the supernatant and dry sample [11]. Oil absorption capacity (OAC) of the flours fractions were determined and reported as the ‘g’ of oil absorbed/100g of flour. [12]. Foam capacity (FC) and foam stability (FS) were determined and the volume of the foam was recorded as foam capacity and monitored at regular intervals for 15 - 30 min to evaluate foam stability [13].

Proximate analysis

Different milled fractions of finger millet flour samples were analyzed for moisture by oven drying method, fat content by Soxhlet method, total ash content was determined by using muffle, nitrogen by Kjeldahl method and converted into protein by using Nx6.25 (AOAC, 2002) [14]. Dietary fibre was estimated by the enzymatic–gravimetric method [15].

Data analysis

Each experiment was performed, at least in duplicate or triplicate, and the results were expressed as the mean values± standard deviation using the Microsoft excel program. Multiple comparisons were made for all experiments employing Duncan’s multiple range test (DMRT) at the 5% level of significance. All statistical analyses were performed using statistical software Statistica' 99 (Stat Soft, Tulsa, OK, USA).

Result and Discussion

Finger millet is mainly used in the form of flour for development of product because the grain is decorticated due to its higher floury endosperm. This flour is widely used in South Indian cuisine to prepare the conventional foods, namely, unleavened pancakes (*roti*), stiff porridge or dumpling (*mudde*) and thin porridge (*ambali*) [16].

Yield of flour fractions

The yield of finger millet flour fraction is represented in Table 1 showed that FF had highest flour yield (36 - 38%) in both the grain variety. This could possibly explain the higher content of endosperm in finger millet flour than other components. The seed coat fractions accounted for about 20% of the total flour and similar were the CF. Colour difference in flour fraction was also observed wherein the CF was the darkest and VFF was lighter in colour.

Table 1: Yield of finger millet flour fractions (%)

Fraction	Flour Fractions	Mesh size (mµ)	KMR-204	ML 365
1st	Very fine flour (VFF)	75	20	23
2nd	Fine flour (FF)	150	38	36
3rd	Medium Flour (MF)	180	23	19
4th	Coarse flour (CF)	Remaining flour	19	22

Table 2: Functional properties of finger millet flour fractions

Flour	Water absorption capacity (%)	Water solubility index (mg/g)	Oil absorption capacity (%)	Foam capacity (%)
KMR-204				
VFF	$1.38^{cd} \pm 0.02$	$38^{bc} \pm 0.02$	$0.72^{c} \pm 0.003$	$12.9^{a} \pm 0.3$
FF	$1.45^{c} \pm 0.01$	$21^{d} \pm 0.08$	$0.64^{d} \pm 0.005$	$11.0^{b} \pm 0.7$
MF	$1.79^{a} \pm 0.03$	$45^{a} \pm 0.03$	$0.79^{ab} \pm 0.002$	$5.3^{d} \pm 0.4$
CF	$1.61^{b} \pm 0.06$	$41^{b} \pm 0.07$	$0.82^{a} \pm 0.003$	$10.1^{c} \pm 0.9$
ML-365				
VFF	$1.49^{d} \pm 0.08$	$36^{bc} \pm 0.05$	$0.81^{bc} \pm 0.002$	$17.9^{a} \pm 0.7$
FF	$1.55^{c} \pm 0.03$	$24^{d} \pm 0.02$	$0.76^{d} \pm 0.005$	$13.5^{b} \pm 0.4$
MF	$1.70^{a} \pm 0.06$	$44^{a} \pm 0.03$	$0.94^{a} \pm 0.010$	$9.1^{d} \pm 0.7$
CF	$1.68^{ab} \pm 0.02$	$37^{b} \pm 0.02$	$0.82^{b} \pm 0.009$	$10.9^{c} \pm 0.6$

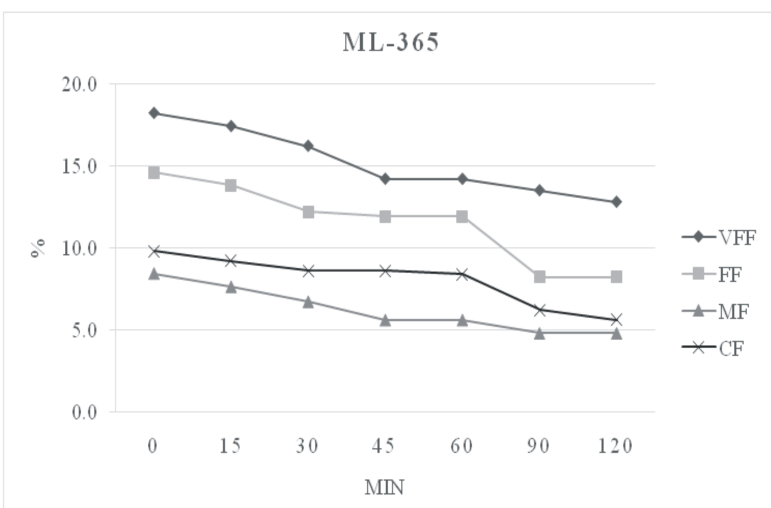

Fig. 1: Foam Stability of KMR-204 finger millet flour fractions

Functional properties

The functional properties of two finger millet cultivars flour fraction is represented in Table 2. The WAC was comparatively higher with wide variation in MF and CF (1.70–1.79%) than VFF and FF fractions (1.38-1.55%). Higher value of WAC in medium and coarse flour could be due to the presence of higher dietary fibre content which has the ability to hold more water. VFF, MF and CF exhibited 38 - 45 mg/g WSI, respectively, whereas FF flour fraction showed lower water solubility index (24 mg/g). The WAC and WSI values were almost nearing in both the finger millet varieties and no significant difference in WAC was observed in VFF and FF of KMR-204 and MF and CF of MR-365. Oil binding capacity of flour is an index to express the capacity to absorb and retain oil, which in turn influences their behaviour in food products. This serves as an important parameter for flours intended for the development of baked and aqueous foods where the ability to hydrate and the presence of shortening are desirable. The WAC is important for flours intended for use in viscous foods as soups, gravies, dough and baked products, while OAC decides the texture and mouth feel of the flour, and is desirable in extenders in meats and baked foods [17].

OAC values of fraction flours ranged between 0.64 – 0.94% showing significant difference among the flour fractions except in case of CF, which was similar when compared with MF of KMR-204 and VFF of MR-365 variety. The foaming capacity of each flour fraction was significantly different which could possibly be because of the different composition of each flour.

VFF and FF milled fractions show higher foaming capacity than that of medium and coarse fractions. Similarly, higher foam stability (Figure 1 and 2) was observed in VFF and FF flours compared to flours of other fractions. ML-365 variety foams showed slightly higher stability than KMR-204 variety. Foam formation and stability generally depend on the interfacial film formed by proteins, which keeps the air bubbles in suspension and slows down the rate of coalescence. Stable foams are known to occur when low surface tension and high viscosity occur at the interface, forming a continuous cohesive film around the air vacuoles in the foam. Foaming properties are dependent on the proteins, as well as on other components, such as carbohydrates present in the flour. FC values for these millet flours were lower than the values reported for legume flours [18]. Therefore,

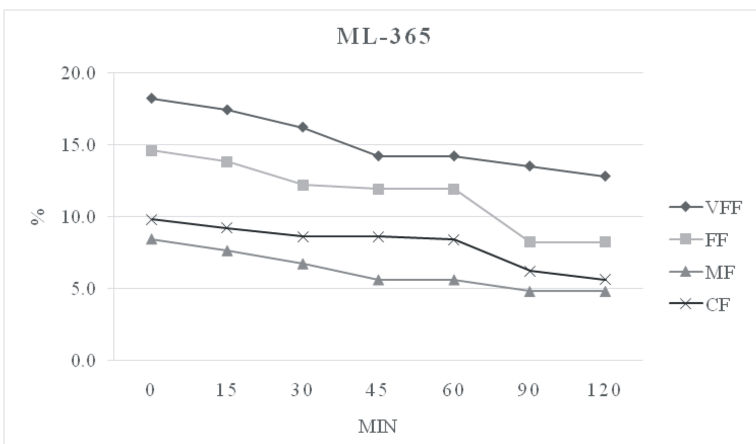

Fig. 2: Foam Stability of ML-365 finger millet flour fractions

Table 3: Proximate composition of finger millet flour fractions (g/100g)

Flour	Moisture	Protein	Fat	Mineral	CHO*
KMR-204					
VFF	11.45 ± 0.08	6.4^{c} ± 0.01(7.2)	1.54^{b}± 0.06(1.7)	2.14^{c} ± 0.06(2.41)	69(77.92)
FF	11.96 ± 0.10	5.7^{d}± 0.03(6.4)	1.01^{d}± 0.01(1.14)	1.57^{d} ± 0.02(1.78)	70(79.5)
MF	11.13 ± 0.06	11.2^{b}± 0.08(12.60)	1.27^{c} ± 0.08(1.42)	3.09^{b} ± 0.04(3.47)	42(47.26)
CF	11.02 ± 0.01	11.9^{a}± 0.05(13.37)	1.56^{a} ± 0.03(1.75)	3.12^{a} ± 0.05(3.5)	44(49.44)
ML-365					
VFF	10.89 ± 0.03	5.9^{c} ± 0.03(6.62)	1.37^{bc} ± 0.01(1.53)	1.95^{c} ± 0.01(2.188)	71(79.67)
FF	10.16 ± 0.10	5.1^{d} ± 0.02(5.67)	0.92^{d} ± 0.02(1.02)	1.65^{d} ± 0.01(1.83)	73(81.25)
MF	10.56 ± 0.04	8.9^{b}± 0.02(9.95)	1.39^{b} ± 0.02(1.55)	3.27^{b} ± 0.02(3.65)	45(50.31)
CF	9.95 ± 0.07	10.9^{a} ± 0.02(12.10)	1.53^{a} ± 0.02(1.69)	3.83^{a} ± 0.05(4.25)	46(51.08)

* CHO – Carbohydrate calculated by difference

millet flours may have potential to be used as an ingredient in composite flour constituents in the formulation of bakery and confectionery products.

Nutritional composition

The major nutrient composition (protein, mineral and fat) of finger millet flours fractions are presented in Table 3. Nutritionally, finger millet serves as good source of nutrients such as carbohydrate, protein, dietary fibre and minerals, and is an important staple food for people under low socio- economic group [19] and also for other group of people, specially for those who are suffering from various metabolic disorders like diabetes and obesity [20]. Looking into the nutrient composition of the analyzed varieties of finger millet flour and their different flour fractions, the moisture content ranged from 9 -11%. The protein content of medium flour (11.2%) and coarse flour (11.9%) fraction was comparatively higher and nearly twice greater than first (6.4%) and second (5.7%) fraction in KMR-204. Similar pattern was observed in case of ML-365 and the content of protein was slightly lesser than its counterpart. The fat content in KMR-301 and ML-365 varieties of finger millet ranged from 0.92 – 1.56%.

Finger millet carbohydrates (72%) comprises of starch as the main constituent and the non-starchy polysaccharides (NSP) which accounts to 15–20% of the seed matter as unavailable carbohydrates [21]. The difference in carbohydrate content was seen in the milled fractions of finger millet flour wherein VFF and FF reported 79-82% and relatively lesser in medium and coarse flour fractions (42-46%). On the counterpart, the total mineral content was higher in medium and coarse flour fractions, which was nearly double the amount present in VFF and FF. Overall, slight variation in nutrient composition was observed among the finger millet varieties and it is also marked that the nutrient content among the analyzed flour fraction was highly significantly different. Results indicate that the MF and CF were high in protein and mineral content which upon incorporating in some product will improve its nutritional content.

Dietary fibre content and antinutrient content of finger millet flour fractions

The dietary fibre and mineral content of finger millet flour fraction is markedly higher than other cereal grains, with fairly well balanced protein [22]. The high fibre content in millet has been shown to exert hypoglycemic effect. The complex carbohydrates along with the fiber are slowly digested and absorbed thus bringing reduction in postprandial glucose [23].

Table 4: Dietary fibre and antinutrient content of finger millet flour fractions (per 100g)

Flour	Insoluble dietary fibre (g)	Soluble dietary fibre (g)	Total Dietary fibre (g)	Phytic acid (mg)
KMR-204				
VFF	$9.2^{cd} \pm 0.2$(10.38)	$0.3^{d} \pm 0.1$(0.33)	$9.5^{cd} \pm 0.2$(10.72)	$7.09^{a} \pm 0.09$(8.0)
FF	$8.9^{d} \pm 0.6$(10.10)	$0.6^{b} \pm 0.1$(0.68)	$9.5^{c} \pm 0.6$(10.79)	$5.12^{d} \pm 0.04$(5.81)
MF	$30.2^{a} \pm 0.4$(33.98)	$0.2^{cd} \pm 0.1$(0.22)	$30.4^{a} \pm 0.1$(10.12)	$7.01^{ac} \pm 0.06$(3.13)
CF	$27.3^{b} \pm 0.3$(30.68)	$0.8^{ab} \pm 0.1$(0.89)	$28.1^{b} \pm 0.2$(31.58)	$7.08^{abc} \pm 0.08$(7.95)
ML-365				
VFF	$8.3^{c} \pm 0.1$(9.31)	$0.3^{c} \pm 0.1$(0.33)	$8.6^{cd} \pm 0.2$(9.65)	$6.28^{a} \pm 0.07$(7.04)
FF	$8.9^{cd} \pm 0.4$(9.90)	$0.2^{d} \pm 0.1$(0.22)	$9.1^{c} \pm 0.1$(10.12)	$2.82^{d} \pm 0.03$(3.13)
MF	$30.0^{a} \pm 0.3$(33.54)	$0.3^{bc} \pm 0.1$(0.33)	$30.3^{a} \pm 0.3$(33.87)	$5.32^{c} \pm 0.07$(5.94)
CF	$25.9^{b} \pm 0.5$(28.76)	$0.7^{a} \pm 0.1$(0.77)	$26.6^{b} \pm 0.2$(29.53)	$6.56^{b} \pm 0.02$(7.28)

Figures in parenthesis represent values in dry weight basis. The superscript differing from each other are significantly different

Fractional separation of finger millet flour resulted in a significant impact on the dietary fibre content; the medium flours contained the highest amount of the total dietary fibre (TDF) because the VFF and FF got separated concentrating the fibre part. In addition, insoluble dietary fibre (IDF), which comprises of lignin, cellulose and hemicelluloses, was also high in medium fraction of flour followed by coarse flours. Soluble dietary fibre (SDF) was higher in FF and coarse flours and lower in VFF and medium flours (Table 4). The interaction between the milled fraction and variety did not show any significant difference. Dietary fibre intake has a beneficial role in the prevention of diseases including cardiovascular disease, diabetes, cancer and weight regulation [24]. Keeping in mind that soluble fibre has the potential to reduce total cholesterol concentration, mainly by lowering LDL cholesterol [25], fractions of millet grain flours should be of interest when designing products for dietary treatment of cardiovascular disorders. The phytic acid content was comparatively lower in FF than remaining flour fractions. Many studies have reported the phytic acid content to be present in higher amount in medium fraction, which upon removal by dehulling would reduce the phytic acid content [26]. The content of phytic acid ranged between 5.21 – 7.11mg/100g and 2.99 – 6.60mg/100g in KMR-204 and ML-365 respectively.

Conclusion

Fractional milling of finger millets results in variations in the content of nutrients and antinutrients in both the variety of grain flours since they are unevenly distributed in the grain. Milling of millets to obtain different fractions may have several advantages. It may lead to the concentration of some interesting components in certain milling fractions (proteins, soluble dietary fibre, phytic acid, and polyphenols) which have distinct flour functionalities. These favourable nutritional and functional properties of flours could be exploited for the development of desired end-use food products. The gluten-free flours from these underutilized millet grains and their milled fractions may also be very attractive for producing composite flours as partial substitutes of wheat in bakery products, snacks, confectionery and other traditional food products.

Increased nutritional awareness challenges the food industries in developing new food products with special health-enhancing characteristics. The dietary fiber and polyphenols in finger millet are known to offer several health benefits such as antidiabetic, antioxidant, hypocholesterolaemic, antimicrobial effects and protection from diet related chronic diseases to its regular consumers. The non-starchy polysaccharides of the millet form bulk of its dietary fiber constituents and offer several health benefits including delayed nutrient absorption, increased faecal bulk and lowering of blood lipids. Regular consumption of finger millet as a food or even as snacks helps in managing diabetes and its complications by regulation of glucose homeostasis and prevention of dyslipideamia. Thus finger millet can be used as a therapeutic and health building food.

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Natural Antioxidants in Bakery Products

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Abstract

Most processed foods contain different ingredients that can easily undergo oxidation. While all compounds possess the ability to undergo oxidation, fats present in these foods in general have the greatest tendency to lose electrons. Auto-oxidation of lipids in food triggered by exposure to light, heat, ionizing radiation, metal ions or metallo-protein catalysts can have a deteriorating effect on the food color, flavor, texture, quality, wholesomeness and safety. However, both natural and synthetic antioxidants have long served as preservatives, used to prevent oxidation reactions, which lead to browning, and rancidity in foods. Major sources of naturally occurring antioxidants are fruits, vegetables and whole grains, spices etc. The beneficial properties of these natural antioxidants have been used in different bakery products. Baked products have popularities in the populace because of their availability, ready to eat convenience and having good shelf life. The purpose of this review is to explore the natural antioxidants, their action mechanism and the potentialities of being used in bakery industry.

Keywords: Bakery Products; Antioxidants; Natural Antioxidants; Food Sources.

Introduction

Bakery industry in India is considered as one of the major food processing industry with an annual demand of over 2758 MT [1]. The Indian bakery industry is passing through an impressive growth phase where it is trying to cater to health and wellness demands of its consumers. Among the bakery products, the most consumed is bread, followed by cakes and biscuits which are also greatly appreciated. India is known to be the second largest manufacturer of biscuits. A variety of products have entered the Indian bakery industry during the last two decades, which have contributed to the change in consumer tastes. Today urban middle and upper class Indians' tastes for bakery products are not restricted merely to bread, biscuit and cake but also to other products including burger, pizza, muffin, doughnut, etc. They are the most popular food consumed by all age groups and are gaining popularity as processed foods because of their availability, ready to eat convenience, and comparatively good shelf life [2]. The search for quality makes this sector a very competitive niche market. Responding to this positive demand, bakery industry has seen a revolution, over the past few decades. The small artisan bakeries have made way for high technologically upgraded bakery industry. As in other global markets, industrial mono-production took over from high variety bakeries to specialized bakeries in India too. Productivity became the key of success. Newer baking technologies were developed to respond better to new market requirements [3]. New materials and ingredients were introduced in products composition while research generated a constant and impressive progress. Continuous improvement in baking technology has immensely contributed in creation of better quality product, development of nutritionally superior product and economic consideration.

However, bakery products, like many processed foods, are subjected to physical, chemical and microbiological changes. Shelf-life is a major consideration in developing, producing and marketing food products. It refers to the time during

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which a product remains acceptable to a consumer in terms of sensory characteristics. There are many factors influencing shelf-life of a product viz., moisture loss, spoilage due to micro organisms, enzymatic changes and oxidation [4]. Processed foods contain fats and oils which oxidize slowly during storage. In general, baked goods have a short shelf-life, but for products such as biscuits, this can be extended from a few days to several weeks, or months, if packaged correctly. Many biscuits are characterized by their crispness and as a result need low moisture content. In addition, products that contain fat should be protected from light, air, and heat to prevent development of 'off' flavours due to rancidity. Fat, being an integral ingredient of bakery products, is susceptible to oxidation leading to the development of rancidity and off-flavour. However antioxidants have been found to enhance shelf life of baked foods [5]. It helps prevent the oxidative deterioration of fats and oils in foods [6]. Since ancient times it has been in practice to use antioxidants in baked foods. The form of antioxidant (powder or solution), method and time of incorporation are particularly important for the dispersion of antioxidant and ultimately stabilization of the product.

Owing to their wide range of availability, a huge number of compounds have been proposed to possess antioxidant activity. However of this diverse collection, only a few can be used in food products. The use of antioxidants in food products is controlled by regulatory laws of a country or international standards [7]. According to FSSAI regulations plant based antioxidants like fruits, herbs and spices etc., may be used in milk ice, frozen dessert, ice cream, cream cheese, cottage cheese, processed cheese and cheese spread, shrikhand, bread, ready-to-eat vegetables, frozen vegetables, frozen fruits/fruit products, soybean sauce, culinary pastes /fruits and vegetable sauces, tomato ketchup and tomato sauce, vegetable juices and soups, pickles, synthetic vinegar, mango chutney, pasta products, fruits and vegetable chutney and meat products (canned chopped meat, canned cooked ham) [8]. However, upper limit of their application is not specified.

Classification of Antioxidants

The antioxidants in food systems may be classified by using diverse indicators. Depending on the origin and the methods of production, food antioxidants may be natural or synthetic . The inclusion of natural sources of antioxidants could be an effective strategy for improving oxidative stability of processed foods and would be a better and more consumer-friendly alternative to synthetic additives.

Natural and Synthetic Antioxidants

Natural antioxidants occur naturally in many foods and are essential for our health. They include vitamin C found in fruits and vegetables and vitamin E found in seeds and nuts. Some vitamins (ascorbic acid and α-tocopherol), many herbs and spices (rosemary, thyme, oregano, sage, basil, pepper, clove, cinnamon, and nutmeg), and plant extracts (tea and grape seed) contain antioxidant components as well. Natural antioxidants or photochemicals antioxidants are secondary metabolites of plants . The total antioxidant capacity of plant materials such as culinary herbs, spices, vegetables, as well as fruits and oilseed products reflects concentrations of ascorbic acid (vitamin C), alphatocopherol (vitamin E), beta-carotene (vitamin A precursor), various flavonoids, and other phenolic compounds [9,10]. Phyto chemicals have been found to possess huge functional activities, such as protection against lipid oxidation, inhibition of cancer cell proliferation, and regulation of inflammatory and immune response [6]. Among the phyto chemicals, phenolic compounds were found to play major role in protection against oxidation. These antioxidants are of high or low molecular weight, can differ in their composition, their physical and chemical properties and in their mechanism and site of action.

Synthetic phenolic antioxidants (butylated hydroxyanisole [BHA], butylated hydroxytoluene [BHT], and propyl gallate), on the other hand, effectively inhibit oxidation, for e.g.: chelating agents such as ethylene diamine tetra acetic acid (EDTA) can bind metals reducing their contribution to the process. Synthetic antioxidants have been used as antioxidants for foods since the beginning of this century [11,12].

While use of synthetic antioxidants (such as butylated hydroxytoluene and butylated hydroxyanisole) to maintain the quality of ready-to-eat food products has become commonplace, consumer concern regarding their safety has motivated the food industry to seek natural antioxidants. The antioxidants that have caused health problems, for some people, are primarily synthetic [13].

Mechanism of Action: Natural and Synthetic Antioxidants

Oxidation reactions can produce free radicals, which start chain reactions that damage cells. Antioxidants terminate these chain reactions by removing free radical intermediates, and inhibit other oxidation reactions by being oxidized themselves. The oxidation of lipids proceeds through three different stages: initiation, propagation, and termination. Hydro-peroxides and secondary oxidation products (aldehydes, ketones, acids, etc.) are responsible for the rancid aroma and off-flavors in foods [12]. The different factors that catalyse lipid oxidation are the presence of oxygen and metal ions, heat, and light. To prevent, minimize, or slow down the rate of lipid oxidation, oxygen and metal catalysts must be removed or sequestered to render them non-reactive. The food prone to oxidation must be stored at low temperatures and/or shielded from light. To prevent the oxidation, antioxidant acts effective way by acting at different stages of lipid oxidation such as initiation, propagation, and termination [14].

The natural antioxidants are the chain breaking antioxidants which react with lipid radicals and convert into more stable products. They are primarily phenolics that may occur in all parts of plants such as fruits, vegetables, nuts, seeds, leaves, roots and barks. They scavenge harmful free radicals, which are implicated in the most common cancers and other degenerative diseases including poor brain function [15,16]. Various natural substances were used, but were soon replaced by synthetic chemicals, which are cheaper, more easily available, of consistent quality, and have greater antioxidant activity [12].

The synthetic antioxidants, on the other hand, are phenolic compounds that perform the function of capturing free radicals and stopping the chain reactions for example butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT) and tertiary butyl hydroquinone (TBHQ) [17,18].

Table 1: Comparison of natural and synthetic antioxidants [5,64]

Synthetic antioxidants	Natural antioxidants
Advantages : • Have well established mechanism of action and more efficiency. • Has stability in varied processing time and temperature. • Simple purification stages. • Cost of production less than natural sources.	**Advantages :** • Higher acceptability as considered safe for health. • GRAS certification as safe for consumption. • No positive results for toxicological studies till date. • Besides antioxidant property, act as colouring agents too.
Disadvantages: • Positive results for some toxicological studies. • May impart unwanted colour, aftertaste and flavour. • Use regulated by PFA, FSSAI.	**Disadvantages:** • Expensive purification and distillation process. • Properties of different prepations differ if not purified. • Maynot be atable under high temperature and processing time • Action mechanism is not well established.

Food Sources of Natural Antioxidants

Plants contain a variety of substances called “phytochemicals” that owe to naturally occurring components present in plants. The phytochemical preparations in preventing lipid oxidation have tremendous potential for extending shelf life of food products. The major sources of naturally occurring antioxidants are fruits [19], vegetables, whole grains [20], green and black tea, coffee, wine, beer, herbs and spices [5,21,22].

Essential oils from various spices, oilseeds, brans etc have also been qualified as natural antioxidants and proposed as potential substitutes of synthetic antioxidants in food preservation. *Zingiber officinale* contains a number of antioxidants such as beta-carotene, ascorbic acid, terpenoids, alkaloids, and polyphenols such as flavonoids, flavones glycosides, rutin, etc. [23].

A study to evaluate efficiency of Z*ingiber officinale* essential oil as antioxidant agent and use in cake preservation as a natural plant preservative due to the harmful effects of synthetic antioxidants reported that cakes treated with Z*ingiber officinale* essential oil in three levels (0.3%, 0.4%, 0.5%), had good antioxidant activity at 0.5% incorporation level in comparison with the control samples (without any synthetic and natural antioxidant agents). However, its activity was less than that of synthetic ones TBHQ as antioxidant agent. Results showed that this essential oil could be used as natural antioxidant in food stuffs especially those containing lipid [24].

Natural Antioxidants from Foods used in Bakery Products

Cereals

Studies have been carried out to find potential sources of natural antioxidants in wheat breads with incorporation of various cereal flours [37]. The incorporation of barley increased the antioxidant properties of the breads and the sensory evaluation showed differences among sensory attributes, depending on the barley variety used [38]. In another study it was found that the buckwheat could be incorporated into wheat bread to get better functional composition and improved antioxidant properties in bread [48].

Baking had a negative impact on antioxidant properties of gluten-free breads and polyphenol content was generally found to be reduced in the bread. It was reported that in the case of wheat bread replaced with 40% barley flour, the amount of free phenolic compounds decreased by up to 23.5% during the baking process, while the amount of bound phenolic increased [26,27]. At the same time, the measured antioxidant activities were relatively stable during the baking process. The addition of phenols-rich materials with wheat bread is an effective technique to improve the antioxidant potential of the final product [28,29]. Wholegrain buckwheat flour is a good source of phenols and possessed good antioxidant activity [28]. Buckwheat bread had a highest content of phenolic compounds [30]. The addition of buckwheat flour to wheat flour can increase total phenols concentration and improve antioxidant status of bread. Baking temperature influenced the loss of total phenols in wheat flour more than in buckwheat flour and increase of antioxidative activity in bread samples by the formation of products of Maillard's reaction [31]. These interactions between added phenolic and bread proteins, and starch influenced the antioxidant capacity, protein and starch digestibility or functional properties of fortified bread [32,33]. Bioavailability of phenolic and antioxidant activities thermal processing can increase the bioavailability of phenolic, and increase antioxidant activities [29]. In another such study, biscuits treated with natural antioxidants (Barnyard millet) received higher sensory score during storage, than control and BHA [34].

Legumes, nuts and oilseeds

A good number of studies have reported the antioxidant activities of many legumes, such as yellow and green peas, chickpea, lentils, common beans (pinto, great northern, navy, black, dark red kidney, light red kidney, red Mexican, pink and alubia bean), fava beans, beach bean, and yellow and black soybeans . Flaxseed, sunflowers, soybean, cottonseed, and canola antioxidants typify the antioxidants from oil seeds. An important group of antioxidants includes the sterols. These compounds have been shown to prevent thermal oxidative degradation of oils. The antioxidants of confectionery and oil sunflowers include phenolic acids, tocopherols and sterols while purple hulled varieties contain significant concentrations of anthocyanins. Tocopherol homologues are phenolic antioxidants that occur naturally in vegetable oils and provide some protection against oxidation by terminating free radicals [35]. The average tocopherol content in sunflowers was found to be 649 ppm [36] with 94% as α-tocopherol and β-tocopherols each accounting for 3% of the total.

A novel fortified biscuit was successfully produced incorporating flaxseed and it was observed as the concentration of flaxseed (10%) increased the moisture, fat, ash, protein showed gradual increase whereas dietary fibre showed a rapid increase and however, carbohydrate content was decreased. The antioxidant activity, phenolic concentration was linearly increased as the fortification was increased [37].The principle effect of flaxseed in humans and animal nutrition are the high levels of alpha linolenic acid (ALA c18; 3 n-3) in its oil and the high fibre in the seed. The total flax plant is approximately 25% seed and 75% stem and leaves. The flaxseed is 35% oil, of which 55% is ALA, a polyunsaturated, n-3 type fatty acid.

Fruits and Vegetables

Plant products are rich in natural antioxidants and functional components which have been suggested to curtail oxidation of foods [38,39,40]. In agreement, many studies showed that adding vegetables to burgers and emulsions improved their oxidative stability and shelf life . Fruits are rich source of vitamin C, carotenoids and polyphenolic compounds [22,41,42]. It has been reported that apples have very strong antioxidant activity, inhibit cancer cell proliferation, decrease lipid oxidation, and lower cholesterol [43]. Dried fruits are widely used in confectionaries, bakery products and sweet industries. Raisin containing bakery products are reported to stay fresher for a longer period. Addition of raisins at 12% (flour basis) inhibited mold growth and increased the shelf-life of wheat bread by 1–3 days [45].

Potato *(Solanum tuberosum)* is considered as a good source of antioxidants such as ascorbic acid, α-tocopherol and polyphenolic compounds. However, most studies have been focused on the antioxidant activity of phenolic compounds in potato [44]. Over 20 compounds of quercetin and kaempferol were found in cabbage [22].

Furthermore, the antioxidant activity of onion *(Allium cepa)* and onion scales has been studied in lipid oxidation models and in radical scavenging assays. Both yellow and red onions were poor antioxidants towards oxidation of methyl linoleate in contrast to their high antioxidant activity towards oxidation of LDL [44]. Vegetables containing natural antioxidants may be an effective natural substitute for prolonging the shelf life of breads. Adding vegetables reduced lipid oxidation in bread. Carrot, beetroot and broccoli reduced protein oxidation and tomato increased it, whilst beetroot and broccoli improved shelf life. The addition of carrot, tomato and broccoli to bread showed equivocal effects on oxidative stability during gastrointestinal digestion and at times appeared to induce it. Beetroot can also be a functional ingredient for the production of bakery and confectionery products, especially cakes and related products because of its high mineral contents. Beetroot has antioxidants called betalains. A study of beetroot powder incorporated (20%) value added cakes; found that total antioxidant activity increased from 5.5 to 47% and Folic Acid from 0.24 to1.9 mg/ 100g with the increase in beetroot powder incorporation Beetroot consistently showed positive effects on macronutrient oxidation during storage [47].

In yet another study, researchers used three plant foods viz., amla (*Emblica officianalis*), drumstick leaves (*Moringa oleifera*) and raisins (*Vitis vinifera*) as sources of natural antioxidants [46]. All the three extracts exhibited a high percentage of antioxidant activity evaluated using b-carotene–linoleic acid in vitro system, compared to synthetic antioxidants. Biscuits prepared by addition of natural extracts were subjected to sensory studies and chemical analysis. Biscuits treated with natural antioxidants, extracted from raisins and drumstick leaves received higher panel scores during storage period of 6 weeks, than control, butylated hydroxyl anisole (BHA) and amla extract incorporated biscuits. Addition of plant extracts from the three plant foods gave an excellent antioxidant effect on the biscuit compared with the effect of BHA, as the % increase in both peroxide and acid values after 6 weeks were lower than that of the control and BHA treated samples. Extracts from drumstick leaves and *amla* were more effective in controlling lipid oxidation during storage.

Vegetables containing natural antioxidants may be an effective natural substitute for prolonging the shelf life of breads. In biscuits, addition of purified extracts of marjoram, mint and basil is reported to have an excellent antioxidant effect compared with the effect of BHA [48].

Spices

Herbs and spices have been used for centuries to preserve foods and to make them more accepatable and appetizing [49]. Many leaf spices are reported to contain biologically active constituents that impart antioxidant, anticarcinogenic and antimicrobial properties to foods [46,50]. Natural aromatic plants and spices have been widely used in many food products including dairy and bakery products [51]. The most commonly used spices in bakery products are cinnamon, mint, mace, cloves, poppy and sesame[46]. The antioxidant activity of herbs and spices is most often due to phenolic acids, phenolic diterpenes, flavonoids, volatile oils and phenyl-propanoids [52,53] (Table 2).

Table 2: Natural antioxidants present in herbs and spices

Sl. No	Group of Phytochemicals	Chemical compound
1	Phenolic Acids	Gallic, protocatechuic, caffeic, and rosmarinic acids
2	Phenolic Diterpenes	Carnosol, carnosic acid, rosmanol, and rosmadial
3	Flavonoids	Quercetin, catechin, naringenin, kaempferol, epicatechin, gallate epigallocatechin gallate and rutin
4	Volatile Oils	Eugenol, carvacrol, thymol, menthol, safrole, 1,8-cineole, *a*-terpineol, p-cymene, cinnamaldehyde, myristicin and piperine
5	Phenylpropanoids	Thymol, eugenol, carvacrol, p-cymene
6	Curcuminoids	Curcumin, demethoxycurcumin ,bis-demethoxy curcumin

Turmeric (*Curcuma longa* L.) is another popular spice containing natural antioxidants, and is reported to possess numerous medicinal properties including antioxidant, anti-protozoal, anti-tumour, anti-inflammatory and anti-venom activities [54]. The major bioactives in turmeric are polyphenols, including curcumin, which is well known, besides other polyphenols, for its strong antioxidant activity [55]. Curcumin is a yellow coloured phenolic pigment and is an effective antioxidant that can scavenges superoxide radicals, hydrogen peroxide and nitric oxide from activated macrophages. It is used as an antioxidative and antimycotic agent in butter cakes [56].

Extracts of *Garcinia* and turmeric powder have been reported to be suitable for use in biscuits as natural antioxidants [5].The quality and antioxidant properties of bread containing turmeric (Curcuma longa L.) Cultivated in South Korea was studied by some researchers [57] and they found that total phenolic contents of breads significantly increased with the addition of turmeric powder. Breads containing turmeric powder also showed good antioxidant activity as tested by the b-carotene-linoleate bleaching assay. A 4% substitution of wheat flour with turmeric powder showed acceptable sensory scores which were comparable to wheat bread. Breads containing turmeric powder can thus be developed as a health-promoting functional food.

Radical scavenging activity (RSA) of coriander seed oil and oil fractions were investigated and it was found that coriander seed oil and its fractions exhibited the strong RSA and can use as a natural antioxidant in lipid-containing foods [58].

In another study, by three different bioassays, indicated that extract and oil of leaves and seeds of coriander has strong antioxidant activity and thus, probably prevent oxidative deterioration of food [59].

The extract of coriander leaves was added to refined sunflower and groundnut oils heated to frying temperature and were kept for four weeks. This plant had good antioxidant activity and it is stable at high temperatures and can be used as substitutes for synthetic antioxidant. Other studies reported, antioxidant and antimicrobial effects of chamomile essential oil in cake preparation were evaluated during 75 days of storage.

The results showed that, the sample containing chamomile at 0.15%, had good antioxidant and antimicrobial activity in comparison with the control samples (without any synthetic and natural antioxidant and antimicrobial agents) ($p<0.01$). But its activity was less than that of synthetic ones (TBHQ and potassium sorbate as antioxidant and antimicrobial agent) ($p<0.01$).

In sensory evaluation, the sample containing chamomile at 0.05% had higher score in flavor, taste and overall acceptability than the samples at 0.15 and 0.1% ($p<0.05$) [60]. Bread samples exhibited higher antioxidant activity than control after addition of some aromatic and medicinal plants (garlic, coriander, sumac, fennel, marjoram, thyme and cardamom) as natural antioxidants[61].

Similar studies on biscuits incorporated with spearmint and peppermint clearly indicated the antioxidant efficiency of different mint forms in preventing the onset of rancidity in biscuits during storage suggesting the retention of bioactive components of mint [62].

Conclusion

The role of antioxidants in today's food systems is constantly expanding, given the level of processing and handling that many foods encounter on their way from farm to the fork. Antioxidant content in foods has achieved prominence on many food labels, including baked products. As long as they are consumed in moderate concentrations, natural antioxidants have been proven to have many positive health effects, such as preventing plaque formation in the arteries and preventing other chronic conditions such as cancer and heart disease.

These beneficial properties have put natural antioxidants on the forefront of recent food advertising, and public levels of awareness concerning natural antioxidants and their positive effects have increased significantly. This in turn has resulted in the increased global interest in finding new and safe antioxidants from natural sources. The challenges in using natural antioxidants derived from food, however, is their strong flavor and aroma and the exorbitant cost of extraction. More research will have to be undertaken in various areas to improve utilization of plant based sources as antioxidants and to increase their availability and efficacy specifically in areas of:

- Refinement in extraction and isolation methods
- Optimization in extraction processes in terms of cost benefit feasibility,
- Optimizing the synergistic effect of combining natural antioxidants,
- Isolation and identification of unexplored phytochemicals responsible for antioxidant activity
- Standardization of novel processes to reduce strong aroma and flavor in the extracts especially from herbs and spices.

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