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Development and evaluation of biscuits from foxtail millet and papaya fruit

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Foxtail millet biscuits with papaya fruit pulp as sugar substitute were studied with an aim to increase antioxidant properties. Different formulations of 0%, 25%, 30% and 35% papaya pulp were prepared. Addition of papaya fruit pulp to foxtail millet biscuits increased color, texture, low hardness at first bite and mouth feel. Physical properties of biscuits such as weight, thickness and bulk density decreased with increase in papaya pulp addition, whereas diameter and spread ratio increased with increase in papaya incorporation. Based on sensory and physical properties, 35% papaya fruit pulp incorporated foxtail biscuits were analyzed for chemical composition and antioxidant properties compared with sugar-added foxtail millet biscuits as a control. Nutritional evaluation of biscuits revealed that 35% addition of papaya pulp increased ash and decreased protein, iron, zinc and copper; there was no significant difference in fat and moisture content. Antioxidant properties such as total carotenoids, total phenolic content and radical scavenging activity were increased with the addition of papaya fruit pulp to the foxtail millet biscuits. It can be further explored for producing more papaya-based therapeutic products to benefit consumers.

Keywords: Antioxidant properties, Millet-fruit biscuits, Minerals, Physico-chemical properties, Sugarless biscuits

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Biscuits represent the largest category of nutritious snack items among baked foods all over the world. Biscuits have now become a loved ready-to-eat product for every age group because they are easy to carry about, have longer shelf-life, are tasty to eat and are reasonably cheap[1]. Biscuits consist of three major components: flour, sugar and fat. The main ingredient is refined wheat flour, which some researchers call "slow poison" owing to its associated side effects on health with long-term consumption. Some call it the "glue of the gut" and discourage people from consuming it or reduce their intake of foods prepared from this flour because of the associated health risk such as diabetes, coeliac diseases, etc[2]. In addition, growing concerns about the increased prevalence of obesity and its metabolic comorbidities have led to reduced consumption of simple sugars and an increase in the intake of sweeteners. Even the Food and Drug Administration, European Food Safety and Authority and Codex Alimentarius considered sweeteners as safe and well tolerated. However, some long-term prospective studies raise the concern that the consumption of artificial sweeteners might actually contribute to the development of metabolic derangements that again lead to obesity, diabetes and cardiovascular disease[3]. The world stands in need of replacing main ingredients of biscuits such as wheat flour with millet flours and sugar with fruits.

Millets are described as "nutritious millets" due to their high balancing nutrients, slow-releasing sugars and lack of gluten[4,5]. Foxtail millet is an important minor millet, considered a crop for poor people. Nutritionally, foxtail is superior to rice and wheat and therefore provides high amounts of proteins, crude fiber, minerals, vitamins and critical amino acids viz., lysine and methionine[6]. Indians traditionally used foxtail millets as a diuretic, to strengthen virility, treat indigestion, dyspepsia and rheumatism. Papaya is the fourth most important tropical fruit around the globe[7]. India is the world's largest producer of papaya, and it is the most important fruit in the caricaceae family[8]. Papaya juice was used in folk medicine for warts, cancers, corns, tumors and thickened skin. The active compounds in papaya are ascorbic acid, β-carotene, α-tocopherol, flavonoids, vitamin B1, kaempferol, quercetin, caffeic acid, chlorogenic acid, papain and

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niacin[9,10]. These compounds possess antioxidant activity, which warrant activity against free radicals by reducing chronic degenerative diseases through the enhancement of endogenous antioxidant enzyme activities[11,12]. Papaya fruit extract can counteract the oxidative stress and protect the kidney against toxic effects[13,14]. Papaya alkaloids, phenolic and flavonoid compounds shown to exhibit antimicrobial, immunomodulatory, anti-dysenteric, antitumor, cardiodepressant, diuretic, hypotensive and vasoconstrictor effects[15]. Soya bean is an excellent source of protein and contains 35%-45% of all essential amino acids, and it is rich in vitamin, mineral and antioxidants like isoflavones which help in cholesterol reduction, preventing cancer and regulation of menopause[16]. All these components of ingredients used in biscuits help to maintain health and prevent diseases such as diabetes and cardiovascular and many other degenerative diseases[17,18]. In the present study, we have developed functional biscuits with foxtail millet flour, papaya fruit pulp, defatted soy flour and refined wheat flour and analyzed them.

Materials and Methods

Location of the work done

Biscuits were formulated in the Millet Processing Incubation Centre, Rajendranagar, Hyderabad. Sensory evaluation and chemical analysis were done in the Department of Foods and Nutrition, Post Graduate & Research Centre, PJTSAU, Rajendranagar, Hyderabad.

Raw material

Foxtail millet flour, refined wheat flour, defatted soy flour, papaya fruit pulp, icing sugar, shortening and baking powder were procured from local market, Hyderabad, and stored in containers at room temperature. Papaya (*C. papaya* L.) ripe fruit, skin in orange color, dark orange-colored pulp with no longer latex and firmness appropriate for consumption was selected as the criteria reported by Basulto[19]. Papaya was washed, peeled, pulp was ground and used immediately for making biscuits.

Biscuit preparation

Functional biscuits were prepared in different formulations as shown in Table 1. Papaya pulp of 25%, 30% and 35% replaced with sugar (0%, 15% and 20%) and foxtail flour (10%). To increase the papaya pulp content more than the sugar percentage, we decreased the foxtail millet flour in experimental biscuits by 10%.

Table 1 — Formulation of foxtail biscuits with papaya pulp

S.no	Ingredient	Control	EXP-1	EXP-2	EXP-3
1	Maida	10%	10%	10%	10%
2	Soy flour	10%	10%	10%	10%
3	Foxtail	35%	25%	25%	25%
4	Papaya	-	25%	30%	35%
5	Sugar	25%	10%	5%	-
6	Fat	20%	20%	20%	20%

A known weight of hydrogenated fat and powdered sugar was creamed together until light and fluffy appearance is formed. Then, composite flour and baking powder was mixed together by sieving 2 times. The mixed flour was added to the creamed paste and mixed until a uniform smooth dough was obtained. The dough was rolled out and cut into a round shape with a biscuit cutter. The biscuits were placed in a greased baking tray and baked in a laboratory preheated oven at 180°C for 10 min, according to the methods of AOAC[20].

Sensory evaluation

Sensory attributes like color, texture, taste, flavor, hardness at first bite, sweetness, mouth feel and overall acceptability were evaluated by 12 panelists using the 9-Point Hedonic Score System. The panelist gives a score of 9-1 to the product, ranging from “liked extremely” to “disliked extremely” to find out the most suitable composition of the biscuit[21].

Physical properties

The physical properties of functional biscuits weight, thickness, diameter, spread ratio and bulk density were determined according to the methods by Peter *et al*. (2017) by using a digital weighing balance and vernier caliper[22].

Chemical composition

The chemical analysis was carried out for the best selected foxtail papaya biscuit (EXP-3). Moisture, ash, protein, fat and minerals by wet digestion method were used to estimate[23-26].

Antioxidant properties

The antioxidant activity was estimated by using 1-diphenyl-2-picrylhydrazil (DPPH), total carotenoid and total phenolic content[27,28].

Statistical analysis

Sensory evaluation of biscuits (12 replications), physical properties, chemical composition and antioxidant properties (3 replicates) were subjected to analysis of variance using INDOSTAT version 9.1. Significance was accepted at $p < 0.05$[29].

Results and Discussion

Sensory properties of the biscuits

Sensory evaluation is the science that measures and determines differences among the control and experimental sample. The sensory hedonic scores of biscuit samples are shown in Table 2. Experimental biscuit with 35% incorporation of papaya scored high in color, texture, hardness at first bite and mouth feel. Color is an important quality indicator of a food system that could affect consumer acceptance. Papaya incorporated in place of sugar had increased the color of the biscuits, which increased along with an increase in addition of papaya (control-7.41; 25%-7.83; 30%-8.08; 35%-8.58). Assefa (2017) reported that color of the cookies had increased along with increase of mango pulp addition that was 20%, 30% and 50%[30]. Texture was related to the external appearance which implies smoothness or roughness of the biscuits. The scores for texture had increased with increase in the addition of papaya pulp (control-7.25; 25%-7.58; 35%-8.08). The texture of control, EXP-1 and 2 were not significantly different (p<0.05) and also among the EXP-1, 2 and 3. Taste, flavor and sweetness scores show it is significantly different for biscuits with 30 and 35% papaya pulp added biscuits compared to control. There was significant difference among control and 25% papaya pulp substituted biscuits in terms of taste and sweetness and not significantly differed for flavor. Hardness at first bite and mouth feel increased with an increase in papaya addition (control-7.08, 7.41; 25%-7.41, 7.5; 30%-7.58, 7.5; 35%-8.16, 8.08). General acceptability was significantly different for all experimental samples compared to control, but there was no significant difference among the experimental biscuits. Yusufa and Akhigbe (2014) reported that cookies produced from the incorporation of 25% papaya flour in wheat flour scored high in all the sensory attributes[31]. Sensory evaluation reveals that 35% substituted papaya pulp was more acceptable than the other experimental biscuits.

Physical parameters of biscuits

Physical parameters of biscuits are given in Table 3. There were significant (p<.05) differences in the weight, thickness, diameter, spread ratio and bulk density of the biscuit samples. Weight and thickness decreased with an increase in papaya pulp addition (Control-8.86, 9.05; 25%-7.69, 8.73; 30%-6, 8; 35%-4.74, 7.52), this may be due to high water levels in the pulp which evaporated in baking. The diameter was highest in 25% papaya pulp-added biscuits, it is

Table 2 — Sensory hedonic scores of biscuits

Biscuits	Color	Texture	Taste	Flavor	Hardness at first bite	Sweetness	Mouth feel	Overall acceptability
Control	7.41±0.14[b]	7.25±0.13[b]	8.25±0.21[a]	8.16±0.16[a]	7.08±0.14[b]	8.33±0.14[a]	7.41±0.19[b]	8.41±0.51[a]
EXP 1 (25%)	7.83±0.24[b]	7.58±0.19[ab]	7.58±0.14[b]	7.75±0.13[a]	7.41±0.14[b]	7.41±0.14[b]	7.5±0.15[b]	7.58±0.51[b]
EXP 2 (30%)	8.08±0.14[a]	7.58±0.22[ab]	7.50±0.19[b]	7.5±0.23[b]	7.58±0.19[b]	7.25±0.21[b]	7.5±0.2[b]	7.41±0.66[b]
EXP 3 (35%)	8.58±0.14[a]	8.08±0.26[a]	6.83±0.27[c]	6.91±0.22[c]	8.16±0.20[a]	6.41±0.22[c]	8.08±0.19[a]	7.25±0.86[b]
Mean	7.97	7.26	7.54	7.58	7.56	7.35	7.62	7.66
CD	0.50	0.60	0.60	0.51	0.52	0.50	0.55	0.55
SE of mean	0.24	0.29	0.29	0.25	0.25	0.24	0.27	0.27
CV (%)	7.61	9.48	9.63	8.17	8.41	8.20	8.71	8.74

Means followed by the same letter in the column are not significantly different at (p<0.05). Each sensory attribute was rated on a 9-point hedonic scale (9 = like extremely, 1 = dislike extremely).

Table 3 — Physical parameters of biscuits

Biscuits	Weight (g)	Thickness (mm)	Diameter (mm)	Spread ratio	Bulk density g/cm^3
Control	8.86±0.21[a]	9.05±0.35[a]	39.86±0.24[b]	4.41±0.19[b]	7.77±0.03[a]
EXP 1	7.69±0.17[b]	8.73±0.13[a]	40.55±0.61[a]	4.64±0.13[b]	7.55±0.006[b]
EXP 2	6.00±0.34[c]	8.00±0.41[a]	41.51±0.38[a]	4.90±0.10[a]	7.49±0.006[c]
EXP 3	4.74±0.05[d]	7.52±0.39[b]	40.51±0.14[a]	5.41±0.30[a]	7.44±0.003[d]
Mean	6.82	8.32	40.60	4.84	7.56
CD	0.73	1.28	1.48	0.63	0.02
SE of mean	0.29	0.52	0.60	0.25	0.01
CV (%)	5.36	7.70	1.83	6.52	0.16

Means followed by the same letter in column are not significantly different at (p<0.05).

Table 4 — Chemical composition of biscuits

	Moisture (g)	Protein (g)	Crude fat (g)	Ash (g)	Iron mg/Kg	Zinc mg/Kg	Copper mg/Kg
Control	7.20±0.20[a]	12.47±0.09[a]	20.22±0.03[a]	2.98±0.27[a]	78.60±0.06[a]	81.31±0.16[a]	7.61±0.10[a]
EXP (35%)	7.69±0.20[a]	11.74±0.12[b]	20.18±0.04[a]	3.26±0.26 [a]	70.33±0.29[b]	62.13±0.27[b]	6.53±0.10[b]
Mean	7.44	12.83	20.20	3.12	74.46	71.72	7.07
CD	1.7	0.37	0.07	2.29	1	1.46	0.89
SE of mean	0.39	0.08	0.01	0.53	0.23	0.34	0.20
CV (%)	5.73	0.84	0.10	20.88	0.38	0.58	3.59

Means followed by the same letter in column are not significantly different at ($p<0.05$).

significantly ($p<0.05$) different from control and showed no significant difference among experimental samples. Spread ratio was highest in EXP-3, that is, 35% papaya pulp-added biscuit which has no significant difference with EXP-2. Bulk density of the biscuits decreased from control-7.77 to EXP-3-7.44. The low bulk density of flours has been reported to be useful for food formulation, such products have less retrogradation and bulk density is a measure of heaviness of a flour sample[32]. Spread ratio and diameter are used to determine the quality of flour used in preparing biscuits and the ability of the biscuit to rise[33]. The higher the spread ratio of biscuit, the more desirable it is[34]. Hence, biscuits prepared from the flour blend containing 35% substitution of papaya and no sugar were most preferred based on the sensory evaluation, spread ratio and bulk density. Similar findings with respect to the spread ratio were reported by other researchers[35,36].

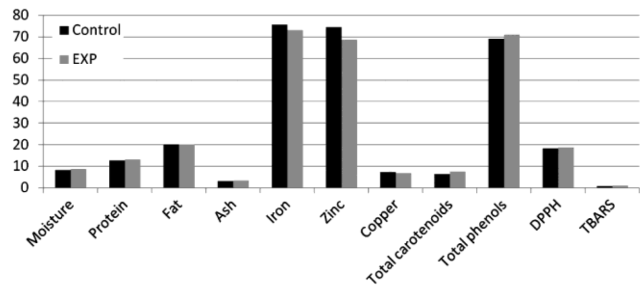

Fig. 1 — Chemical composition of biscuits

Chemical composition of foxtail-papaya biscuits

The chemical analysis of biscuits showed (Table 4) no significant ($p<0.05$) difference in moisture content (7.20 to 7.69 g) between control and experimental sample ensures the storage stability. Figure 1 shows the chemical composition of biscuits. According to Ajila *et al*. (2010), both control and experimental biscuits were in the generally acceptable range of moisture for dry products in order to obtain desirable shelf life of the product[37]. Protein has significantly ($p<0.05$) decreased from 12.47 to 11.74 g, this may be due to decrease in the percentage of foxtail. Fat content of biscuits (20.22 to 20.18 g) have shown no significant ($p<0.05$) difference. This was because of the viscosity produced by the dietary fiber of papaya pulp that prevents the fat extraction during the process of baking the cookies[38,39]. Table 4 shows that the ash content of biscuits was 2.98 to 3.26 g in control and sample, respectively. Even though it did not differ significantly, the percentage increase was 9.39. Ash content of experimental biscuits was perhaps because of the high mineral content and existence of magnesium and calcium, phosphorus and sulfur in the papaya fruit[40]. Varastegani *et al*. (2015) reported that the ash content of cookies increased with increase in papaya pulp flour addition[41]. Iron, zinc and copper in experimental biscuits were significantly decreased from 78.60 to 70.33, 81.31 to 62.13 and 7.61 to 6.53. The decrease in these three minerals was because of lesser contents in papaya fruit than foxtail millet.

Antioxidant properties of foxtail-papaya biscuits

Antioxidants are promising compounds which help in delaying or inhibiting oxidation. These antioxidants possess diverse biological activities, such as anti-inflammatory, anti-atherosclerotic and anticarcinogenic activities[42]. Antioxidant properties of biscuits were given in Table 5 and Figure 1. Total phenolic content was increased from 68.66 to 71.56 μg retinol equivalents because of the substitution of papaya[43]. These phenolic compounds affect sensory qualities and are major contributor of antioxidant capacity. There was a significant difference of total carotenoids between control and experimental biscuits. Addition of 35% papaya fruit pulp increased total carotenoids content by 63.63%. Carotenoids have antioxidant properties, particularly efficient scavengers of singlet oxygens. There was a significant difference of free radical scavenging activity between control-17.71% and experimental sample-19.26%. It indicates good scavenging activity of 35% papaya-incorporated biscuits. Pavithra *et al*. (2017) reported

Table 5 — Antioxidant properties of biscuits

	Total carotenoids µg/g	Total phenolic content µg RE	DPPH%
Control	5.28±0.01^b	68.66±0.69^b	17.71±0.01^b
EXP	8.64±0.08^a	71.56±0.09^a	19.26±0.01^a
Mean	6.96	70.11	18.48
CD	0.39	2.64	0.07
SE of mean	0.09	0.61	0.17
CV (%)	1.62	1.07	0.11

Means followed by the same letter in column are not significantly different at ($p<0.05$).

that papaya peel powder and papaya peel paste incorporated chapathi have shown significant increase of free radical scavenging activity compared to control chapathi[44]. Enhanced antioxidant activities were observed in raw and ripened papaya on freeze drying[45]. Fermented papaya exerts both immunomodulator and antioxidant activity in macrophage cell line[46]. Papaya cocktail has shown inhibition of lipid peroxidation in vivo which was by concentrated bioactive compounds[47].

Conclusions

Addition of papaya pulp as a sugar substitute to the foxtail millet biscuits increased color, texture, low hardness at first bite, mouth feel, ash, total carotenoid content, phenolic content and percentage scavenging activity. It is a good functional food of great nutritional benefit. Therefore, papaya fruit pulp could replace sugar in the production of quality biscuits and as a sweetener in other bakery products. Considering papaya-foxtail biscuit's composition and antioxidant properties, it is not only recommended for diabetics but also for other metabolic health-related patients as it has an advantage of antioxidant properties and not having any added sugar content. Further development of products with millet and fruit combination adds benefit to the therapeutic products by enhancing antioxidant activity which is a vital requirement for the people.

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Conflict of Interest

Authors declare that there are no conflicts of interest

Author(s) Contribution

SK conducted the experiment, developed the products, did statistical analysis and wrote the first draft of manuscript. HTV guided throughout the study, helped in designing the work, proof reading and critical correction of manuscript; and SSK assisted in analysis, writing drafts and final corrections of manuscript.

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