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Research Article

DEVELOPMENT, NUTRITIONAL AND FUNCTIONAL EVALUATION OF MIXED MILLET AND MIXED MILLET SOY BASED COOKIES

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Abstract: The present study is focussed on development and evaluation of cookies with millets and soy flour. Two cookies were optimized using mixed millet flour and using mixed millet soy flour. The mixed millet and mixed millets soy flour had considerable oil and water holding capacity which are important properties of dough for baking. Starch viscosity property of the flour was studied and low setback value was observed which clearly states that the starch of these flours has moderate peak viscosity with moderate process tolerance and susceptible to over-cooking. Proximate analysis was done to study the nutritional composition of the flours and cookies. The mixed millet soy cookies were rich in protein (13.50%) when compared to mixed millet cookies (5.71%). Nutritional composition of the developed cookies was comparable to other cookies made with wheat-composite flour. Amino acids namely histidine, threonine, valine, methionine, phenylalanine, isoleucine, leucine and valine are present in significant quantity in both mixed millet cookies and mixed millet soy cookies. The low biting/breaking strength (0.861 -1.069 kg) along with high hardness (2.136-2.842 kg) gives an added advantage to the cookies.

Keywords: *Millet, Cookies, Gluten free, Millet flour, Soy flour, Characteristics of flour, Texture analysis*
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Introduction

The demands for healthy and nutritious foods are high. In order to suffice the needs of people, many novel sources and products are used as raw materials [4]. Recently, millets are identified as nutritional foodstuff. As millets can be grown in certain adverse climatic conditions, it is referred to as the crop of food security [25]. Millets provide several benefits in managing diabetes and overall health. The millets are rich in essential amino acids like lysine, which is in partial amounts in wheat and rye flour. Starch is the main carbohydrate component in millets and they contain a high proportion of dietary fibres. Prolamine and glutelin form the major portion of the proteins in millets. Milled millets are free from the anti-nutritional factors that are confined in the seed coat [47]. In the recent times, millets are being used as a combination with other ingredients and aids in development of gluten-free cereal products. Traditionally, millets have been used in household cooking to develop snack items and infant foods [13]. It can also be processed on a commercial scale to develop RTS and RTE products. Millet flour is a highly nutritious and a good source of protein, essential amino acids and dietary fibre. Millet flour imparts a subtle and mild, buttery flavour. People suffering from celiac disease are unable to consume baked goods from wheat and rye, due to presence of gluten. Soy flour is an excellent health food as it contains 40% good quality protein, 23% carbohydrates, 20% cholesterol free oil and sufficient amounts of minerals and vitamins. Amino acid profile of soy protein is excellent amongst plant proteins. It is most economical source of dietary protein. Carbohydrates, in soy flour helps in water binding and controlling viscosity [27]. Soy proteins possess many important properties and play a major role in hydration, gelation, emulsification, foaming and flavour binding. Due to their gluten free property, both millet and soy flour can be well fitted as basic ingredients in health foods. Biscuits and cookies are one of the affordable bakery products with a long shelf life.

The recent lifestyle caused mankind to several health issues and fatal congenital diseases. Commercial products like biscuits and cookies should be processed and enriched with nutrients, such that it can be an aid to prevent these symptoms and diseases. The quality of flour influences the final quality and texture of the cookies. Studies reveal that, incorporation of millet flour affects the quality and rheological properties of the batter, but it enhances the nutritious value without compromising the taste [26]. Different studies on millets as a composition of health food yielded positive and promising results. Malleshi and Desikachar [31] reported promising results on popping and milling of millets. Arora et al. [6] suggested that fermentation of pearl millet by probiotic enhances the protein content in the millets. Very scanty research has been done on developing RTE functional food products using millets.

In this paper, the study was conducted to develop a healthy nutritious cookie by replacing the traditional and commonly used ingredients and it would be beneficial for the baking industry. The millet flour and soy flour were used as a substitute for refined wheat flour (maida) and common sugar was replaced with palm sugar. Palm sugar is a natural sweetener and more nutritious with low glycemic index as compared to commercial cane sugar. The composition of the ingredients, baking temperature and other process parameters were optimized. The nutritional, physical properties, texture and phytochemical analysis of finished baked product are reported.

Materials and methods

Barnyard millet (*Echinochloa frumentacea*), Little millet (*Penicum milliare*), Foxtail millet (*Setaria italic*), Kodo millet (*Paspalum scrobiculatum*) and Great millet (*Sorghum bicolor*) were dehusked and milled using the flour mill facility at Food Process Engineering Laboratory, SRM University, Kattankulathur, India.

Other ingredients used for the preparation of cookies include defatted soy flour, palm sugar and cooking butter. All the ingredients required for cookies preparation were purchased from the local market in Chennai, Tamil Nadu, India.

Cookies formulation and preparation

Mixed millet cookies and mixed millet soy cookies were prepared using the traditional method. Cookies were prepared from the blend containing 30g of each millet flour (Barnyard millet, Little millet, Foxtail millet, Kodo millet, Great millet). Different formulations of the ingredients were tested to optimize the flour composition. In this study, cookies were made using two different base formulations; with mixed millet flour and combination of soy flour with mixed millet flour. The amount of butter, sugar and baking time differed as the recipe under study did not contain wheat flour. 50g, 75g, 100g, 125g, 150g and 175g of butter was added to 150g of flour after undertaking appropriate preliminary trials of their suitability, kneaded well and consistency of the dough was checked. Similarly, with effect of preliminary trials on fixing the suitable level, 50g, 75g, 100g, 125g, 150g and 175g of palm sugar was added to the flour, kneaded well and cookies were made. Sensory analysis was performed to optimize the amount of butter and palm sugar, to achieve a good texture and taste. In order to optimize the baking time, the cookies were baked at 180C baking temperature in single deck baking oven (M/s Hi Tech Equipment, Chennai, India) for 8min, 10min, 12min and 14min, respectively. Various proportions (20%, 40%, 60%, 80% and 100%) of soy flour were used to optimise the mixed millet-soy cookies with good consistency.

Physical characteristics of flour

Water Absorption Capacity (WAC) of mixed millet flour and mixed millet soy flour was determined according to the method described by [5] and [11]. Oil Absorption Capacity (OAC) was determined using method described by [11]. Swelling capacity of the flour was tested using method described by [15, 29, 42]. Bulk density was determined according to the method of [33].

Foam capacity and foam stability was performed by mixing 2g flour sample with 50ml distilled water at 30ºC in a 100ml measuring cylinder. The suspension was mixed and properly shaken to form foam; the volume of the foam was observed after 30 seconds. The foam capacity was expressed as a percentage increase in volume [34]. Foam stability was determined by comparing the initial foam volume with foam volume recorded after whipping for one hour [34]. Pasting properties of flour was determined according to [24] using Rapid Visco Analyser (RVA) Model 3-D (Newport Scientific Pvt. Ltd, Australia) with Thermocline software (3.0 version). The procedure explained by [9] was followed. Sample suspension was prepared by placing flour (3.5g) in an aluminium canister containing 30g distilled water. Each sample was stirred at 960 rpm for 10 s, while being heated at 50ºC and then constant shear rate of 160 rpm was maintained for rest of the process. Sample was held at 50ºC for 1 min and heated from 50 to 95ºC taking 3 min 42 s and held at 95ºC for 2 min 30 s. Subsequently samples were cooled down from 95 to 50ºC taking 3 min 48 s and then held at 50ºC for 2 min. A RVA plot of viscosity (cp) versus time (s) was used to determine pasting point, pasting temperature, peak viscosity, break down viscosity, final viscosity and set back.

Physical characteristics of cookies

Diameter of the cookies was determined by placing six cookies in horizontal position (edge to edge) and the sum of the total diameter was divided by 6. Height of the cookies was measured by placing six cookies vertically in natural surface position and the total height of the cookies was divided by six [35], [50].

The spread ratio was calculated using the following formula:

Proximate composition of raw material of the developed cookies

The samples were analyzed for moisture content, ash, protein, fat, total dietary fiber, carbohydrate and calorific value using standard method [7]. The tannin content of the cookies was assessed using Folin Denis reagent [43]. Total polyphenolic content of the cookies was estimated using Folin Ciocalteau reagent, using spectrophotometer [12]. The phytate content in the cookies were determined by the method suggested by [48]. The estimation of amino acid was performed using HPLC [49].

Texture analysis of cookies

Texture analysis of the mixed millet cookies and mixed millet-soy cookies were done by Texture Analyzer (Stable Micro System HD+UK, Model No.-5197). Texture Expert™ software was used for analysis of the curve. The hardness and cutting strength of the cookies were determined using 5mm cylindrical probe P/5 and HDP/BSK cutting probe respectively. The TA setting for all tests was kept at: pre-test speed of 2 mm/s, test speed of 3 mm/s; post-test speed of 10 mm/s. The individual samples of cookies were placed on the platform and the probe was attached to the crosshead of the instrument. The breaking test simulates the evaluation of hardness by consumer holding the cookies in hands and breaking the same by bending. The absolute peak force from the respective resulting curve was considered the hardness and breaking strength of the cookies [19], [46].

Statistical analysis

Each parameter was measured in triplicate and the mean values with standard error at 5% significance levels are reported in this paper. Statistical analyses (analysis of variance, standard deviation, multiple comparison procedure etc.) were performed using the statistical software package of Microsoft Excel 2007 (Microsoft Corporation, Redmond, WA, USA).

Results and discussion

Different combinations of the ingredients were tried on trial and error basis to optimize the final formulation, so as to obtain the desired flavour, taste and texture. [Table-1] shows the effect of butter and palm sugar on the texture and taste of mixed millet cookies for 150g of mixed millet four. It was observed on sensory analysis that the addition of 100g butter, gave the desired softness and texture to the cookies. The dough became watery, on addition of butter greater than 100g. 100g palm sugar was observed to give optimum sweetness to the cookies. The baking time was optimized as 8min and 10min, for mixed millet cookies and mixed millet-soy cookies respectively. Addition of 44.44% of soy flour to mixed millet flour gave good texture to the mixed millet soy cookies.

The optimized composition obtained for the mixed millet cookies to yield 100g of cookies flour was Barnyard millet - 20g, Little millet - 20g, Foxtail millet - 20g, Kodo millet - 20g, Great millet - 20g, palm sugar - 66.67g, cooking butter - 66.67g and a baking time of 8 min. Similarly, for the mixed millet-soy cookies, the amount of ingredients were optimized as; Barnyard millet - 15g, Little millet - 15g, Foxtail millet - 15g, Kodo millet - 15g, Great millet - 15g, Soy flour - 25g, palm sugar - 66.67g, Cooking butter - 66.67g and baking time of 10 minutes. The developed cookies were evaluated by 20 semi trained sensory panellist and it was observed by the panellist that the developed cookies were good in taste with satisfactory texture. Both the samples were easy to bite and chew. The mixed millet cookies were slightly darker in colour when compared to mixed millet soy cookies.

Table-1 *Effect of butter and palm sugar on the texture and taste of mixed millet cookies for 150g of mixed millet four.*

S	Amount of butter	Texture	Amount of palm sugar	Taste
1	50g (33.33 %)	Hard	50g (33.33 %)	Bland
2	75g (50 %)	Hard	75g (50 %)	Bland
3	100g (66.67 %)	Soft	100g (66.67 %)	Sweet
4	125g (83.33 %)	watery	125g (83.33 %)	Extreme sweet
5	150g (100%)	Very watery	150g (100%)	Extreme sweet
6	175g (116.67 %)	Very watery	175g (116.67 %)	Extreme sweet

Physical characteristics of flour

[Table-2] shows the physical characteristics of mixed millet flour and mixed millet soy flour. The water absorption capacity for the mixed millet flour and mixed millet soy flour was found to be 2.729 ml/g and 2.388 ml/g, respectively. Higher water absorption capacity of mixed millet flour could be attributed to the presence of greater number of hydrophilic constituents like soluble fiber and lower amount of fat content. There was a significant difference among the water absorption capacity of both the flours. This value was observed to be higher than 2.3 ml/g for raw jackfruit seed flour [38], 1.26 – 1.37 ml/g for tiger nut flours [40] and 1.7 ml/g for African yam bean flour [16]. It is lower than 3.4 ml/g for raw camphor flour [37]. Water absorption capacity describes flour-water association ability under limited water supply.

The result obtained shows that the flours have good water binding ability, thus suggesting that mixed millet flour and mixed millet soy flour could be used in bakery industry. The oil absorption capacity was found to be 7.57 ml/g and 7.45ml/g, for mixed millet flour and mixed millet-soy flour respectively. Oil absorption is an important property in food formulation because fat improve the flavour and mouth feel of the foods. It can also be influenced by the lipophilicity of protein [27]. The result obtained is higher as compared to 2.8 ml/g reported for raw jackfruit flour [38]. This result obtained shows that the mixed millet and mixed millet-soy flours are S. high flavour retainers and therefore might find useful applications in food systems such as ground meal formulations.

Table-2 *Physical characteristics of mixed millet flour and mixed millet soy flour*

Indices	Mixed millet flour	Mixed millet-Soy flour
Water Absorption capacity (ml/g)	2.729±0.059[a]	2.388±0.053[b]
Oil Absorption Capacity (ml/g)	7.57±0.06[a]	7.45±0.04[a]
Bulk Density (g/cm³)	0.60±0.01[a]	0.63±0.02[a]
Foaming Capacity (%)	19.6±1.1[a]	25.7±0.6[b]
Foam Stability (%)	26.0±2.1[a]	35.0±2.1[b]
Swelling Power (g/g)	4.95±0.05[a]	4.87±0.05[a]

Bulk density depends upon the particle size of the sample. The value obtained from the study was 0.6 g/cm³ and 0.63 g/cm³, respectively for mixed millet flour and mixed millet soy flour. Odoemelam [38] also reported bulk density of raw flour from jack fruit seed to be 0.61 g/cm³. Bulk density is the measure of heaviness of the flour sample. Oladele and Aina [40] reported values of 0.55-0.62 g/ml for tiger nut flours. The value obtained is comparable with those in literature, but it is higher than the other types and flours. Therefore, it can also be used as a thickener in food industries.

Swelling power is a measure of hydration capacity. The swelling power is 4.95 and 4.87, respectively for mixed millet and mixed millet soy flour. The foam capacity of the sample flours was found to be 19.6 % and 25.7%, respectively for mixed millet and mixed millet soy flour. Significant difference in foam capacity was observed between the two flours. Higher amount of proteins in soybean could contribute in increased foam capacity because of their surface-active property. This is higher than values reported for pearl millet flour and quinoa flour, 11.30% and 9%, respectively [41]. However, the value is comparable to values reported for African breadfruit kernel flour and wheat flour respectively (20% and 40%) [1]. Foam capacity is reported to be related to the amount of solubilised protein [34] and the amount of polar and non-polar lipids in the sample [36]. Foam stability of the mixed millet and mixed millet-soy flours were found to be 26% and 35%, respectively and significant difference was observed among the two flours studied. This value is observed to be higher than that for the soy flour (14.6%) and pigeon pea (20%) as reported by [41]. However, it is comparatively lower than 50.6-58.99% reported for tiger nut flour [40] and 60% and 80% have been reported for wheat flour and African breadfruit kernel flour, respectively [1]. Food ingredients with good foaming capacity and stability are required in bakery products [2].

Pasting characteristics of flour

The pasting characteristics of mixed millet flour and mixed millet-soy flour were determined by Newport Scientific Starch Master and the results are shown in the [Table-3]. For mixed millet flour, a pasting temperature of 87ºC was obtained which is slightly higher than the value of 81ºC reported for jackfruit seed flour [45]. Pasting point of 223cP and 197cP was obtained for mixed millet flour and mixed millet soy flour. Significantly higher values of peak, hold and final viscosity were observed for mixed millet soy flour. The peak, hold and final viscosity were obtained as 964, 861, 1529 cP, respectively for mixed millet flour and 2529, 1815, 4793 cP respectively for mixed millet-soy flour. The hot paste stability for mixed millet flour and mixed millet soy flour at 94°C was observed to be 94 and 100 cP respectively, suggesting a further breakdown of granules due to stirring. On cooling, the paste from 94°C to 50°C, there was a significant decrease in hot paste stability and increase in viscosity. According to [30], amylose content of flour showed greater degree of entanglement and expressed increased viscosity level during cooling phase. It was observed to be as 1416 cP for mixed millet soy flour and 2481 cP for mixed millet soy flour. From the result, however the viscosity of the cooled sample was observed to be higher than the peak viscosity value obtained. The paste stability at 50°C was 45 cP and 78 cP for mixed millet flour and mixed millet soy flour respectively; this suggests that the paste is quite resistant to shear. The low setback value of 78 cP and 82 cP for mixed millet flour and mixed millet soy flour respectively shows that the paste has a non cohesive property. The breakdown viscosity value for mixed millet flour was 103 cP which was significantly lower than mixed millet soy flour (127 cP). This higher value indicates the instability of paste.

Table-3 *Pasting characteristics of mixed millet flour and mixed millet soy flour*

Indices	Mixed millet flour	Mixed millet soy flour
Pasting point (cP)	223±13[a]	197±6[a]
Pasting temperature (°C)	87±3[a]	95±4[a]
Peak viscosity (cP)	964±38[b]	2523±80[a]
Hold viscosity (cP)	861±20[b]	1815±72[a]
Final viscosity (cP)	1529±105[b]	4793±77[a]
Viscosity at 94°C (cP)	807±22[b]	2499±63[a]
Viscosity at 94°C after 15min (cP)	861±27[b]	2399±57[a]
Viscosity at 50°C (cP)	1416±41[b]	2481±61[a]
Viscosity at 50°C after 15min (cP)	1461±27[b]	2559±31[a]
Paste stability at 94°C (cP)	94±6[a]	100±9[a]
Paste stability at 50°C (cP)	45±3[b]	78±4[a]
Breakdown (cP)	103±2[b]	127±4[a]
Setback (cP)	78±4[a]	82±4[a]

With increase in temperature from 50°C to 94°C, a constant rise in viscosity was observed. This temperature and viscosity increase were due to the gelatinization of starch. During gelatinization, the starch granules take up warm water; they soak and swell, causing an increase in viscosity. As the starch granules expanded due to water absorption during heating, their volume fraction increased and reached a maximum peak value. This value is reflective of the concentration of starch and level of amylase. The dough when held at 94°C, further enzymatic breakdown of the gelatinized starch occurred due to the combined action of α- and β-amylase. Due to the action of β-amylase, maltose production is continuous and viscosity is started to reduce. This decrease can be attributed mainly to the endo-hydrolytic action of α-amylase rather than the exo-hydrolytic action of β-amylase. The temperature was further increased to 95°C, wherein β-amylase is less active. Enzyme inactivation is the interaction between time and temperature. With increase in time at temperature 95°C, β-amylase is inactivated. The α-amylase further breaks down the gelatinized starch and low molecular weight components [45]. The pasting profile of millet mixed flour and millet-soy flour suggests that the starch of these flours has moderate peak viscosity with moderate process tolerance and may be susceptible to over-cooking.

Physical characteristics of cookies

[Table-4] shows the physical properties of mixed millet cookies and mixed millet soy cookies. The thickness of the cookies was optimized as 5.2mm and 7.1mm, respectively for mixed millet cookies and mixed millet soy cookies, respectively. When the thickness was increased, the end product obtained was not desirable due to uneven baking of the centre and crust of cookies. On increasing the time to bake, the centre portion was baked, the crust portion started to get over-baked. Diameter of the cookies was fixed with 5.3cm for both samples. Increasing the diameter did not have any effect on the baking characteristic of the cookies. Spread ratio was found to be 10.19 and 7.46 for mixed millet cookies and mixed millet soy cookies, respectively. Chauhan et al. [14] observed that the diameter and spread ratio of the cookies displayed an increasing trend along with the increasing level of amaranth flour. It implies that the quality of protein may also affect the water absorption characteristics of flour and hence spread ratios of cookies. The main hydrophilic components of cookies are flour and sugar. Dough with lower viscosity causes cookies to spread at a faster rate [22]. Cookies having higher spread ratio are considered most desirable [17, 28]. Singh et al. [44] documented that the spread ratio of cookies increased as non-wheat protein content increased.

Table-4 *Physical characteristics of mixed millet cookies and mixed millet soy cookies*

Indices	Mixed millet cookies	Mixed millet soy cookies
Height/Thickness	5.2 mm	7.1 mm
Diameter	5.3 cm	5.3 cm
Spread ratio	10.19	7.46

Table-5 *Nutritional composition of flour and cookies*

Proximate Composition	Mixed millet flour (g per 100g)	Mixed millet cookies (g per 100g)	Mixed millet soy flour (g per 100g)	Mixed millet soy cookies (g per 100g)
Moisture	9.99±0.40a	4.31±0.47b	10.21±0.99a	5.08±0.57b
Ash	1.13±0.38b	0.97±0.14b	3.17±0.57a	2.06±0.46b
Crude fibre	1.18±0.20b	0.01±0.003c	4.32±0.42a	0.18±0.03c
Crude fat	2.21±0.32b	26.65±1.15a	1.56±0.14b	27.20±1.43a
Crude protein (Nx6.25)	8.93±0.32c	5.71±0.43d	25.63±0.35a	13.50±0.80b
Carbohydrate	76.51±0.74a	62.25±0.38b	55.09±1.55c	50.80±1.85d
Calorific value (kcal)	379±10.60b	533±12.74a	384±16.70b	565±8.08a

Changes in proximate composition after baking

Baking decreases the level of all the nutrients to a considerable extent. Hence the nutritional profile of the flour was compared with the prepared cookies. The significant reduction in moisture content was observed during baking operation. Moisture content of mixed millet cookies and mixed millet soy cookies was 4.31% and 5.08 %, respectively after baking. [Table-5] shows the nutritional composition of flour and cookies.

Ash content of the mixed millet cookies was decreased from 1.13 % to 0.97 % after baking, similarly the ash content of mixed millet soy cookies has significantly decreased from 3.17 % to 2.06 % after baking. Ash content in wheat-fish protein concentrate biscuits was reported as 7.28 % [23], 8.01% in acha-beniseed biscuit [8] and 5.9% in sesame-refined wheat flour-maize biscuit [18]. Crude fibre content also decreased significantly during baking of both the flours. Significant increase in the fat content of the cookies was observed due to the addition of butter during cookies preparation. Protein is of prime importance in any food product. Though the protein content has decreased significantly during baking, mixed millet soy cookies had 13.5 % protein. The protein content of mixed millet-soy cookies was higher than wheat-orange peel and pulp biscuit [32] which had 6.71%, wheat-fish protein concentrate biscuit [23] with 12.5% protein, wheat-maize biscuit [20] in which protein content was found to be 11.56%, wheat-cassava-soybean biscuit with 11.39% protein and pigeon pea-cocoyam-wheat-refined wheat flour biscuit [39] in which 9.55% protein was recorded. It is however lower when compared to wheat-soybean biscuit [10] wherein protein content was 24% and sesame-maida-maize biscuit which had 18.3% protein [18]. Carbohydrates play an important role in human body as they provide energy. The carbohydrate content of mixed millet cookies and mixed millet soy cookies were found to be 62.25 and 50.8% respectively. Significant change in carbohydrate was observed during baking and among two types of cookies studied. It is higher than the level in wheat-fish protein concentrate biscuit which was found to be 40.26% [23]. It is however lower than 71.56% as reported in pigeon pea-cocoyam-wheat-maida biscuit [39]. The calorific value of the mixed millet and mixed millet-soy cookies were found to be 533kcal and 565kcal, respectively. Calorific value was observed to be increased significantly during baking of both the flours and significant difference in calorific value was found among two types of cookies prepared.

Phytochemical analysis

The amount of anti-nutritional factors found in the cookies is shown in [Table-6]. The tannin content of both the cookies was observed to be less as compared to the cookies made from cocoyam and soy flour. The cocoyam-soy biscuit contained 0.50 and 0.67 mg/100g tannin and phytic acid, respectively [39]. Wheat flour biscuit had 0.69 and 0.47 mg/100g of tannin and phytic acid, respectively. Significant difference in tannin and total polyphenol content of both the cookies was observed.

Table-6 *Phytochemical composition of mixed millet and mixed millet-soy cookies*

Indices	Mixed millet cookies	Mixed millet-soy cookies
Tannin (mg)	0.393±0.005a	0.310±0.008b
Total polyphenol (mg)	0.509±0.007a	0.642±0.008b
Phytic acid (mg)	0.68±0.02a	0.72±0.02a

Amino acid analysis

The amino acid analysis of the mixed millet cookies and mixed millet soy cookies was carried out by HPLC and the composition of the amino acids are shown in [Table-7]. Eight essential amino acids namely, histidine, threonine, valine, methionine, phenylalanine, isoleucine, leucine and valine are present in significant quantity. The amount of all the amino acids in mixed millet soy cookies was observed to be higher than the amino acids in wheat biscuits supplemented with fish protein concentrate. The glycine, threonine, methionine, phenylalanine, isoleucine, leucine and lysine levels in mixed millet-soy cookies were higher than the recommended requirement as per FAO/WHO. The valine and isoleucine levels were almost equal to the recommended allowance for both child and adult [23]. It is evident that the developed cookies contain all the essential amino acids in good proportion.

Table-7 *Amino acid composition of mixed millet and mixed millet-soy cookies*

Amino Acid (g/100g protein)	Mixed millet cookies	Mixed millet soy cookies
Aspartic acid	4.88±0.14a	3.47±0.09b
Glutamic acid	8.64±0.13a	6.37±0.12b
Serine	1.78±0.10b	9.76±0.13a
Histidine	0.931±0.018b	42.87±0.71a
Glycine	0.878±0.011b	4.932±0.091a
Threonine	2.2±0.18b	3.3±0.33a
Alanine	3.617±0.251b	17.899±0.608a
Arginine	1.85±0.08b	6.06±0.46a
Tyrosine	1.142±0.030b	4.113±0.098a
Valine	1.92±0.11b	3.7±0.26a
Methionine	1.8±0.092a	1.8±0.084a
Phenylalanine	3.43±0.13b	9.63±0.36a
Isoleucine	0.99±0.11b	2.6±0.09a
Leucine	4.2±0.33b	12.58±0.23a
Lysine	1.14±0.20b	7.05±0.42a

Table-8 *Hardness and breaking strength of the cookies*

Indices	Mixed millet cookies	Mixed millet-soy cookies
Hardness (kg)	2.842±0.145a	2.136±0.124b
Breaking strength (kg)	1.069±0.039a	0.861±0.058b

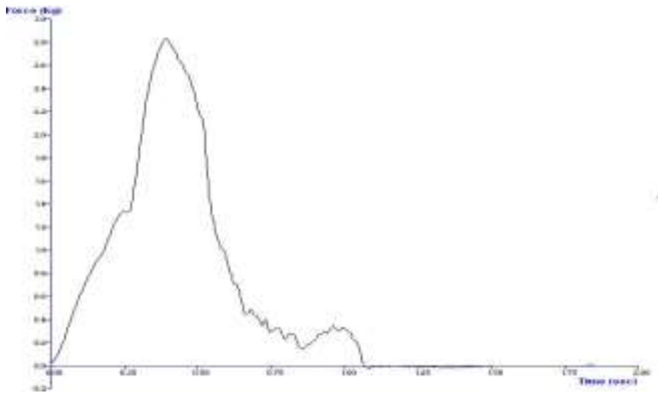

Fig-1 Typical graph showing hardness of mixed millet cookies in texture analyser

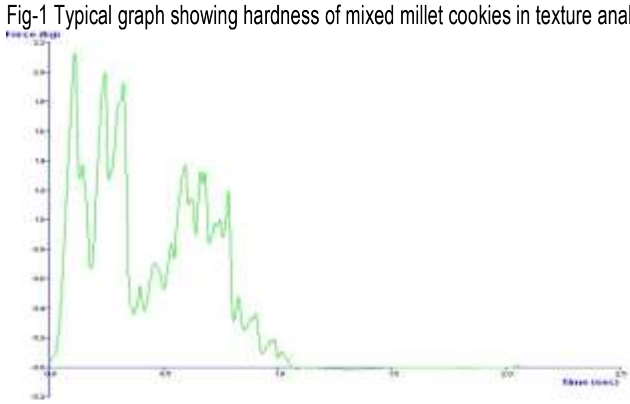

Fig-2 Typical graph showing hardness of mixed millet-soy cookies in texture analyser

Texture analysis of cookies

Textural properties are one of the most important quality parameters, which affect the demand for cookies. The breaking strength of mixed millet cookies and mixed millet soy cookies are 1.069 kg and 0.861 kg, respectively [Table-8], the results are in correspondence with breaking strength of wheat-plantain biscuits which had a value of 1.90 kg and wheat biscuits which had a value of 1.10 kg. It is however lower than wheat or maida free plantain biscuits (3.45 kg) [21] and wheat-african breadfruit biscuit which had breaking strength of 2.494kg [3]. [Fig-1] and [Fig-2] shows typical graphs of hardness of mixed millet and mixed millet soy cookies measured in texture analyser. Hardness of the cookies were observed as 2.842 kg and 2.136 kg, respectively, for mixed millet cookies and mixed millet soy cookies. Significant difference in hardness and breaking strength among the two types of cookies was observed. The low biting/breaking strength along with high hardness gives more advantage to the cookies as the shape can be maintained during storage and transportation, without any difficulty in biting and chewing.

Conclusion

Gluten-free and healthy cookies were formulated in this study using equal proportion of Barnyard millet, Little millet, Kodo millet, Proso millet and Great millet. For millet-soy cookies, millets and soy in the ratio 3:1 resulted in the required texture, flavour and quality. The mixed millet and mixed millet-soy flour have good water binding ability (2.729 ml/g and 2.388 ml/g respectively), high flavour retaining capacity (7.57 ml/g and 7.45 ml/g respectively), good water retention power (4.95g/g and 4.85g/g, respectively), and good foam capacity and stability. The amount of tannin, phytate and polyphenols was low and in reasonable agreement with those reported by commonly consumed food articles. The glycine, threonine, methionine, phenylalanine, isoleucine, leucine and lysine levels in millet-soy cookies were higher than the level recommended by FAO/WHO. The valine and isoleucine levels were nearly equal to the recommended allowance for both child and adult. The pasting profile of millet mixed flour and millet-soy flour suggested that the starch of these flours has moderate peak viscosity with moderate process tolerance and may be susceptible to over-cooking. The low biting/breaking strength along with high hardness provides desirable to the cookies as the shape can be maintained during storage and transportation, without any difficulty in biting and chewing. It is inferred that acceptable and good quality cookies could be produced from millet flour and soy flour completely without the use of wheat/maida which could be a healthy alternative to the conventional biscuits and also for consumers with gluten sensitivity/celiac disease.

Application of Research: This study guides the utilization of minerals and nutrient rich millets in the development of affordable gluten free cookies to the mankind and pet animals which can provide the food security to the millet growing economies.

Research Category: Food Technology, Biochemistry

Abbreviations: RTE: Ready to eat
g: gram; kg: kilo gram; s: seconds; min: minutes
cP: centi poise; kcal: kilo calories; ml: milli litres
HPLC: High performance liquid chromatography
FAO: Food and Agriculture Organization
WHO: World Health Organization

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Study area / Sample Collection: Local Market, Chennai

Cultivar / Variety name: Barnyard millet (*Echinochloa frumentacea*), Little millet (*Penicum milliare*), Foxtail millet (*Setaria italica*), Kodo millet (*Paspalum scrobiculatum*) and Great millet (*Sorghum bicolor*)

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