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Nutritional, sensory, and antioxidant characteristics of composite multigrain flour biscuits blended with sweet potato flour

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Abstract

Biscuits prepared using composite flour (CF) blends made from multigrain flour (MGF) and sweet potato flour (SPF) were compared with biscuits prepared using wheat flour (WF; control). Three proportions of MGF:SPF were used to prepare CF biscuits: T1 (80:10), T2 (75:15), and T3 (70:20), while 100% WF biscuits served as control. MGF enriched the biscuits with antioxidants, dietary fibre, and protein. The addition of SPF produced softer biscuits. When 5% each of pumpkin flour (PF) and extruded soy chunk flour (ESF) were added to CF biscuits, it helped in improving their colour, texture, and taste scores. The physicochemical, antioxidant, textural, and sensory analyses were performed on both CF and control biscuits, and results showed a significant difference in nutritional contents between them. Substitution of wheat flour with MGF in experimental biscuits led to a significant increase in protein contents of T1 and T2 samples. Fibre and ash contents were the highest for T3 sample at 1.52 and 1.71%, respectively. T3 sample was also found to have higher levels of antioxidant activity (22%) and total phenolic content (234 mg GAE/100 g). The CF biscuits had a higher β-carotene content (390 to 823 μg/100 g). CF biscuits were darker in colour and less hard. T3 sample gave a sensory performance comparable to that of the control. Therefore, the present work suggested that composite multigrain flour with sweet potato flour can be used to produce biscuits with superior nutritional, antioxidant, and sensory qualities as compared to ordinary wheat biscuits.

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Introduction

Good health begins with a healthy diet and sound nutrition. So the true definition of food and nutrition follows the dictum “bringing diverse diets that fulfil all the needs of human beings, to everyone’s table” (WHO, 2003). To achieve good nutrition, widely consumed food products like biscuits can be targeted for nutrient enrichment. The use of composite flour (CF) with a lower proportion of wheat, in addition to different indigenous types of cereals as a source of carbohydrates, has been explored in recent years. The nutritional quality of multigrain flour (MGF) biscuits with combinations of cereal millets like sorghum and pearl millet has been found to improve due to the presence of a higher amount of phenolics and higher antioxidant activity (Laguna *et al.*, 2011; Omoba *et al.*, 2015; Nzamwita *et al.*, 2017: Giuberti *et al.*, 2018). But, the millet multigrain flour tends to produce darker biscuits with less visual appeal (Walde *et al.*, 2021). The utilisation of sweet potato in biscuit-making has been widely studied due to the presence of constituents like anthocyanins, carotenoids, dietary fibres, phenolics, antioxidants, and vitamins (Brennan and Samyue, 2004; Nzamwita *et al.*, 2017). Sweet potato flour (SPF) has been found to produce lighter and softer biscuits (Sun *et al.*, 2014; Nzamwita *et al.*, 2017). The inclusion of extruded soy chunk flour (ESF) in the preparation mix increases protein, dietary fibre, and ash, in addition to improving the functional qualities of biscuits (Silva *et al.*, 2018). The inclusion of pumpkin (*Cucurbita moschata* L.) as pumpkin flour (PF) during preparation tends to enrich ash, fibre, and protein without affecting the sensory quality of the biscuits (Gurung *et al.*, 2016).

The use of short doughs with high levels of unsaturated fats and sugars in biscuits are known to

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make them unhealthy. Therefore, in the present work, fat was replaced with unrefined groundnut oil, and sugar with palm jaggery, to acquire overall nutritional benefits. The use of multigrain flour (MGF) obtained from KVK, Kattupakkam, India for nutritious product development and better marketability was thus explored. The present work aimed to develop nutritious and palatable biscuits using natural ingredients such as MGF, SPF, ESF, and PF. The effect of varying the concentration of SPF on physicochemical, antioxidant, and sensory qualities was also analysed.

Materials and methods

Raw materials

Fleshy sweet potato (*Ipomoea batatas*), palm jaggery, groundnut oil, mature pumpkin (*Cucurbita pepo*), and soy chunks were purchased from a local market in Red Hills, Chennai, India. Multigrain flour (MGF) prepared with 70% wheat flour, 10% sorghum flour, 10% foxtail millet, and 10% finger millet was purchased from KVK Centre, Veterinary and Animal Sciences University, Tamil Nadu, India. All other baking ingredients were purchased from a local market in Red Hills, and stored at room temperature.

Preparation of flours from sweet potatoes, pumpkin, and soy chunks

Sweet potatoes of medium size were chosen, cut into cubes of 2 cm thickness, blanched at 50 - 60°C, and dried at 60°C for 6 h in a convection oven (Stericox 2, Model STXLO28, India). The dried pieces were milled into powder using a mixer grinder (Preethi, Model MG 139, India), and were sieved using a 80 µm mesh screen (Figure 1).

Yellow-fleshed mature pumpkins were washed, sliced (2 cm thickness), and dried. After drying at 60°C for 6 h in a convection oven (Stericox 2, Model STXLO28, India), the pumpkin pieces were ground into powder and sieved using 52 µm mesh sieves.

Extruded soy chunks were heat-roasted at 80°C for a few seconds and then cooled, milled, and sieved in 60 µm mesh sieves. The flours were stored until use in air-tight containers.

Combinations of composite flours

The composite flour (CF) was prepared by blending MGF with SPF. Then, 5% each of PF and ESF were added to provide natural colour and flavour (the proportion of 5% was selected based on sensory acceptability in preliminary trials). ESF was added to enrich the flour with protein and fibre contents. Table 1 shows the different blends of SPF and MGF used in the preparation of composite flour and their respective codes.

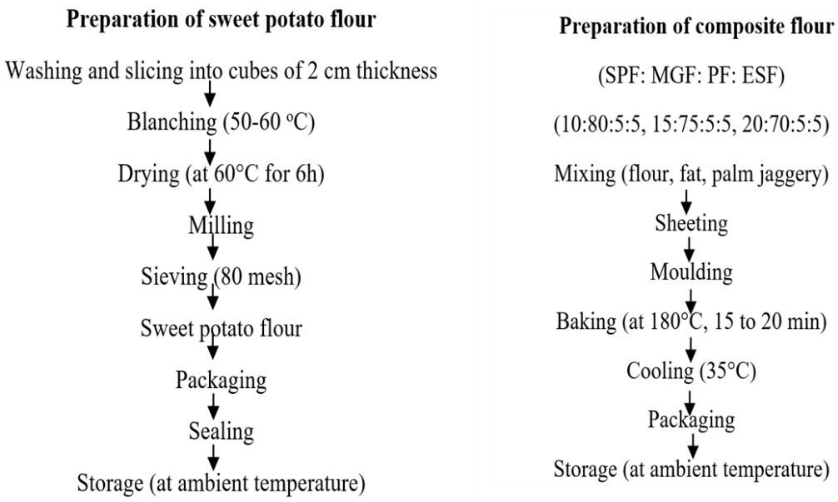

Figure 1. Flow chart for preparation of sweet potato flour and composite flour biscuits.

Table 1. Composite flour combinations.

Treatment	Sweet potato flour (%)	Multigrain flour (%)	Pumpkin flour (%)	Extruded soya chunk flour (%)
T1	10	80	5	5
T2	15	75	5	5
T3	20	70	5	5

Preparation of biscuits

The recipe for the preparation of biscuits was adapted from a previous study, where composite flour (100 g), unrefined oil (50 ml), and palm jaggery (50 g) were mixed together (Davidson, 2016). The dough was kneaded with groundnut oil and palm jaggery for 15 - 20 min to obtain a suitable consistency. It was then sheeted and cut into pieces using docker holes. The sheeted and pieced dough was baked at 180°C for 15 - 20 min, followed by cooling for 30 min. The process flow chart is depicted in Figure 1. The biscuits were then packed in high-density polyethylene (HDPE) bags, and stored for further analysis. Biscuits prepared with wheat flour (WF) using the same procedure served as control.

Physical properties of biscuits

Biscuits' physical properties including thickness, circumferential diameter, and spread ratio (calculated by dividing the diameter by thickness) were determined using the method described by Bala *et al*. (2015). The readings were taken using vernier calliper by placing four biscuit samples edge to edge. Six readings were repeated, and the mean values were reported.

The hardness of biscuits was determined using a texture analyser (StableMicro Systems, model no. TA-TX2) with a load cell of 50 kg. A 3-point bend ring was used to perform a 'snap' test for which the settings were as follows: pretesting speed, 0.5 mm/s; testing speed, 0.5 mm/s; post-testing speed, 2 mm/s; distance, 5 mm; trigger type, auto 20 g; the rate of data acquisition was at 100 points per second. A minimum of ten biscuits were kept for each set, and the peak force to break them was recorded for all samples. From the force-time plots, the peak force measured as hardness (N) was determined (Mudgil *et al.*, 2017). Six readings were repeated, and the mean values were reported.

Colour of biscuits

The colour attributes of redness or greenness (a* value), yellowness or blueness (b* value), and lightness (L* value) were determined using a colour measuring device (Chromameter CR-400, Minolta). The readings were taken after calibrating the device with a standard whiteboard (Mudgil *et al.,* 2017). Six readings were repeated, and the mean values were reported.

Chemical properties of biscuits

Proximate analysis

The proximate composition (moisture, protein content, fat, crude fibre, and ash content) of raw materials and the biscuit samples were determined using the standard procedures prescribed by the Association of Official Analytical Chemists (AOAC). Carbohydrates were determined by difference (AOAC, 2007). Six measurements for each combination were made, and the mean values were reported.

Total phenolic content

The biscuits samples were extracted with 60% methanol for 4 h at 27°C, and filtered after centrifuging for 15 min at 10,000 g. The phenolic content of the samples was determined by Folin's Ciocalteu method using gallic acid standard as described by Katalinic *et al.* (2006). Absorbance was then taken at 753 nm with an ELICO UV-Visible spectrophotometer (Model SL 159, India). The absorbance obtained was expressed as GAE/100 g of dry mass. Six measurements for each combination were taken, and the mean values were reported.

β-carotene

The biscuit samples were extracted with 95% ethanol, and their absorbance was measured at 540 nm using an ELICO UV-Visible spectrophotometer (Model SL 159, India). Six measurements for each combination were taken, and the mean values were reported.

Antioxidant activity

Antioxidant activity was determined by estimating the level of free radical scavenging in the samples using DPPH assay following the method described by Brand-Williams *et al*. (1995). Approximately 2 mL of 10 mM DPPH solution was added to the sample extract (different volumes between 0.4 and 2 mL), and made up to 2 mL with ethanol. Contents were mixed well, and incubated at dark for 30 min. Absorbance of the prepared sample was read at 520 nm using an ELICO UV-Visible spectrophotometer (Model SL 159, India). The % scavenging activity was calculated using Eq. 1:

$$\text{\% Scavenging activity} = \frac{(D_0) - (D_1)}{(D_0)} \qquad \text{(Eq. 1)}$$

where, D_0 and D_1 = % absorbance of control and the sample, respectively. Six measurements for each combination were taken, and the mean values were reported.

Sensory evaluation

The sensory evaluation is an important test in the food industry. Biscuits prepared by blending of MGF with different levels of SPF were subjected to sensory evaluation, and compared with the sensory evaluation results of the control biscuits made of 100% WF. The organoleptic attributes of the biscuits including colour, taste, texture, flavour, chewability, as well as overall acceptance were assessed by 25 trained panellists who were regular biscuit consumers. The samples were randomly coded, and panellists were requested to assess the biscuits using a 9-point hedonic scoring, with the values ranging from 9 for 'like extremely' to 1 for 'dislike extremely'. The ethical code of sensory testing was followed during the trials (Adegunwa *et al*., 2020). The results of the sensory assessment (colour, flavour, taste, texture, chewability, and overall acceptability) are given in Table 2.

Table 2. Sensory evaluation of biscuits made from composite flour blends.

Treatment	Colour	Flavour	Taste	Texture	Chewability	Overall
Control	8.63 ± 0.05^a	8.33 ± 0.05^a	8.65 ± 0.05^a	8.55 ± 0.09^a	8.32 ± 0.03^a	42.60 ± 0.02^a
T1	6.66 ± 0.57^b	7.00 ± 0.00^b	7.33 ± 0.57^b	7.00 ± 0.00^b	7.00 ± 0.00^b	35.00 ± 1.00^b
T2	7.66 ± 0.57^c	7.33 ± 0.57^b	7.66 ± 0.57^b	7.66 ± 0.57^c	8.00 ± 0.00^c	38.30 ± 0.57^c
T3	8.66 ± 0.57^a	8.33 ± 0.57^a	8.66 ± 0.57^a	8.00 ± 0.00^c	8.00 ± 0.00^c	41.60 ± 0.57^a

Mean values with different lowercase superscripts within columns are significantly different ($p < 0.05$).

Ethical responsibility

All procedures performed in studies involving human participants were as per the ethical standards of the institutional and/or national research committee, and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Statistical analysis

The data were analysed statistically using suitable tests wherever required. Standard deviation and ANOVA were used in the statistical analysis. One-way ANOVA and multiple comparisons test (Duncan's *post-hoc* test) were used to analyse the data. The significant difference in the data at $p < 0.05$ was assessed. Statistical analyses were performed using the statistical package SPSS (Version 20).

Results and discussion

Physical and colour attributes of biscuits

The physical characteristics of the biscuits are reported in Table 3.

Table 3. Physical and colour characteristics of biscuits made from composite flour blends.

Parameter	Control	T1	T2	T3
Hardness (N)	87.27 ± 1.29^a	70 ± 1.72^b	65.86 ± 1.63^c	54.95 ± 3.39^d
Diameter (cm)	4.01 ± 0.00^a	4.15 ± 0.00^b	$4.17 \pm 0.00b^c$	4.18 ± 0.02^c
Thickness (cm)	0.64 ± 0.00^a	0.66 ± 0.01^{ab}	0.67 ± 0.01^{bc}	0.69 ± 0.01^c
Spread ratio	6.27 ± 0.02^a	6.29 ± 0.14^{ab}	6.22 ± 0.12^{bc}	6.06 ± 0.11^c
L^*	61.53 ± 0.7^a	50.23 ± 0.17^b	44.72 ± 0.96^c	42.57 ± 0.83^d
a^*	4.67 ± 0.21^b	0.37 ± 0^a	0.34 ± 0^a	0.41 ± 0^c
b^*	27.39 ± 0.31^c	19.68 ± 0.34^b	22.58 ± 0.19^a	22.38 ± 0.22^a

Mean values with different lowercase superscripts within rows are significantly different ($p < 0.05$).

The diameter and thickness increased ($p < 0.05$) with the addition of SPF in CF, yet considerable decrease in the spread ratio was seen in the test samples. T1 sample reported the highest spread ratio (6.29 ± 0.14). Even though the diameter increased, overall decrease in the spread ratio was pronounced by the eventual increase in the thickness (inversely related to spread ratio). The desirable changes in the spread ratio were directly dependent on the composition of the flour used. The pronounced decrease in the spread ratio and weakening of the texture with SPF addition might have been due to the loss of water retention capacities of proteins and carbohydrates present in SPF after blanching and drying (Fustier *et al*., 2008). This could also have been due to the lower gluten interactions with SPF addition (Mudgil *et al*., 2017). Even though an increase in the spread ratio is considered a desirable functional attribute of biscuits, chewability scores of T2 (15% SPF) and T3 (20% SPF) were comparable to that of the control, and did not seem to greatly affect the texture scores (Table 2). The differences in the hardness values of CF biscuits were significant ($p < 0.05$) in comparison to the control (WF biscuits). Moreover, the hardness values decreased in a concentration-dependent manner with the addition of SPF at $p < 0.05$, leading to a desirable softer texture. Rheological properties tend to get affected by the method used for processing starches, and in the present work, the blanching step involved in SPF production could have been the cause for decreased hardness in biscuit making. It can again be correlated to the lower protein and carbohydrate contents, which in turn resulted in fewer interactions of these ingredients with one another, while a higher level of gluten interactions are generally responsible for harder cookies (Fustier *et al*., 2008; Olagunju *et al*., 2013; Mudgil *et al*., 2017).

Colour is the first and major attribute impacting consumers' acceptability. The results of the colour determination are depicted in Table 3. The lightness (L^*), redness (a^*), and yellowness (b^*) values were lower ($p < 0.05$) in the test samples as compared to those of the control samples. Maillard browning and caramelisation of the starches present in the SPF could have led to the lower L^* values (Srivastava, 2012). A similar study on the development of multigrain chappatis from composite flour combination of wheat, bajra, and ragi at a ratio 75:15:10, respectively, showed a similar reduction in L^* values (46.29) than the one prepared at a ratio 75:10:15 (54.64), and that prepared with wheat and ragi at 90:10 (49.27). It was also quoted that L^* value of 100% wheat chappatis (50.38) was higher than any of these combinations (Walde *et al*., 2021), which agreed with the results observed in the present work. The yellowish-brown to greenish-yellow colour of the biscuits as depicted by positive a^* and b^* values might have been due to significant amount of carotenoids and other polyphenolic compounds present in SPF and PF (Hamdani *et al*., 2020).

Proximate composition of biscuits

The results of the proximate compositional analysis of raw ingredients are presented in Table 4, while those obtained for WF biscuits and biscuits made from composite flour (CF) are presented in Table 5.

Table 4. Proximate composition of raw materials.

Parameter (%)	MGF	WF	SPF	PF	ESF	Palm jaggery
Moisture	6.33 ± 0.03^a	5.89 ± 0.21^b	9.33 ± 1.10^c	6.83 ± 0.05^d	2.83 ± 0.14^e	1.03 ± 0.00^f
Fat	1.09 ± 0.02^a	1.11 ± 1.14^a	0.49 ± 1.90^b	1.70 ± 0.00^c	4.05 ± 0.05^d	0.21 ± 0.11^e
Protein	15.43 ± 0.03^a	8.09 ± 2.07^b	5.41 ± 0.50^c	12.90 ± 0.03^d	41.43 ± 0.01^e	1.14 ± 0.21^f
Crude fibre	2.83 ± 0.00^a	0.97 ± 0.02^b	3.91 ± 0.34^c	9.43 ± 0.01^d	3.01 ± 0.03^e	0.01 ± 0.00^f
Ash	2.12 ± 0.09^a	1.87 ± 0.62^b	1.06 ± 0.02^c	7.52 ± 0.08^d	2.10 ± 0.19^e	2.81 ± 0.01^f
Carbohydrate	72.22 ± 0.47^a	82.06 ± 0.00^b	83.22 ± 0.42^b	61.67 ± 0.88^c	46.58 ± 1.13^d	94.83 ± 0.00^e

Mean values with different lowercase superscripts within rows are significantly different ($p < 0.05$).

Table 5. Proximate composition of biscuits made from composite flour blends.

Parameter (%)	Control	T1	T2	T3
Moisture	6.33 ± 0.06^a	5.63 ± 0.08^b	5.83 ± 0.13^c	6.01 ± 0.01^d
Fat	21.12 ± 0.01^a	21.04 ± 0.04^a	21.05 ± 0.05^a	21.11 ± 0.11^a
Protein	6.07 ± 0.03^a	7.76 ± 0.06^c	6.68 ± 0.01^b	6.16 ± 0.11^a
Crude fibre	0.83 ± 0.01^a	0.65 ± 0.02^b	0.86 ± 0.03^a	1.52 ± 0.00^c
Ash	0.91 ± 0.01^a	1.01 ± 0.03^a	1.43 ± 0.11^b	1.71 ± 0.01^c
Carbohydrate	70.66 ± 0.41^a	70.98 ± 0.25^a	69.82 ± 1.13^b	67.98 ± 0.00^c

Mean values with different lowercase superscripts within rows are significantly different ($p < 0.05$).

CF biscuits had their moisture contents lower than that of WF biscuits. Furthermore, the crude fibre and ash contents seemed to be significantly higher for T2 and T3 samples. Crude fibre contributions came from PF, SPF, and ESF (Table 4). Pumpkin flour (9.43%) enriched crude fibre in the test samples followed by SPF (3.91%) and ESF (3.01%). The richness of nutritionally valuable dietary fibre components in SPF were observed by several authors (Lund *et al*., 1983; Srivastava, 2012). A study on the crude fibre content of 40 sweet potato cultivars revealed that its fibre content varied from 9.15 ± 0.49 to 14.26 ± 0.38% dw (Scott and Matthews, 1957). In the present work, crude fibre content of CF biscuits having SPF content of 20% was 1.8 times higher than that of WF biscuits (0.84%). This finding is in agreement with an analogous study conducted with composite flour cookies using SPF and spent grain flour, in which the fibre content was reported to be 1.8 - 3.1% (Laguna *et al*., 2011). A similar study on biscuits made by blending different levels of SPF reported that the addition of 20% SPF resulted in the production of bakery goods with improved functional properties (Srivastava, 2012). With an increase in the SPF level in the CF, the carbohydrate content decreased significantly ($p < 0.05$). This might have been the reason for the carbohydrate loss observed in sweet potato during processing and storage, as well as for the increase in other nutrients such as proteins, fibres, and minerals in CF biscuits as shown in Table 5 (Hamdani *et al*., 2020). A similar trend of decreased carbohydrate content was also reported by Farzana and Mohajan (2015) when the biscuit flour was supplemented with malted soy flour. Even though SPF had a lower protein content (5.41%) than WF (8.09%), the CF in which ESF (41.43%) and MGF (15.43%) were added acted well to mitigate the protein loss in CF biscuits (Farzana and Mohajan, 2015). Protein content was significantly higher ($p < 0.05$) in T1 sample (7.76%) followed by T2 (6.68%), which could be attributed to MGF (protein content of 15.43%). While protein content of T3 was comparable to that of the control. There was no significant difference ($p > 0.05$) in ash and fat contents at lower levels of SPF (10%). However, a significant difference was observed for crude fibre and protein contents.

Total phenolic content, antioxidant activity, and β-carotene content of biscuits

The total phenolic content of CF biscuits was significantly higher ($p < 0.05$) for various proportions of SPF blends, as shown in Table 6.

Table 6. Phenolic content, antioxidant activity, and β-carotene content of biscuits made from composite flour blends.

Parameter	Control	T1	T2	T3
DPPH activity (%)	0.92 ± 0.01^{a}	6.55 ± 0.27^{b}	17.18 ± 0.18^{b}	22.06 ± 0.04^{d}
TPC (mg GAE/100 g)	40. 11 ± 0.01^{a}	134.5 ± 0.51^{b}	142.46 ± 0.52^{c}	234.61 ± 0.45^{d}
β-carotene (µg/100 g)	2.06 ± 0.04^{a}	390.32 ± 0.73^{b}	611.7 ± 0.82^{c}	823.64 ± 1.12^{d}

Mean values with different lowercase superscripts within rows are significantly different ($p < 0.05$).

The phenolic content ranged between 134 and 234 mg GAE/100 g, showing maximum values for the T3 sample, which had the highest SPF content (20%) among the samples. The obtained values were higher than the values reported by Aziz *et al.* (2018), where incorporation of 30% SPF in biscuits resulted in a phenolic content of 54 mg GAE/100 g. The drastic increase in phenolic content observed in the present work might have been attributed to the native phenolic composition of composite flour consisting of pumpkin, soy, and sweet potato flours. Studies have reported that the phenolic content of sweet potato ranges from 9.6 to 54 mg/g dw depending on its variety (Ji *et al*., 2015), and 10 - 15 g/kg (Ahmed *et al*., 2010) depending on the demography. It was also reported in studies that the pumpkin and soy flours possess total phenolics of 1237 mg GAE/100 g dw and 4.76 g/kg dw (Šebečić *et al*., 2007; Aydin and Gocmen, 2015). It is well known that phenolic content is directly proportional to antioxidant activity. Our results also exhibited a linear relationship indicating higher DPPH values with increasing SPF levels. The antioxidant activity determined by DPPH assay was 6 - 22%. A similar increase in antioxidant activity was observed in biscuits fortified with soy flour and SPF (Omoba *et al*., 2015; Aziz *et al*., 2018). In addition to SPF, the presence of phenolics in pumpkin and soy flours might have also contributed to the antioxidant activity of biscuits. These values were far higher in comparison to WF biscuits, which were reported to possess 2% antioxidant activity and non-detectable levels of total phenolics (Sengev *et al*., 2015; Gadallah and Ashoush, 2016).

The β-carotene content in WF biscuits was 2 μg/100 g. There was a significant increase in β-carotene content with increasing levels of SPF. In biscuits where 10 - 20% of SPF was added, the initial β-carotene content was 390 and 823 μg/100 g, respectively (Table 6). A similar result was observed in cookies made from SPF having β-carotene levels of 304 μg/100 g (Sengev *et al*., 2015). The highest concentration of β-carotene was observed in biscuits in which 20% SPF was added.

Sensory evaluation of biscuits

From Table 2, it can be seen that as the level of SPF increased, the biscuits showed an increasing acceptability by the panellists. In 20% SPF biscuits, all the sensory attribute scores were the highest. Studies have shown that the incorporation of SPF up to 40% gave better results in terms of texture, flavour, colour, and overall acceptability (Srivastava, 2012). In a similar study, a composite flour made from wheat and unripe plantain flours improved the fibre content, and endowed the biscuits with better functional and sensory properties (Adegunwa *et al*., 2020). In the present work, 20% SPF was the optimum for the preparation of biscuits as these biscuits had the highest ratings in overall acceptability after WF biscuits. Therefore, the MGF in combination with extruded soy and pumpkin flour, and SPF used in the present work resulted in biscuits with a good sensory preference.

Conclusion

In the present work, composite multigrain, extruded soy chunk, and pumpkin flour with varying levels of sweet potato flour were used to prepare nutritionally enriched biscuits. The composite flour blend with a MGF:SPF:PF:ESF ratio of 70:20:5:5 was identified as the optimum combination based on the physical, chemical, and sensory properties of the prepared biscuits. The composite flour blend produced darker biscuits than the control biscuits. Pumpkin flour along with sweet potato flour gave the biscuits yellowish colour, while the extruded soy chunk and multigrain flour enriched the biscuit's protein content. The hardness of the biscuits decreased in composite flour biscuits, thus improving their textural and the overall sensory performance. From a nutrition point of view, the composite flour biscuits had a higher protein, ash, and fibre, and a lower carbohydrate content as compared to wheat flour biscuits. The phenolic content of the biscuits made from composite flour blend increased four- to six-fold as compared to control. The β-carotene content and antioxidant activity also increased linearly with the increasing concentration of SPF. Therefore, millet-based flour in combination with SPF produced highly acceptable nutritionally rich biscuits.

References

Adegunwa, M. O., Bamidele, B. O., Alamu, E. O. and Adebanjo, L. 2020. A. production and quality evaluation of cookies from composite flour of unripe plantain (*Musa paradisiaca*), groundnut (*Arachis hypogaea* L.) and cinnamon (*Cinnamomum venum*). Journal of Culinary Science and Technology 18(5): 413-427.

Ahmed, M., Akter, M. S. and Eun, J. B. 2010. Impact of α-amylase and maltodextrin on physicochemical, functional and antioxidant capacity of spray-dried purple sweet potato flour. Journal of the Science of Food and Agriculture 90(3): 494-502.

Association of Official Analytical Chemists (AOAC). 2007. Official methods of analysis of AOAC International. United States: AOAC.

Aydin, E. and Gocmen, D. 2015. The influences of drying method and metabisulfite pre-treatment on the color, functional properties and phenolic acids contents and bioaccessibility of pumpkin flour. LWT - Food Science and Technology 59(1): 26-34.

Aziz, A. A., Padzil, A. M. and Muhamad, I. I. 2018. Effect of incorporating purple-fleshed sweet potato in biscuit on antioxidant content, antioxidant capacity and colour characteristics. Malaysian Journal of Analytical Sciences 22(4): 667-675.

Bala, A., Gul, K. and Riar, C. S. 2015. Functional and sensory properties of cookies prepared from wheat flour supplemented with cassava and water chestnut flours. Cogent Food and Agriculture 1(1): 1019815.

Brand-Williams, W., Cuvelier, M. E. and Berset, C. 1995. Use of a free radical method to evaluate antioxidant activity. LWT - Food Science and Technology 28: 25-30.

Brennan, C. S. and Samyue, E. 2004. Evaluation of starch degradation and textural characteristics of dietary fiber enriched biscuits. International Journal of Food Properties 7(3): 647-657.

Davidson, I. 2016. Biscuit baking technology: Processing and engineering manual. United States: Academic Press.

Farzana, T. and Mohajan, S. 2015. Effect of incorporation of soy flour to wheat flour on nutritional and sensory quality of biscuits fortified with mushroom. Food Science and Nutrition 3(5): 363-369.

Fustier, P., Castaigne, F., Turgeon, S. L. and Biliaderis, C. G. 2008. Flour constituent interactions and their influence on dough rheology and quality of semi-sweet biscuits: A mixture design approach with reconstituted blends of gluten, water-solubles and starch fractions. Journal of Cereal Science 48(1): 144-158.

Gadallah, G. E. M. and Ashoush, S. I., 2016. Value addition on nutritional and sensory properties of biscuit using desert truffle powder. Food and Nutrition Sciences 7(12): 1171-1181.

Giuberti, G., Rocchetti, G., Sigolo, S., Fortunati, P., Lucini, L. and Gallo, A. 2018. Exploitation of alfalfa seed (*Medicago sativa* L.) flour into gluten-free rice cookies: Nutritional, antioxidant and quality characteristics. Food Chemistry 239: 679-687.

Gurung, B., Ojha, P. and Subba, D. 2016. Effect of mixing pumpkin puree with wheat flour on physical, nutritional and sensory characteristics of biscuit. Journal of Food Science and Technology Nepal 9: 85-89.

Hamdani, A. M., Wani, I. A. and Bhat, N. A. 2020. Gluten free cookies from rice-chickpea composite flour using exudate gums from acacia, apricot and karaya. Food Bioscience 35: 100541.

Ji, H., Zhang, H., Li, H. and Li, Y. 2015. Analysis on the nutrition composition and antioxidant activity of different types of sweet potato cultivars. Food and Nutrition Sciences 6(1): 161.

Katalinic, V., Milos, M., Kulisic, T. and Jukic, M. 2006. Screening of 70 medicinal plant extracts for antioxidant capacity and total phenols. Food Chemistry 94(4): 550-557.

Laguna, L., Salvador, A., Sanz, T. and Fiszman, S. M. 2011. Performance of a resistant starch rich ingredient in the baking and eating quality of short-dough biscuits. LWT - Food Science and Technology 44(3): 737-746.

Lund, E. D., Smoot, J. M. and Hall, N. T. 1983. Dietary fiber content of eleven tropical fruits and vegetables. Journal of Agricultural and Food Chemistry 31(5): 1013-1016.

Mudgil, D., Barak, S. and Khatkar, B. S. 2017. Cookie texture, spread ratio and sensory acceptability of cookies as a function of soluble dietary fiber, baking time and different water levels. LWT - Food Science and Technology 80: 537-542.

Nzamwita, M., Duodu, K. G. and Minnaar, A. 2017. Stability of β-carotene during baking of orange-fleshed sweet potato-wheat composite bread and estimated contribution to vitamin A requirements. Food Chemistry 228: 85-90.

Olagunju, A. 2013. Nutritional composition and acceptability of cookies made from wheat flour and germinated sesame (*Sesamum indicum*) flour blends. British Journal of Applied Science and Technology 3(4): 702-713.

Omoba, O. S., Taylor, J. R. N. and de Kock, H. L. 2015. Sensory and nutritive profiles of biscuits from whole grain sorghum and pearl millet plus soya flour with and without sourdough fermentation. International Journal of Food Science and Technology 50(12): 2554-2561.

Scott, L. E. and Matthews, W. A. 1957. Carbohydrate changes in sweet potatoes during curing and storage. In Proceedings of the American Society for Horticultural Science, p. 407-418. United States.

Šebečić, B., Vedrina-Dragojević, I., Vitali, D., Hečimović, M. and Dragičević, I. 2007. Raw materials in fibre enriched biscuits production as source of total phenols. Agriculturae Conspectus Scientificus 72(3): 265-270.

Sengev, I. A., Gernah, D. I. and Bunde-Tsegba, M. C. 2015. Physical, chemical and sensory properties of cookies produced from sweet potato and mango mesocarp flours. African Journal of Food, Agriculture, Nutrition and Development 15(5): 10428-10442.

Silva, F. O., Miranda, T. G., Justo, T., Frasão, B. S., Conte-Junior, C. A., Monteiro, M. and Perrone, D. 2018. Soybean meal and fermented soybean meal as functional ingredients for the production of low-carb, high-protein, high-fiber and high isoflavones biscuits. LWT - Food Science and Technology 90: 224-231.

Srivastava, S. 2012. Preparation and quality evaluation of flour and biscuit from sweet potato. Journal of Food Processing and Technology 3(12): 113-118.

Sun, H., Mu, T., Xi, L., Zhang, M. and Chen, J. 2014. Sweet potato (*Ipomoea batatas* L.) leaves as nutritional and functional foods. Food Chemistry 156: 380-389.

Walde, S. G., Agrawal, S. and Mittal, S. 2021. Development of multigrain chapatti with spices mix to enhance the nutritional values and their storage study. Journal of Food Science and Technology 58(3): 1132-1142.

World Health Organization (WHO). 2003. Diet, nutrition and the prevention of chronic diseases. In WHO Technical Report Series 916. Geneva: WHO.