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Research Article

Proximate Composition of Sweet Potato Cookie Influenced by Different Flour Ratios

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Abstract

Cookies are widely consumed bakery products due to their pleasant taste, convenience, ready-to-eat snack. However, conventional cookies are generally high in carbohydrates and fat but relatively low in dietary fiber and essential micronutrients. Therefore, the incorporation of nutritious ingredient into cookie has gained increasing attention to enhance their nutritional quality. Sweet potato (*Ipomoea batatas* L.) is a nutrient-rich tuber with high dietary fiber and bioactive compounds, making it a promising functional ingredient for bakery products. This study was carried out at Department of Food Science and Technology, Yezin Agricultural University, to investigate the effect of substituting wheat flour with different ratios of orange-fleshed sweet potato flour on the physicochemical properties, proximate composition, water activity and color characteristics of cookie during 90 days of storage. Cookies were prepared with six substitution levels of sweet potato flour (0, 10, 20, 30, 40, and 50%) using a randomized complete block design with four replications. The proximate composition, water activity and browning index were evaluated at (0, 30, 60 and 90) days of storage. The results showed that increasing the proportion of sweet potato flour were significantly increased moisture, crude fiber, and ash contents, while crude fat and crude protein contents were decreased. The water activity (a_w) values of all treatments remained below 0.60 throughout the storage period, indicating good shelf stability, although control (without sweet potato flour) cookie consistently showed higher (a_w) values than those made with sweet potato flour. The storage time had a significant effect on all measured parameters showing slightly increased in moisture and water activity (a_w) while the proximate composition gradually declined over the time. As the ratios of sweet potato flour increased in the cookie formulations, the browning index also increased correspondingly. Among the treatments, cookies containing 30% of sweet potato flour was the most desirable balance between nutritional enhancement and acceptable physicochemical properties by maintaining low water activity (a_w) during the storage. The lower ratios (10% and 20%) of sweet potato flour did not provide sufficient nutritional benefits whereas higher levels (40% and 50%) offered excessive fiber and sugar content which negatively affected cookie texture and increased browning. Therefore, the incorporation of 30% sweet potato flour was recommended for developing cookie with nutritional enhancement (fiber, minerals) without compromising the physicochemical qualities (texture, color, water activity (a_w) and shelf life) that revealed sweet potato was as a functional ingredient for the potential value-added bakery products.

Keywords: Cookies; Proximate Composition; Sweet Potato Flour

Introduction

Cookies are popular bakery products and widely consumed all over the world due to their pleasant taste, convenience, ready-to-eat snack [1]. One of the main advantages of cookie is that they provide a quick and convenient source of nutrient-rich food [2]. Generally, they are high in carbohydrates, fat and calorie, but low in fiber, vitamin, and mineral. Therefore, fortifying the cookies with natural ingredients appears to be the only solution that can enhance both the aesthetic and nutritional quality [3].

Traditionally, cookies are made from wheat flour which contain gluten that contribute to dough structure and product quality, which also contain elevated levels of fat and sugar [4]. In recent years, foods fortification has increasingly focused on improving nutritional quality [5,6]. Moreover, demand for healthy or functional foods, including fruit and vegetable-based snacks, has increased as consumers have become more aware of the importance of healthy eating habits [7]. Therefore, the food industry is focused on developing products that are affordable, readily available and able to provide desirable functional and sensory properties [8].

Sweet potato (*Ipomea batatas* L) is a starchy tuber crop that belongs to family Convolvulaceae and cultivated in over 100 countries of the world [9]. It is widely consumed across many regions and serve as a secondary staple food [10] and great source of vitamins, minerals and antioxidants. Different varieties of sweet potatoes are (orange, purple, white and yellow) which may differ in their physical and chemical characteristics. Among them, the orange fleshed sweet potato varieties have been reported to contain high level of carotenoids [11]. They are an excellent source of beta-carotene and also a good source of vitamin C and manganese. Consequently, orange-fleshed sweet potato shows strong potential for utilization in the production of bakery products, snack foods, and confectionery items [12]. The incorporating of sweet potato flour to cookie making can develop nutritional composition and promote the utilization of sweet potato as a functional ingredient in bakery products. Therefore, the research was conducted with these objectives; to assess the physicochemical properties of cookie affected by different ratios of sweet potato flour and to investigate the suitable ratio of sweet potato flour on the nutritional value and shelf life.

Materials and Methods

This experiment was conducted at the Department of Food Science and Technology, Yezin Agricultural University (YAU) from July, 2025 to January, 2026. There were six treatments (0, 10, 20, 30, 40 and 50%) of sweet potato flour in cookie making with four replications using randomized complete block design (RCBD). The ingredients for cookie making included wheat flour, orange-fleshed sweet potato flour, sugar, butter, baking powder, and salt.

Preparation of sweet potato flour

Fresh sweet potatoes (orange- fleshed) were washed, peeled and manually cut into thin slices around 1mm in thickness. Slices were directly immersed into 1% NaCl solution, and then immersed in citric acid 0.5% solution for 30 minutes to prevent enzymatic browning which inhibits polyphenol oxidase activity and microbial growth. These slices were dried at 60 °C for 6 hours by hot air oven drying and the dried chips were ground into flour using an electric grinder and passed through a sieve. The flour was packed in an air tight plastic cup and stored at ambient condition until further use.

Preparation of sweet potato cookie

The formulation and process of cookies were referred to [13] with a minor modification. The ingredients were 100 g flour (including wheat flour and sweet potato flour according to treatment), butter (35 g), sugar (30 g), salt (0.5 g), baking powder (2 g) and water (25 ml). The butter and sugar were mixed with a hand mixer at high speed for 3 minutes until it forms a smooth cream. Then, the cream and all ingredients were mixed in a stand mixer at a medium speed to be a uniform mixture dough. The dough was shaped using roller until thickness of dough about 0.3 cm and cut by cookie cutter into pieces which were baked at 170°C for 18 minutes using an electric oven. The finished cookies were taken out, cooled and packaged in semi- transparent multi-layered aluminum foil pack and then they were stored at room temperature to evaluate physicochemical and organoleptic properties.

Data collection

The proximate composition (moisture, crude fibre, total ash, crude fat and crude protein) was determined by method [14] and the data were collected at (0, 30, 60 and 90) days after storage. The water activity (a_w) and browning index of sweet potato cookie (based on the measurement of L*, a* and b*) were also measured.

Data analysis

All collected data were statistically subjected to analysis of variance (ANOVA) using Statistix 8.0 version software, and treatment means were compared using the least significant difference (LSD) test at a 5% level of significance ($P < 0.05$).

Results and Discussion

Moisture content

The effect of different sweet potato flour on moisture content of cookie is presented in Table 1. The moisture content of cookie was highly significant difference among the treatments. There was an increasing trend in moisture content during the storage days. The moisture content of all treatments significantly showed the increasing trend ranging from 3.21 to 4.02% during the storage time. The moisture content was increased with the increasing level of sweet potato flour. At 0 day, the highest moisture content was observed in the cookie treated with 50% sweet potato flour (3.35%), the lowest one was recorded in control (3.21%). At 90 days after storage, the highest moisture content was observed in the cookie treated with 50% sweet potato flour (4.02%), while the lowest one was recorded in control (3.57%). The increase in moisture content with higher proportions of sweet potato flour may be attributed to the higher water holding capacity of sweet potato, which contains starch and dietary fiber capable of binding water. Singh, Riar and Saxena (2008) [13] reported that increased in moisture content of cookies due to high fiber content of sweet potato. This finding was similar to the findings of [15] who observed that the moisture content of cookies increased when the proportions of sweet potato flour increased.

Treatments	Moisture content (%)			
	0 das	30 das	60 das	90 das
Control	3.21 d	3.31 c	3.43 d	3.57 d
SPF_{10}	3.24 cd	3.37 bc	3.52 d	3.69 c
SPF_{20}	3.26 bcd	3.38 bc	3.55 cd	3.74 c
SPF_{30}	3.29 abc	3.46 ab	3.66 bc	3.83 b
SPF_{40}	3.31 ab	3.51 a	3.72 ab	3.86 b
SPF_{50}	3.35 a	3.57 a	3.82 a	4.02 a
$LSD_{0.05}$	0.06	0.11	0.13	0.08
Pr>F	**	**	**	**
CV%	0.95	1.83	1.94	1.18

Table 1: Effect of sweet potato flour on moisture content (%) of cookie till 90 days.

In a column, means followed by the same letters are not significantly different at P< 0.05.

**= highly significant difference; das = days after storage; Control = (without sweet potato flour); SPF_{30} = 30% sweet potato flour; SPF_{10} = 10% sweet potato flour; SPF_{40} = 40% sweet potato flour; SPF_{10} = 10% sweet potato flour; SPF_{50} = 50% sweet potato flour.

Crude fibre

The effect of different sweet potato flour on crude fibre content of cookie is presented in Table 2. The crude fibre content of cookie was highly significant differences among the treatments. There was decreasing trend in crude fibre content during the storage days. The crude fibre content of all treatments significantly showed the decreasing trend ranging from 5.25 to 4.67% during the storage time. The crude fibre content was increased with the increasing level of sweet potato flour. At 0 day, the highest crude fibre content was observed in the cookie treated with 50% sweet potato flour (5.25%) and the lowest one was recorded in control (4.73%). At 90 days after storage, the same trend remained, the highest crude fibre content was observed in the cookie treated with 50% sweet potato flour (5.20%) while the lowest one was recorded in control (4.67%). Singh, Riar and Saxena (2008) [13] stated that the crude fiber content was increased due to high fiber content of sweet potato which absorbed a large amount of water [16].

Treatments	Crude fibre (%)			
	0 das	30 das	60 das	90 das
Control	4.73 f	4.72 e	4.70 f	4.67 f
SPF_{10}	4.92 e	4.91 d	4.89 e	4.88 e
SPF_{20}	5.06 d	5.04 c	5.03 d	5.01 d
SPF_{30}	5.12 c	5.11 b	5.09 c	5.08 c
SPF_{40}	5.19 b	5.18 a	5.17 b	5.16 b
SPF_{50}	5.25 a	5.24 a	5.22 a	5.20 a
$LSD_{0.05}$	0.03	0.07	0.02	0.03
Pr>F	**	**	**	**
CV%	0.33	0.74	0.24	0.38

Table 2: Effect of sweet potato flour on crude fibre (%) of cookie till 90 days.

In a column, means followed by the same letters are not significantly different at P < 0.05.

** = highly significant difference; das = days after storage; Control = (without sweet potato flour); SPF_{30} = 30% sweet potato flour; SPF_{10} = 10% sweet potato flour; SPF_{40} = 40% sweet potato flour; SPF_{10} = 10% sweet potato flour; SPF_{50} = 50% sweet potato flour.

Ash content

The effect of different sweet potato flour on ash content of cookie is presented in Table 3. The ash content of cookie was highly significant differences among the treatments. There was decreasing trend in ash content during the storage days. The ash content significantly decreased across all treatments, ranging from 1.21% to 1.04% during storage. The ash content was increased with the increasing levels of sweet potato flour. At 0 day, the highest ash content was observed in the cookie treated with 50% sweet potato flour (1.21%) and the lowest one was recorded in control (1.05%). At 90 days after storage, the same trend remained, the highest ash content was observed in the cookies treated with 50% sweet potato flour (1.20%), while the lowest value was recorded in control (1.04%). Thus, the ash content was increased with the increasing levels of sweet potato flour. An increase in ash content showed that cookie made from sweet potato is rich in minerals and vitamins [17]. This finding was similar to [18] who observed that the ash content of cookies increased when the level of sweet potato flour increased.

Treatments	Ash content (%)			
	0 das	30 das	60 das	90 das
Control	1.05 e	1.05 d	1.04 f	1.04 d
SPF_{10}	1.07 e	1.06 d	1.06 e	1.05 d
SPF_{20}	1.11 d	1.11 c	1.10 d	1.10 c
SPF_{30}	1.14 c	1.14 b	1.14 c	1.13 b
SPF_{40}	1.19 b	1.19 a	1.18 b	1.18 a
SPF_{50}	1.21 a	1.21 a	1.20 a	1.20 a
$LSD_{0.05}$	0.02	0.03	0.02	0.03
Pr>F	**	**	**	**
CV%	1.12	1.23	0.90	1.51

Table 3: Effect of sweet potato flour on ash content (%) of cookie till 90 days.

In a column, means followed by the same letters are not significantly different at P < 0.05.

** = highly significant difference; das = days after storage; Control = (without sweet potato flour); SPF_{30} = 30% sweet potato flour; SPF_{10} = 10% sweet potato flour; SPF_{40} = 40% sweet potato flour; SPF_{10} = 10% sweet potato flour; SPF_{50} = 50% sweet potato flour.

Crude fat

The effect of different sweet potato flour on the crude fat content of cookies is presented in Table 4. The crude fat content of cookie was highly significant differences among the treatments. There was decreasing trend in crude fat content during the storage days and the crude fat of all treatments significantly showed the decreasing trend ranging from 21.71 to 18.65% during the storage time. The crude fat content was decreased with the increasing levels of sweet potato flour. At 0 day, the highest crude fat content was observed in control (21.71%) and the lowest one was recorded in the cookies treated with 50% sweet potato flour (18.95%). At 90 days after storage, the same trend remained, the highest crude fat content was observed in control (21.59%), while the lowest one was recorded in the cookie treated with 50% sweet potato flour (18.65%). The reduction in crude fat content during storage may be attributed to lipid oxidation and fat degradation overtime. Musa and Lawal (2013) [19] stated that low crude fat content may contribute to the prevention of fat rancidity. Similar results were reported by [16] who observed a reduction in crude fat content when the level of sweet potato flour increased.

Treatments	Crude fat (%)			
	0 das	30 das	60 das	90 das
Control	21.71 a	21.67 a	21.64 a	21.59 a
SPF_{10}	20.74 b	20.69 b	20.61 b	20.55 b
SPF_{20}	20.40 bc	20.35 bc	20.31 b	20.18 bc
SPF_{30}	20.11 cd	20.06 cd	19.98 bc	19.88 cd
SPF_{40}	19.80 d	19.73 d	19.64 c	19.54 d
SPF_{50}	18.95 e	18.89 e	18.75 d	18.65 e
$LSD_{0.05}$	0.52	0.55	0.64	0.56
Pr>F	**	**	**	**
CV%	1.40	1.49	1.75	1.53

Table 4: Effect of sweet potato flour on crude fat (%) of cookie till 90 days.

In a column, means followed by the same letters are not significantly different at P < 0.05.

** = highly significant difference; das = days after storage; Control = (without sweet potato flour); SPF_{30} = 30% sweet potato flour; SPF_{10} = 10% sweet potato flour; SPF_{40} = 40% sweet potato flour; SPF_{10} = 10% sweet potato flour; SPF_{50} = 50% sweet potato flour.

Crude protein

The effect of different sweet potato flour on crude protein content of cookie is presented in Table 5. The crude protein content of cookie was highly significant differences among the treatments. There was decreasing trend in crude protein content during the storage days. The crude protein content of all treatments significantly showed the decreasing trend ranging from 5.87 to 4.48% during the storage time. The crude protein content was decreased with the increasing levels of sweet potato flour. At 0 day, the highest crude protein content was observed in control (5.87%) and the lowest one was recorded in the cookies treated with 50% sweet potato flour (4.61%). At 90 days after storage, the same trend remained, the highest crude protein content was observed in control (5.75%), while the lowest one was recorded in the cookies treated with 50% sweet potato flour (4.48%). According to Musa and Lawal (2013) [19], crude protein content decreased with higher incorporation of sweet potato may be due to lower protein content of sweet potato and protein denaturation caused by high baking temperatures. Omran and Hussien (2015) [18] was conducted a similar study and observed a decrease in crude protein content when the level of sweet potato flour increased.

Treatments	Crude protein (%)			
	0 das	30 das	60 das	90 das
Control	5.87 a	5.84 a	5.80 a	5.75 a
SPF_{10}	5.22 b	5.19 b	5.15 b	5.11 b
SPF_{20}	4.98 c	4.96 c	4.93 c	4.91 c
SPF_{30}	4.85 d	4.83 d	4.80 cd	4.77 c
SPF_{40}	4.80 d	4.78 d	4.76 d	4.74 d
SPF_{50}	4.61 e	4.58 e	4.53 e	4. 48 e
$LSD_{0.05}$	0.06	0.09	0.13	0.13
Pr>F	**	**	**	**
CV%	0.62	1.02	1.48	1.39

Table 5: Effect of sweet potato flour on crude protein (%) of cookie till 90 days.

In a column, means followed by the same letters are not significantly different at P < 0.05.

** = highly significant difference; das = days after storage; Control = (without sweet potato flour); SPF_{30} = 30% sweet potato flour; SPF_{10} = 10% sweet potato flour; SPF_{40} = 40% sweet potato flour; SPF_{10} = 10% sweet potato flour; SPF_{50} = 50% sweet potato flour.

Water activity (a_w)

The effect of different sweet potato flour on water activity (a_w) value of cookie is presented in Table 6. The water activity (a_w) value of cookie was highly significant differences among the treatments. There was an increasing trend in water activity (a_w) value during the storage days. The water activity (a_w) value of all treatments significantly showed a slightly increasing trend ranging from control 0.57 to 0.59 during the storage time. The water activity (a_w) values were increased with increasing levels of sweet potato flour. At 0 day, the highest water activity (a_w) value was observed in control (0.57) and the lowest one was recorded in the cookies treated with 10% sweet potato flour (0.51). At 90 days after storage, the same trend remained, the highest water activity (a_w) values were observed in control (0.59), while the lowest one was recorded in the cookie treated with 10% sweet potato flour (0.53). The control cookies exhibited the highest water activity (a_w), whereas sweet potato flour cookies showed lower (a_w) values. This reduction may be attributed to the higher fiber content of sweet potato flour, which has strong water-binding capacity and thereby lowers (a_w) in food systems [20]. However, water activity (a_w) values increased with increasing levels of sweet potato flour in the composite cookies in agreement with the findings of [15].

Treatments	Water activity (a_w)			
	0 das	30 das	60 das	90 das
Control	0.57 a	0.57 a	0.58 a	0.59 a
SPF_{10}	0.51 d	0.51 c	0.52 e	0.53 e
SPF_{20}	0.52 cd	0.53 bc	0.53 de	0.54 de
SPF_{30}	0.53 c	0.53 bc	0.54 cd	0.55 cd
SPF_{40}	0.54 bc	0.54 ab	0.55 bc	0.56 bc
SPF_{50}	0.55 ab	0.55 ab	0.56 ab	0.57 ab
$LSD_{0.05}$	0.02	0.02	0.02	0.02
Pr>F	**	**	**	**
CV%	1.76	2.41	1.91	1.70

Table 6: Effect of different sweet potato flour on water activity (a_w) of cookie till 90 days.

In a column, means followed by the same letters are not significantly different at P < 0.05.

**= highly significant difference; das = days after storage; Control = (without sweet potato flour); SPF_{30} = 30% sweet potato flour; SPF_{10} = 10% sweet potato flour; SPF_{40} = 40% sweet potato flour; SPF_{10} = 10% sweet potato flour; SPF_{50} = 50% sweet potato flour.

Browning index (BI)

The effect of different sweet potato flour on browning index of cookie is presented in Table 7. The browning index of cookie was highly significant difference among the treatments. There was an increasing trend in browning index during the storage days and the browning index of all treatments significantly showed the increasing trend ranging from 76.84 to 200.94 from the product day to 90 days after storage. The browning index was increased with the increasing level of sweet potato flour. At 0 day, the highest browning index was observed in cookies made with 50% sweet potato flour (162.70) and the lowest one was observed in the control (76.84). At 90 days of storage, the same trend remained, with the highest browning index was observed in the 50% sweet potato flour cookies (200.94) and the lowest one was recorded in the control (84.72). The higher browning index in sweet potato cookies is primarily due to the compositional characteristics of sweet potatoes which promote non-enzymatic browning reactions during baking and storage. Moreover, the Maillard and caramelization reactions from its natural sugars enhanced higher browning due to reducing sugars and amino compounds, thereby intensifying the Maillard reaction [21]. Similar results were reported by [22], who observed an increase in browning index when the level of sweet potato flour increased.

Treatments	Browning index (BI)			
	0 das	30 das	60 das	90 das
Control	76.84 f	78.62 f	82.43 f	84.72 f
SPF_{10}	103.71 e	105.92 e	108.12 e	114.52 e
SPF_{20}	113.47 d	120.26 d	122.98 d	133.68 d
SPF_{30}	130.42 c	137.00 c	142.90 c	148.57 c
SPF_{40}	147.90 b	158.16 b	161.44 b	167.71 b
SPF_{50}	162.70 a	177.64 a	182.43 a	200.94 a
$LSD_{0.05}$	6.94	4.84	6.35	6.20
Pr>F	**	**	**	**
CV%	3.12	2.06	2.62	2.41

Table 7: Effect of sweet potato flour on browning index of cookie till 90 days.

In a column, means followed by the same letters are not significantly different at P < 0.05.

**= highly significant difference; das = days after storage; Control = (without sweet potato flour); SPF_{30} = 30% sweet potato flour; SPF_{10} = 10% sweet potato flour; SPF_{40} = 40% sweet potato flour; SPF_{10} = 10% sweet potato flour; SPF_{50} = 50% sweet potato flour.

Conclusions

This study was evaluated the effect of different ratios of sweet potato flour on the proximate compositions, water activity (a_w) and browning index of cookies during 90 days of storage. The results indicated that increasing the ratios of sweet potato flour significantly improved crude fibre and ash contents, while crude fat and protein contents decreased progressively with higher substitution levels. Cookies incorporated with sweet potato flour also exhibited lower water activity (a_w) values compared to the control, indicating improved shelf stability. However, the higher ratios of (40-50%) resulted in higher moisture content, darker browning and higher in minerals and vitamins with reduction in protein content. Among all treatments, cookies containing 30% sweet potato flour demonstrated that the most desirable balance in—nutritional value and quality attributes. This formulation provided a significant increase in dietary fibre, vitamin and mineral contents while maintaining acceptable moisture content, less in browning color, protein retention with lower water activity (a_w) value than those of (40-50%) ratio of sweet potato flour. Therefore, the incorporation of 30% sweet potato flour was revealed as the optimum incorporation ratio for cookie making as it enhanced nutritional value and stable shelf life while maintaining physicochemical quality. The findings of this study highlight the potential of sweet potato flour as a functional ingredient in bakery products and support its utilization in the development of nutritionally improved cookies. Thus, sweet potato flour was the potential ingredient for the bakery products by developing nutritional and functional properties and by maintaining shelf stable product.

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