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Development of biscuits using sweet potato flour (*Ipomoea batatas* L.) and evaluation of its physicochemical, microbiological and sensory properties

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Abstract

Biscuits are one of the most important food products consumed by people in the world regardless of gender, age, religion, caste, creed *etc.* Exploring the possibility of using various flour types in biscuit manufacture has been an important research area among scientists in the recent past. Therefore, the objectives of the present study were to explore the possibility of using sweet potato flour in biscuit manufacture and to evaluate its physicohemical, microbiological and sensory properties. Well-mature, peeled off orange color sweet potato pieces ($1cm^3$) were dried at 60°C for 6 - 8 h and flour was prepared using a laboratory grinder (Waring Commercials, Torrington, USA) and a sieve (mesh size = 0.5mm). The recipe for the biscuit dough consisted of flour, butter, milk powder, baking powder, sugar, salt and shortening agents. Biscuit cutter (d = 2 inch) was dipped into the dough to cut round-shaped biscuits. Biscuits were baked in a preheated oven (180°C) (Tesmacks, Hvidovre, Denmark) for 10 - 12 min until a golden colour was observed. Biscuits containing 70%, 80%, 90% and 100% (w/w) sweet potato flour were prepared and were compared with a commercial biscuit sample in terms physicochemical and sensory properties. Moisture content, proximate composition, microbiological and sensory properties of Sweet potato biscuits were determined during storage at 30°C. Sensory properties were determined on a five-point hedonic scale with 30 untrained sensory panelists. Sensory results were analyzed using Kruskal Wallis non-parametric ANOVA test with STATISTIX Computer software (Ver 2.0) for windows. Biscuits containing sweet potato flour (90%) and wheat flour (10%) showed significantly higher ($P<0.05$) overall acceptability. Moisture content of the sweet potato biscuit increased from 8.8% to 11.8% during storage. The proximate composition of the sweet potato biscuit included proteins (11.34%), fat (14.2%), ash (2.8%), fiber (0.48%) and carbohydrates (62.38%). Yeast and mold populations in all the biscuits were less than 10^2 CFU/g and *E. coli* was not detected throughout the storage period. Shelf-life of the biscuit was approximately 90 days considering the changes in moisture content and microbiological and sensory properties. Therefore, it can be concluded that sweet potato flour can successfully be introduced to the biscuit industry in order to develop a novel value-added biscuit with improved sensory and nutritional properties.

Keywords: sweet potato flour, biscuit, sensory properties, shelf-life, value addition

Introduction

Biscuit industry has been growing rapidly in developed as well as developing countries including Sri Lanka. Therefore manufacturers tend to produce different types of biscuits by using modern technology and raw materials.

Biscuit is popular among all people in the world regardless of gender, age, religion, caste, creed *etc.* because of its high nutritive value and ease of consumption. Biscuits are generally classified

into soft biscuits, hard biscuits and crackers. Large amounts of sugar, fat, milk and eggs have to be used for soft biscuit and the protein content is around 8 - 10%. In making hard biscuits, the amount of sugar, oil, milk and egg to be used are comparatively low. Therefore, the protein content is around 4 - 5%. The crackers require a low amount of additives such as sugar, oil and a high amount of wheat flour. Cracker manufacturing industry uses yeast for the leavening process of biscuits (Heyman, 1999).

Main ingredients used in the biscuit industry include soft wheat flour, shortening agents, sugar leavening agents, milk powder, colorings, flavoring agents, water and other materials with respect to the recipe. Therefore, soft wheat flour plays an important role in manufacturing high quality hard biscuit because this product needs less gluten content Moreover, there is a good potential to substitute soft wheat flour with other type of starch sources such as rice flour, corn flour, millet, sorghum flour, sweet potato flour *etc* (Matz, 1996). Sri Lanka spends foreign exchange on importation of wheat flour and this has an adverse impact on the economy of developing countries like Sri Lanka. Therefore, it is essential to explore the possibility of using alternative products that could be used to substitute wheat flour required in biscuit production

Sweet potatoes are native to the tropical parts of South America and were domesticated in there at least 5000 years ago. Sweet potatoes are now cultivated throughout the tropical and warm temperate regions wherever there is sufficient water to support their growth (Lewwless and Heymann, 1999). Sweet potato is readily cultivable in Sri Lanka being a low-input crop. It can be grown successfully without adding any chemical fertilizers and is a very productive and effective crop under inter cropping systems. Sweet potato is used and consumed as a curry in Sri Lankan cuisine and flour of this crop can be used to produce breads, biscuits, buns and other bakery products.

Therefore, the objectives of the present study were to explore the possibility of using sweet potato flour in manufacturing of biscuits and to evaluate its sensory, physicochemical and microbiological properties during storage.

Materials and Methods

Well-mature, peeled off orange colour sweet potato pieces (1 cm^3) were dried at 60°C for 6 - 8 h and flour was prepared using a grinder (Waring Commercials, Torrington, USA) and a sieve (mesh size = 0.5mm). The recipe for the biscuit dough consisted of flour (90 g), butter (10 g), milk powder (20 g), baking powder (½ tsp), sugar (14 g), salt (¼ tsp) and shortening agents (20 g). The ingredients were combined and mixed until soft dough was obtained. Dough was spread on a lightly floured work surface, kneaded 3 - 4 turns and pressed out to a flattened circle of ½ inch thick.

Biscuit cutter was dipped into flour and biscuits were cut into 2 inch rounds. Biscuits were arranged with edges toughing on an ungreased or parchment-lined baking sheet. Biscuits were baked in a preheated (180°C) oven (Tesmacks, Hvidovre, Denmark) for 10 - 12 min until a golden colour was observed. Biscuits containing 70%, 80%, 90% and 100% (w/w) sweet potato flour were prepared and were compared with a commercial biscuit sample in terms of physicochemical and sensory properties. Sensory properties of biscuits were determined using 30 untrained sensory panelists on a 5-point hedonic scale. Sensory attributes such as appearance, aroma, texture, taste, and overall acceptability were determined and the results of the sensory evaluation were analyzed using Kruskal Wallis Non-parametric one way ANOVA test with STATISTIX Computer software (Ver 2.0) for windows. The yeast, mold and *E. coli* populations in each biscuit were also determined using Potato Dextrose Agar (PDA: Oxoid Ltd, Hampshire, UK) and *E. coli* broth (EC Broth: Oxoid Ltd) in the beginning and after 30, 60, 100 days of manufacture. Moisture content,

proximate composition, microbiological and sensory properties of Sweet potato biscuits were determined during storage at 30°C. All the experiments were completely homogeneous and statistical analysis was carried out according to the Complete Randomized Design (CRD) and a probability level of 5% (α=0.05) was used in statistical analysis.

Results and Discussion

The product with 90% Sweet potato flour and 10% Wheat flour Biscuits showed the highest overall acceptability compared to other biscuits (Table 1). Moreover, sensory scores for appearance, smell, taste, hardness and mouth feel of the same product were significantly (P<0.05) higher than those of other biscuits. Therefore, the biscuit consisting of 90% Sweet potato flour and 10% Wheat flour Biscuits was selected as the best biscuit considering the highest sensory properties.

Table 1: Estimated mean rank sums of sensory attributes of different sweet potato biscuits

Type of Biscuit	Appearance	Smell	Sweetness	Taste	Crunchiness	Texture	Hardness	Mouth feel	Overall acceptability
A	108.48 ^{a}	103.62^{a}	83.117^{a}	99.283^{a}	79.983^{a}	80.550^{a}	97.867^{a}	106.42^{a}	91.767^{a}
B	87.383^{alb}	52.200^{b}	73.450^{a}	64.183^{b}	77.117^{a}	72.900^{a}	57.717^{c}	60.233^{b}	60.033^{b}
C	62.750 ^{b}	97.750^{a}	69.267^{a}	77.767^{alb}	77.017^{a}	73.933^{a}	68.300^{abc}	99.267^{a}	78.450 ^{alb}
D	61.133 ^{b}	64.967^{b}	75.600^{a}	67.383^{b}	71.717^{a}	71.467^{a}	61.450^{bc}	58.400^{b}	66.217^{ab}
E	57.750 ^{b}	58.967^{b}	76.067^{a}	68.883^{ab}	71.667^{a}	78.650^{a}	92.167^{ab}	53.183^{b}	60.033 ^{alb}

A - 90% Sweet potato flour and 10% Wheat flour Biscuits, B - 100% Sweet potato flour, C - Commercial biscuit, D - 70% Sweet potato flour and 30% Wheat flour Biscuits, E - 80% Sweet potato flour and 20% Wheat flour Biscuits

In the present study, orange color tubers were used for biscuit manufacturing process. Adeleke and Odedeji (2010) also used different color sweet potato tubers such as orange, red and white and they were used to produce tuber flour. In their study, the fractions from each tuber color were added into the biscuit mixture and the effects of tuber source and fraction composition were observed in terms of physico-chemical characteristics of biscuits. They reported that addition of sweet potato flour and fiber fractions to white wheat flour significantly (P<0.05) reduces the pasting properties. Biscuit texture significantly decreased (P<0.05) with the incorporation of sweet potato fiber into the biscuit dough preparation and this was linked to a reduction in biscuit thickness and spread ratio. However, the addition of sweet potato flour and starch resulted in biscuits of similar firmness as the wheat flour biscuit.

It was observed in the present study that Sweet potato biscuit contained high amounts of fat, fiber, ash and carbohydrates compared to commercial biscuit (Table 2). Similar results were observed by Mais (2008) in one of their studies and they reported that Sweet potato flour contained a low level of protein, although it is rich in dietary fiber and carbohydrates. Therefore an appropriate combination of wheat flour and sweet potato flour needs to be used for biscuit production.

Table 2 shows the proximate composition of sweet potato biscuits produced in the laboratory. It appears to be a good source of carbohydrate, dietary fiber, ash and fat and could be a good supplementary food for the entire family (Table 2).

Table 2: Proximate composition of laboratory prepared sweet potato biscuits

Type of Biscuit	Avg. Protein %	Avg. Fat %	Avg. Ash %	Avg. crude Fiber %	Avg. Moisture %	Avg. carbohydrate and others %
A	11.34	14.20	2.8	0.48	8.8	62.38
B	8.50	10.32	3.4	0.57	11.91	65.3
C	15.31	9.75	2.4	0.36	12.91	59.27
D	13.80	14.02	2.2	0.45	13.8	55.73
E	12.62	11.70	2.6	0.43	13.1	59.55

A - 90% Sweet potato flour and 10% Wheat flour biscuits, B - 100% Sweet potato biscuits, C - Commercial Wheat flour biscuit, D - 70% Sweet potato flour and 30% Wheat flour Biscuits, E - 80% Sweet potato flour and 20% Wheat flour Biscuits

Carbohydrates provide energy where was fiber is important for the proper digestion process in the digestive tract. An abundance of carbohydrates and minerals in sweet potato biscuits could give energy and nutrients that are needed the physical and mental growth of children. Table 4 shows the yeast and mould populations in biscuit during storage.

Table 3: Population level of yeast and mould in biscuits during storage

Dilution	Number of Colonies forming units per gram just after manufacture	Colony forming units per gram after 30 days	Colony forming per gram after 60 days	Colony forming units per gram after 100 days
10^{-1}	Nil	Nil	Nil	3
10^{-2}	Nil	Nil	Nil	1
10^{-3}	Nil	Nil	Nil	1
10^{-4}	Nil	Nil	Nil	Nil

Yeast and mold population increased up to 1.0×10^3 cfu/g after 100 days of biscuit manufacture (Table 3). The shelf-life of the biscuit was 90 days and the yeast and mould populations surpassed the recommended maximum population level of 10^2 cfu/g after 100 days of storage. Considering mould and yeast counts observed in the present study, it can be concluded that that the products need to be consumed within 90 days of manufacture (Hozova, 2002). Gas formation was not observed in any test tubes that contained EC broth indicating that *Escherichia coli* was not present in any of the biscuit products.

According to the sensory evaluation there were off flavors and off odors developed in all the biscuits after storage of 100 days. It was mainly due to the microbial growth and increased moisture content. Moisture content of the selected sweet potato biscuit increased from 8.8% to 11.8% during storage. In 30th and 60th day there were no off flavors and off odors and the overall acceptability was very low after 100days of biscuit manufacture (Figure 1).

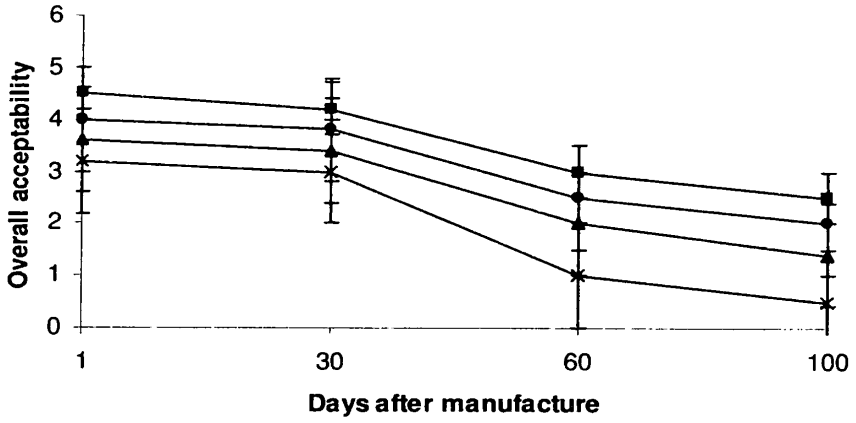

Figure 1: Overall acceptability of biscuits during storage
■ - 90% Sweet potato flour and 10% Wheat flour biscuits, ● - 100% Sweet potato biscuits, - 80% Sweet potato flour and 20% Wheat flour biscuits, ▲ - 70% Sweet potato flour and × - 30% Wheat flour Biscuits

Conclusions

Sweet potato flour can be introduced as a substitute for the wheat flour in the process of biscuit manufacture. The physicochemical and sensory properties of sweet potato flour incorporated biscuit were higher compared the commercial brand of wheat flour biscuits. Best composite flour combination in preparing sweet potato flour biscuit was 90% Sweet potato flour and 10% Wheat flour. This biscuit had the highest sensory properties in comparison to other biscuits. The shelf-life of this Sweet potato flour biscuit was approximately 90 days considering changes in physicochemical, microbiological and sensory properties. It can be concluded that Sweet potato flour can successfully be introduced to the biscuit industry to produce a value-added biscuit with improved nutritional and sensory properties.

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