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RESEARCH

Evaluation of Physical and Sensory Properties of Biscuits Made from Blended Wheat Flour and Pumpkin Powder

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ABSTRACT

Biscuit is a type of confectionery popular among all age groups and able to change to become a complete food with necessary nutrients. Pumpkin is a nutritious vegetable that has high post-harvest losses in Sri Lanka. The aim of this research was to analyze the composition of pumpkin powder and evaluate the physical and sensory properties of biscuits made from blended wheat flour and pumpkin powder. Analyses revealed that moisture, protein, fat, ash, crude fiber, and carbohydrate content of pumpkin powder were 8.5%, 5.2%, 1.2%, 3.4%, 4% and 77.7% respectively. Biscuits were made by replacing wheat flour with pumpkin powder at different levels as 0, 5, 10, 20, 30, and 40% (w/w) in the standard formulation. When the percentage of pumpkin powder increased from 10 to 40%, the thickness of biscuits decreased significantly compared to control (0%) There was a significant increment in the spread ratio of biscuits between 10 and 40% levels of pumpkin powder when compared with the control. While 10 to 40% replacement levels of pumpkin powder resulted in significant increase in biscuit hardness, it decreased moisture content significantly compared to control. The color of the biscuits was assessed in terms of lightness, redness, and yellowness. When increasing the pumpkin powder percentage in biscuit, lightness reduced, while redness and yellowness increased gradually. Consumer acceptability test on sensory attributes indicated 5% (w/w) level of pumpkin powder was the most preferred replacement level. The study concludes that pumpkin powder has the potential to be used in biscuit applications.

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INTRODUCTION

Biscuits are one of the oldest baked goods and consumed by all age groups. Biscuits are popular among consumers because this food item is highly palatable, nutritious, quickly released energy and available in convenient sizes, as well as in various forms. In addition, the biscuit formulations can be modified easily and beneficially meet the nutritional and sensory demands of the target consumers (Ashaye et al., 2015). A biscuit is a kind of confectionery which is small flat, crisp, and made from wheat flour (FAO,2016). Wheat is the major ingredient in a variety of food products such as bread, biscuits, cakes, crackers (Lee et al., 2002; Pongjanta et al., 2006). Baking properties, color, taste, and texture are more important qualities of biscuits affecting consumer acceptance. In recent years, biscuits are fortified with various nutrients to enrich them to become a complete food with all necessary nutrients. Pumpkins belong to the Cucurbitaceae family is one of the largest families in the Plant Kingdom (Manjunath et al., 2008). Some nutritional characteristics of pumpkin are equal or even better than some other widely cultivated vegetables and fruits, and it can be consumed in a variety of ways, such as fresh or cooked as well as being stored, frozen or canned (Jesmin et al.,2016). Pumpkin contains important dietary sources such as fiber, carotene, minerals, and vitamins (Loy and Broderick, 1990). Pumpkin is a medicinal vegetable due to the presence of valuable natural substances such as alkaloids, flavonoids, and palmitic, oleic, and linoleic acids. It also has anti-diabetic, antioxidant, anticarcinogenic, and anti-inflammatory like various critical medicinal traits (Yadav, et al, 2010). Pumpkins are extensively grown in tropical and subtropical countries. Pumpkin is high in β-carotene, which gives its characteristic yellow or orange color (Bhaskarachary et al., 2008). β -carotene is a major source of vitamin A (Lee, 1983). Incorporation of β-carotene rich foods in diets can help to overcome the problems and diseases caused by Vitamin A Deficiency (Chandrashekhar and Kowsalya, 2002).

In Sri Lanka, there is a huge post-harvest loss in fruit and vegetables at peak seasons. Post-harvest losses of pumpkin could be high as 50%-60% or more of the harvest. Fresh pumpkins are very susceptible to the attacks of pathogenic fungi and bacteria due to high moisture level of the fruit and wrong post-harvest practices. Hence, value addition may be the best solution to overcome this problem. In recent decades, consumer requirements for food products have changed significantly. Producing bakery products without wheat flour can be a big challenge because wheat flour contains gluten protein that gives proper texture for the products. However, wheat flour can be replaced partially by other flour types to meet the expected nutritional properties while maintaining sensory properties that demand by the consumers. The main objectives of this study were to prepare pumpkin powder, analyze its nutritional properties (proximate analysis), and study the effect of partially replacing wheat flour with pumpkin powder on the physical and sensory properties of biscuits.

METHODOLOGY

Material

The matured pumpkin (*Cucurbita maxima*, Var. ANK Ruhunu) fruits were purchased from the different local markets of Kandy, Dambulla and Colombo city area for composite sample. All other ingredients for biscuit production such as wheat flour, shortening, fine sugar, milk powder, salt and leaving agents were purchased from the local market. All chemicals used in the experiment were of analytical grade from reputed manufacturers. Calibrated laboratory equipment and utensils were used.

Pumpkin powder production

The pumpkins were washed and peeled. After peeling, the stem was removed, and the fruit was cut into two halves. Then the seeds and stringy bits were taken out and pumpkins were cut into small shreds (about 10mm cubes). Next, the shreds were blanched for 2-3 minutes in 500 ppm of potassium meta-bisulphite at 98 °C. After blanching, shreds were placed on trays and dehydrated at 65 °C in Cabinet Dryer to get desired moisture content of 7-8 %. After dehydration, shreds were ground, sieved (250µm sieve) and stored at ambient temperature conditions in metallized polyethene pouches for further use.

Proximate analysis of pumpkin powder

Moisture, protein, ash, crude fiber, fat, and carbohydrate content were determined according to the standard methods described by the Association of Official Analytical Chemists (AOAC).

Preparation of biscuit

The biscuits were made using the standard recipe consisting of refined wheat flour 100 g, fine sugar 32 g, fat 35 g, skim milk powder 10 g, salt 1 g, sodium bicarbonate 0.5 g, ammonium bicarbonate 0.2 g, lecithin 0.15 g and water 15 g. Biscuits dough was prepared by replacing wheat flour with pumpkin powder at different levels as; 0, 5, 10, 20, 30 and 40 % (w/w) in the standard formulation (Table 1). The shortening and sugar were creamed using a mixer before the homogenized mixture of dried ingredients was added. Smooth dough was formed and rolled and flattened to a 0.4 cm thick sheet with the help of a rolling pin. A round cutter of 4 cm diameter was used to create a uniform shape for all biscuits. Then, they were transferred to a lightly greased baking tray and baked at 150 °C for 12 minutes in a preheated oven. After baking, all biscuits were allowed to cool completely (about 30 minutes) and stored in airtight containers for 12 hours before using in analyses.

Analysis of physical parameters of biscuits

Weight, diameter, and thickness

Weight, width (diameter), spread ratio, and thickness were estimated as physical parameters. The width of biscuits was measured by placing 5 biscuits edge-to-edge to get the average value in millimeters. The thickness was measured by stacking 5 biscuits on top of each other to get the average value and recorded in millimeters. The spread ratio was defined as width (diameter) divided by thickness. Digital weighing scale was used to determine the weight (in grams) of biscuits. Diameter and thickness were measured with a Vernier caliper mounted with measurement instrument at four different places in each biscuit.

Color analysis

Surface color was measured using a colorimeter fitted with optical sensor (Chroma meter CR-400, Konica Minolta Sensing, Inc, Japan) on the basis of CIE L^*, a^*, b^* color system. L^* values measure black to white (0–100), a^* values measure redness when positive, and b^* values measure yellowness when positive.

Moisture analysis

Moisture contents of biscuits were determined using laboratory moisture meter (OHAUS –MB45, made in Switzerland). Each sample was ground into powder form using mortar and pestle, and 3 g from each sample was used to measure the moisture content. Moisture content was determined in five replicates from each treatment and the average value was calculated

Table 1: Wheat flour and pumpkin powder combination in biscuit recipe

Treatments	Flour Combination Ratio	
	Wheat Flour (%)	Pumpkin Flour (%)
Control	100	0
S 1	95	5
S 2	90	10
S 3	80	20
S 4	70	30
S 5	60	40

Texture analysis

The hardness of the baked biscuits was measured using a texture analyzer (TA-XT2i, Stable Micro Systems, UK) in a compression mode with a sharp blade-cutting probe. Hardness, a maximum peak force, was measured with more than six biscuits for each sample. The peak force to snap the biscuit was reported as fracture force in N.

Sensory evaluation

The sensory test was performed by 5-point hedonic scoring test (most preferred (1) to least preferred (5)) for color, flavor, texture, and overall acceptability of pumpkin biscuit. The products were cooled and packed in clear polythene bags and kept at room temperature awaiting sensory evaluation the following day. The consumer likability test was carried out by using 30 Semi-panelists. All panelists were regular consumers of biscuits. The food samples were prepared in identical sample containers, coded with three-digit random numbers and each sample was presented with a different number. The randomized order of the sample was presented one at a time to each panelist and asked to evaluate the coded samples for each sensorial parameter including color, flavor, texture, and overall acceptability based on their degree of liking.

Statistical analysis

Parametric data was analyzed using analysis of variance (ANOVA) and tested by One-way ANOVA. Mean comparison was done by Turkey test at 95% probability level. The Friedman test was used to analyze nonparametric data. All analyses were set at 95% confidence level ($p<0.05$).

RESULTS AND DISCUSSION

The composition of pumpkin powder

According to the proximate analysis, the composition of the pumpkin powder prepared with ANK Ruhunu variety is presented in Table 2.

Compared to wheat flour, pumpkin flour has more fiber and ash. Moreover, various studies show that some other nutrients are also relatively high in pumpkin flour. For instance, Kundu et al. (2014) reported that pumpkin powder contained a higher amount of calcium (121.7 mg/100 g), iron (7.1 mg/100 g), zinc (3.1 mg/100 g) and β-carotene (1.8 mg/100 g) than that of wheat flour which contained calcium, iron and zinc at 17.0 mg/100 g, 5.3 mg/100 g and 2.8 mg/100 g, respectively (Kundu et al. 2014). Similar results were reported by Murkovic et al. (2002). Thus, pumpkin powder can be incorporated to produce nutritious confectionary products.

Effect of Pumpkin Powder Percentage on Physical Properties of Biscuits

The physical properties of the biscuits were significantly affected ($p<0.05$) by the level of replacement wheat flour with pumpkin powder (Table 3).

Table 2: Nutritional composition of pumpkin powder in comparison to wheat flour

Composition	Amount in pumpkin powder	Amount in wheat flour
Moisture content (%)	8.525 ± 0.73	10.425 ± 0.479
Protein (%)	5.2 ± 0.87	9.25 ± 0.645
Fat (%)	1.2 ± 0.56	0.815 ± 0.1367
Ash (%)	3.4 ± 0.59	0.5625 ±0.0967
Crude fiber (%)	4.02 ± 0.51	0.51± 0.086
Carbohydrate (%)	77.7 ± 6.12	77.98 ± 0.808

Values are presented as mean ± standard deviation.

Table 3: The effect of partially replacing wheat flour with pumpkin powder at 0 to 40 % on physical properties of biscuits

Treatment	Thickness (mm)	Diameter (mm)	Spread Ratio	Hardness (mm/s)	Moisture (%)
Control (0%)	6.51±0.42^{A}	44.9±0.88^{A}	6.92±0.47^{D}	1193.7±52.5^{C}	1.60±0.16^{A}
S1 (5%)	6.18±0.19^{AB}	44.8±1.03^{A}	7.26±0.32^{CD}	1198.7±75.1^{C}	1.56±0.09^{A}
S2 (10%)	5.99±0.22^{B}	44.8±1.03^{A}	7.72±0.58^{BC}	1229.0±81.6^{BC}	1.50±0.13^{AB}
S3 (20%)	5.46±0.28^{C}	44.7±0.82^{A}	8.21±0.50^{AB}	1290.2±99.5^{ABC}	1.45±0.12^{AB}
S4 (30%)	5.46±0.37^{C}	44.8±0.63^{A}	8.24±0.56^{AB}	1315.3±101.5^{AB}	1.44±0.13^{AB}
S5 (40%)	5.16±0.26^{C}	44.8±0.63^{A}	8.70±0.49^{A}	1357.7±81.3^{A}	1.38±0.16^{B}

Values are presented as mean ± standard deviation. The means followed by the same letter in each column are not significantly different at p=0.05 level.

The thickness of biscuits decreased significantly at 10, 20, 30 and 40% replacement levels relative to the control (0%) and there was no significant difference between 20 and 40% levels. The thickness of the control was 6.51mm and it was the highest value among samples and the lowest thickness was observed in replacement levels of 40% (Table 3). Thickness reduction with increase in pumpkin powder content may be partly due to the dilution of gluten. In addition, high-water absorption characteristic of fiber can attract more water, thus, the dough viscosity would decrease, leading to decreased thickness.

The biscuit diameter was not affected by treatments. There was a significant increment in the spread ratio of biscuits between 10 and 40% levels when compared with the control. According to the results, the highest and lowest spread ratio values were shown in Control (0%) and the 40% replacement level, respectively. Spread ratio is an important quality parameter and it correlates with mouth feel, texture, and fineness of the biscuits (Murugkar et al., 2015). According to Hoseney and Rogers (1994), cookie spread rate is controlled by dough viscosity; dough with low viscosity causes cookies to spread at fast rate and vice versa. Furthermore, more sugar is dissolved in the presence of a high amount of water in the dough system during mixing. According to Hoseney and Rogers (1994), a high-water absorption property of flour components may cause less water to be available for dissolving of sugar. Thus, the initial viscosity is higher, and the cookies spread less during baking.

Biscuit Hardness was significantly increased with 30 and 40% replacement levels relative to the control (0%). The lowest and the highest values were exhibited in Control (0%) and 40% levels, respectively (Table 3). The moisture content of biscuits significantly changed when wheat flour was replaced with pumpkin powder at 40% level (Table 3). Replacement levels of 5 to 30% had no significant impact on moisture content of the biscuits.

Biscuit Color

The color of biscuits was assessed in terms of lightness (L*), redness (a*), and yellowness (b*). Table 4 presents the variation in L*, a* and b* values of biscuits according to the replacement levels of pumpkin powder.

The 40% level had significantly lower L* values than the control (Table 4). This could be attributed to caramelization of the sugar or a Maillard reaction causing browning during the baking process. The replacement level of pumpkin flour in biscuits significantly affected the lightness of the biscuit surface. The lightness has reduced gradually when the pumpkin flour percentage in the biscuit (Table 4, Figure 1). The lightness of the biscuit was affected by the sensory attribute (color) of the biscuit. The a* values are indicative of the red

or green color. The b* color value indicates the yellowness. Both a* and b* values of biscuits increased with the increasing level of pumpkin powder substitution. Lightness reduction and yellowness increment with increase in pumpkin powder substitution (Figure 1) may be partly due to the presence of carotenoids in pumpkin powder. An increase in the color of biscuits is attributed to the sugar caramelization and Maillard reactions between sugars and amino acids. Other factors that might contribute to the color of final products were ingredients, composition, and time of baking (Cronin and Preis, 2000).

Sensory Evaluation

Pumpkin powder substitution at 5% was much accepted with flavor point of view in biscuit. It scored the maximum (4.62). 40% level scored the minimum value (1.6) for the flavor. The likeliness of the biscuit flavor has reduced gradually when increase the pumpkin powder percentage in biscuit sample (Table 5). The maximum and the minimum score values for the color attribute were observed in the level of 5% and 40%, respectively. When increasing the replacement level of pumpkin powder beyond 5%, color became gradually darker, and likeness was reduced gradually. The score for texture also followed the same trend as the scores for flavor and color. The maximum and the minimum mean value corresponded to the samples of biscuit prepared by replacing level of 5 and 40%, respectively. As the level of replacement was increased from 10 to 40%, the texture of the biscuit became inferior due to the gradual increase in hardness. It is also evident from the texture analyzer data for the biscuit hardness (Table 3). Results re volved that lowest thickness value (5.16 ± 0.26) was represented in replacement level of 40%. Protein gluten in wheat flour plays a vital role in forming a web-like structure during dough heating.

Table 4: Color meter values of biscuits surfaces

Treatment	Color Meter Values		
	"L" Lightness	"a" Redness	"b" Yellowness
Control (0%)	68.82 ± 1.42^{A}	7.34 ± 0.29^{D}	35.81 ± 0.72^{C}
S1 (5%)	61.08 ± 1.07^{B}	8.26 ± 0.88^{CD}	39.12 ± 1.13^{B}
S2 (10%)	56.76 ± 1.03^{C}	8.88 ± 0.61^{C}	44.66 ± 2.40^{A}
S3 (20%)	50.58 ± 1.04^{D}	10.41 ± 0.88^{B}	44.12 ± 1.52^{A}
S4 (30%)	42.92 ± 2.83^{E}	12.21 ± 1.66^{A}	44.29 ± 2.11^{A}
S5 (40%)	38.54 ± 2.39^{F}	12.42 ± 1.04^{A}	45.33 ± 1.82^{A}

Values are presented as mean ± standard deviation. The means followed by the same letter in each column are not significantly different at p=0.05 level.

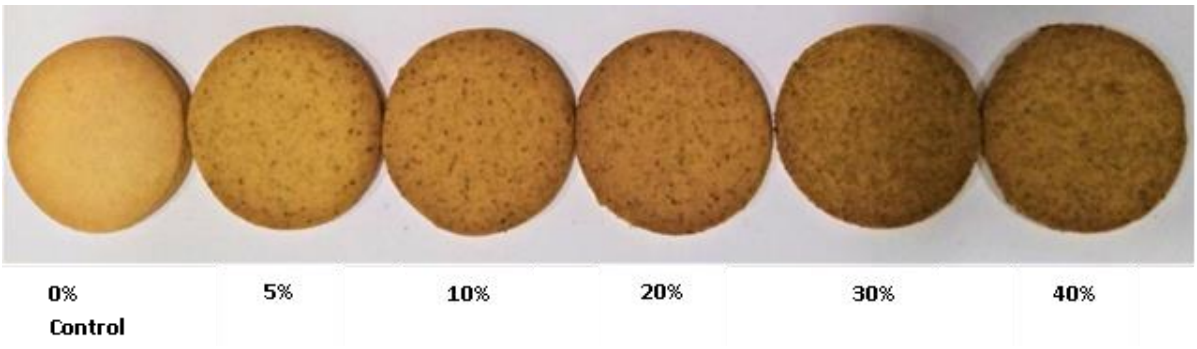

Figure 1: Color variation of biscuits prepared from different pumpkin powder combinations.

Table.5: Mean sensory score for biscuit prepared by replacing wheat flour with pumpkin powder.

Sensory Attributes	Treatments or Recipes					P value
	TR 237 5%	TR 456 10%	TR 758 20%	TR 229 30%	TR 347 40%	
Flavor	4.62^{A}	3.3^{C}	2.36^{D}	1.96^{E}	1.6^{F}	<0.001
Color	4.58^{A}	3.42^{C}	3.04^{D}	2.34^{E}	1.88^{F}	<0.001
Texture	4.44^{A}	4.46^{A}	3.76^{B}	2.48^{C}	1.98^{D}	<0.000
Overall Acceptability	4.54^{A}	3.04^{C}	2.02^{D}	1.74^{E}	1.34^{F}	<0.000

The means followed by the same letter in each row are not significantly different at p=0.05 level.

Overall Acceptability

The mean score for overall acceptability varied from 4.54 to 1.34. The maximum and minimum mean values were shown at 5 and 40% replacement levels respectively. It was observed that the minimum replacement level of 5% (w/w) was more accepted and scored higher. It was observed that more than 5% replacement of wheat flour with pumpkin powder in biscuit formulation had a strong negative influence on sensory properties of the biscuit (Table 5).

Biscuits are an easy to buy and popular snack among people of all age groups, so they can be used to meet nutritional needs. Pumpkin is a crop with high nutritional value and high post-harvest damage. Value addition methods for such crops will help minimize post-harvest damage by creating new products with high nutritional value.

CONCLUSION

This study revealed the proximate composition of pumpkin powder and the effect of replacement of wheat flour with pumpkin powder on the physical and sensory properties of biscuit. The pumpkin powder is a nutritious ingredient, and it could be very well utilized to prepare biscuits. As the replacement level of wheat flour with pumpkin powder was increased from 0 to 40% (w/w), physical and sensory properties of biscuits were significantly affected. Accordingly, biscuit thickness and moisture were reduced and spread ratio and hardness were increased relative to the control (0% replacement level). The lightness value was reduced gradually when increasing the pumpkin powder percentage in the biscuit. Redness and yellowness were increased accordingly. Using pumpkin powder at 5 % (w/w) in place of wheat flour was the most preferred replacement level according to the sensory evaluation. The results confirm that pumpkin powder is an ingredient with potential use in the biscuit industry.

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