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Studies on the Preparation of Biscuits Incorporated with Potato Flour

[1]Vasantharuba Seevaratnam, [1]P. Banumathi, [1]M.R. Premalatha, [2]S.P. Sundaram and [3]T. Arumugam

[1]Department of Food Science and Nutrition, Tamil Nadu Agricultural University, Madurai, India
[2]Department of Agricltural, Microbiology, Tamil Nadu Agricultural University, Madurai, India
[3]Departmnet of Horticulture, Tamil Nadu Agricultural University, Madurai, India

Abstract: The feasibility of partially replacing wheat flour with potato flour in biscuit making was evaluated in several formulations, aiming to find a formulation for the production of potato flour incorporated biscuits with better nutritional quality and consumer acceptance. Potato flour was incorporated in the traditional recipe to replace wheat flour at levels of 10, 20 and 30 percent in preparation of biscuits with maintaining all other ingredients constant. Results of the sensory (appearance, colour, flavour, texture and taste) evaluation revealed that no significant difference was observed in acceptability of the product with substitution levels of 20 percent, with that of control. However, a declining trend in acceptability was observed with increasing level of potato flour for all the sensory characteristics. The nutritional value of the biscuits (protein, fat, carbohydrate and ash) with the highest acceptable level of potato flour (20 %) was similar to the wheat flour biscuit. The physical characteristics of biscuits like bulk density, spread ratio and spread factor were decreased significantly with the increasing level of potato flour replacement. The bacterial count of the 20 percent potato flour incorporated biscuits sample after 60 days was $6.5x10^3$ CFU/g and this was well below the acceptable limit and there was no rancidity development observed in the formulated biscuits up to 60 days.

Key words: Potato flour · Biscuit · Sensory evaluation · Nutritional value

INTRODUCTION

Potatoes are one of the most popular major food items consumed throughout the world because of their high yield, relatively low cost of production and adaptability to a wide variety of soil and climate types [1, 2]. Potatoes are a versatile food that are easy to prepare and can be eaten as a staple food, as a complementary vegetable or as a snack item [3]. Moreover, potatoes contribute significantly to the nutritive value of a meal as they contain good quality edible grade protein, dietary fiber, several minerals and trace elements, essential vitamins and little or negligible fat [4]. Despite the advantages associated with crop, the bulk of the crop produced has a short storage life [5]. Moreover, due to inadequate cold storage capacity, the diversion of potatoes to processed potato products would benefit both growers and consumers, as it would help extend the storage life and serve as a means of increasing the supply in off-seasons [4].

Among several processed products, potato flour is the oldest commercial potato product, which can be stored safely and incorporated into various recipes. Potato flour has diversified uses in the home as well as in the food industry, especially, in the baking industry in preparation of bread and biscuits. Potato flour with negligible fat content, high dietary fiber, high vitamins, a good amount of minerals and 6-12 percent protein content [6] can be substituted for wheat flour in the preparation of biscuits. This also helps in lowering the gluten level and prevent from Coeliac disease [7]. Addition of potato flour also enhances the sensory characteristics of biscuits and industries also find it economical to use in biscuit manufacture. Potato flour can be prepared by drying the peeled slices in a hot air drier or by drying the cooked mash with a drum drier into flakes followed by grinding and sieving [8].

Hence the present study was undertaken to archive the following objectives i) to formulate biscuits using potato flour in different proportions, to replace wheat flour: ii) to evaluate the sensory and other quality characteristics of biscuits.

MATERIALS AND METHODS

The study was conducted in the laboratory of the Department of Food Science and Nutrition, Tamil Nadu

Corresponding Author: Vasantharuba Seevaratnam, Department of Food Science and Nutrition, Tamil Nadu Agricultural University, Madurai, India

Agricultural University, Madurai, Tamil Nadu, India. Potatoes (*Solanum tuberosum* L., var. *Kufri jyothi*) and other raw materials were procured locally.

Preparation of Potato Flour: Uniform sized potatoes having no signs of infection or infestation were thoroughly washed in running tap water to remove any adhering soil, dirt and dust. Then the tubers were dipped in 3 percent salt solution for 30 minutes. After draining the water the tubers were surface dried at room temperature (30-32°C) and their weight was taken using an electronic balance. Then the potatoes were sliced into thin slices of 2-3 mm thickness and steam blanched for five minutes. The blanched potatoes were dried in a cabinet drier at 50°C for two hours and at 60°C for six hours. After complete drying, the slices were milled, passed through 80 mesh sieve to obtain fine flour of uniform size. After measuring the final weight the flour was packed in airtight plastic containers until further use [4].

Formulation of Biscuits: Potato flour was incorporated in the traditional recipe to replace refined wheat flour at levels of 10, 20 and 30 percent in preparation of biscuits. Biscuits were produced from the four formulations using the method described by Whitley [9]. The biscuits were allowed to cool for 30 minutes and stored in airtight plastic container before further analysis.

Evaluation of Physical Characteristics of Biscuits: The AACC method [10] was used to determine biscuits diameter, thickness and spread factor. Biscuits diameter was measured by placing 6 biscuits edge-to-edge to get the average diameter in millimeters. Biscuit thickness was measured by stacking 6 biscuits on top of each other and gets the average thickness. Diameter divided by thickness gave the spread factor. Bulk density was determined as described by Singh *et. al* and result was expressed as g/cm^3.

Evaluation of Sensory Attributes of Biscuits: The biscuits prepared by incorporating potato flour were evaluated for their sensory characteristics: appearance, color, flavor, texture, taste and overall acceptability, by a panel consisting of fifteen judges. The judges included the professors and senior research scholars of the Department of Food Science and Nutrition. The 9 point Hedonic scale score-card method was used to determine the sensory characteristics of the biscuits made. All samples of biscuits (prepared from 0-30% potato flour incorporation) were given different code letters.

Table 1: Basic formula for potato flour incorporated biscuits

Ingredients	A	B	C	D
Refined wheat flour (g)	100	90	80	70
Potato flour(g)	0	10	20	30
Powdered sugar(g)	50	50	50	50
Shortenings(g)	50	50	50	50
Baking powder(g)	0.5	0.5	0.5	0.5

The quality factors such as appearance, color, flavor, texture, taste and overall acceptability were allotted a maximum score of 9 each. The scoring scale was: 1 (Dislike extremely), 2 (Dislike very much), 3 (Dislike moderately), 4 (Dislike slightly), 5 (Neither dislike nor acceptable), 6 (Slightly acceptable, 7 (Moderately acceptable), 8 (Highly acceptable) and 9 (Extremely acceptable) [12].

Evaluation of Nutrient Content of Biscuits: The sensory evaluation of the biscuits prepared by incorporating different levels of potato flour helped to determine the level of potato flour which was acceptable. Nutrient content of the accepted potato flour incorporated biscuit sample was determined. This was compared with the nutrient content of the control wheat flour biscuit sample. The nutritional values like crude protein, fat and ash content of biscuits were determined by official methods [13]. Carbohydrate was expressed as the difference from moisture, protein, fat and ash.

Evaluation of Moisture, Crude Fibre, Peroxide Value and Microbial Quality of Biscuits: The moisture and crude fibre content of the selected biscuit samples were estimated by AOAC method [13]. Peroxide value is an indicator of rancidity development during storage. Peroxide value of fresh as well as 30 and 60 days old biscuits samples were determined as per the method described by Sadasivam and Manickam [14].

Microbial populations like bacteria and fungus were estimated by serial dilution followed by solidification in petriplate using nutrient agar and rose Bengal agar respectively. After solidification both bacteria and fungus colony containing plates were incubated at room temperature for 24 to 48 hours. Then formed colonies were count and convert them as number of colony forming units (CFU) per gram of sample [15]. Microbial load estimation for the biscuits samples were carried out for fresh as well as 30 and 60 days old samples.

Statistical Analysis: All measurements were performed in triplicate for each sample. Data were analyzed using statistical software (SPSS for Windows Version 12.0).

Significant differences between the means were estimated using Duncan's multiple range tests. Differences were considered significant at $p < 0.05$.

RESULTS AND DISCUSSION

Potato flour prepared by the cabinet drier method after steam blanching produce good quality flour and can be used as partial replacements for wheat flour in preparation of various bakery products. According to Khaliduzzaman *et al*. [16] potato flour prepared by blanching the potato slices in water at 90°C for 08 minutes and cooled quickly in cool water gave better quality flour when compared to other treatments. Nazni and Pradeepa [17] developed good quality potato flour by following some pretreatments like immersing the potato slices in 0.05% ascorbic acid solution and 0.2 % KMS solution before blanching. This potato flour was used in the preparation of biscuits as a partial replacement for wheat flour [16, 17].

Average yield recovery of potato flour as a percent of fresh tuber was 19.6 percent. Nazni and Pradeepa [17] also studied the effect of processing on the potato flour recovery. They found the percentage yield of recovery of potato flour was 15.4 percent.

Evaluation of Physical Characteristics of Biscuits: The Table 2 shows the weight, diameter, bulk density and spread factor of biscuits were decreased significantly with the increasing level of potato flour replacement up to 30 %. But the volume of biscuits was increased significantly and thickness of biscuits increased slightly as substitution level of potato flour increased.

According to Khaliduzzaman *et al*. [16] thickness of biscuit increased slightly with the increasing level of potato flour replacement up to 25%. On the other hand diameter of biscuits and spread ratio are decreased as substitution level of potato flour increased in the baked samples and this may be due to the higher water holding capacity of potato flour. Singh *et al*. [18] reported higher extensibility of dough made by the addition of potato flours from different Indian potato cultivars. The differences in spread factors of cookies containing flours of different potato cultivars may be attributed to the differences in swelling patterns and rheological properties.

Sensory Quality Scores for Potato Flour Incorporated Biscuits: The sensory evaluation of the potato flour incorporated biscuits showed that the overall acceptability limit was 100% up to the level of 30%

Table 2: Physical characteristics of biscuits

Level of potato flour incorporation	Weight (g)	Volume (ml)	Bulk density (g/cm^3)	Diameter (mm)	Thickness (mm)	Spread factor
0 %	10.26^b	15.95^a	0.643^c	41.2^b	6.5^a	6.33^c
10 %	10.21^b	16.07^b	0.635^b	41.0^b	6.6^a	6.21^b
20 %	10.14^a	16.12^b	0.629^b	40.7^a	6.6^a	6.16^b
30 %	10.09^a	16.24^c	0.621^a	40.5^a	6.8^b	5.95^a

All values are average of triplicates

The values denoted by different letters in the same column are significantly different ($p< 0.05$)

Table 3: Average scores of the sensory attributes of potato flour incorporated biscuits

Characters	W.F:P.F=100:0	W.F:P.F=90:10	W.F:P.F=80:20	W.F:P.F=70:30
Colour and appearance	8.86^b	8.86^b	8.66^b	8.33^a
Flavour	8.66^c	8.40^b	8.46^{bc}	7.93^a
Texture	8.33^c	8.06^b	8.33^c	7.66^a
Taste	8.53^c	8.26^b	8.40^{bc}	7.66^a
Overall acceptability	8.60^c	8.20^b	8.46^c	7.80^a

WF= Refined wheat flour PF = Potato flour

The values denoted by different letters in the same row are significantly different ($p< 0.05$)

Table 4: Nutrient contents of wheat flour biscuits and 20 % potato flour incorporated biscuits

Nutrient contents	Wheat flour biscuits	20 % potato flour incorporated biscuits
Carbohydrate (g/100g)	64.0	63.9
Crude protein(g/100g)	6.6	6.1
Fat(g/100g)	25.9	25.8
Total ash(g/100g)	1.4	1.7

All values are average of triplicates on dry weight basis

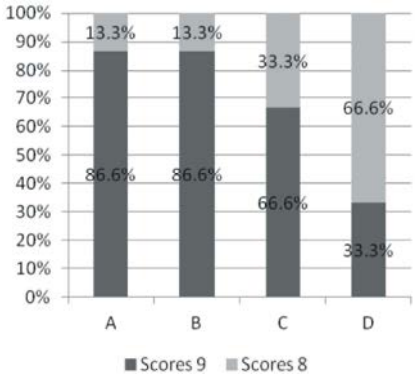


Fig. 1: Sensory attributes (Colour)

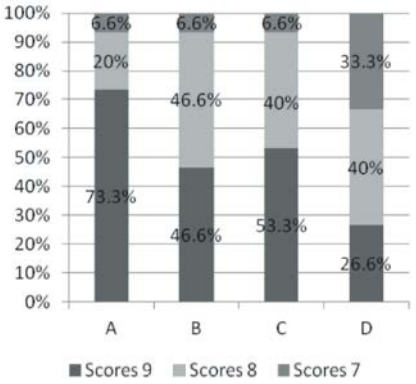


Fig. 2: Sensory attributes (Flavour)

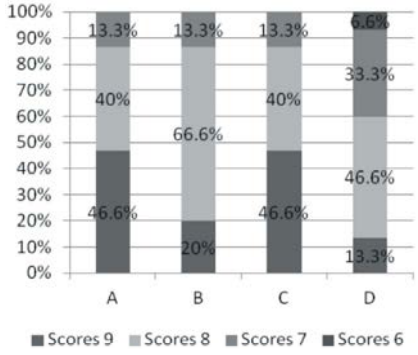


Fig. 3: Sensory attributes (Texture)

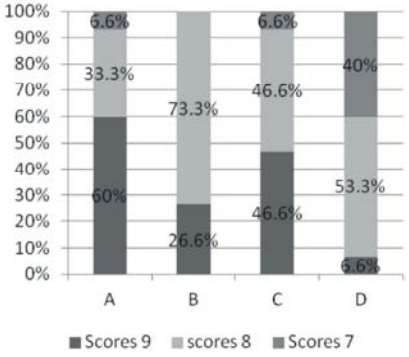
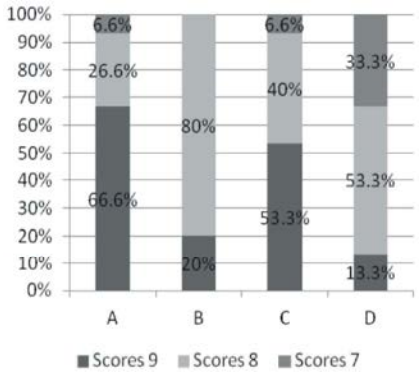


Fig 4: Sensory attributes (Taste) and



A = 100% Refines wheat flour
B = 90% Refined wheat flour + 10% Patato folur
C = 80% Refined wheat flour + 20% Potato flour
D = 70% Refined wheat flour + = 30% Potato flour

Fig. 5: Sensory attributes (Overall acceptability) of the potato flour incorporated biscuits as in percentage

incorporation. But a declining trend in the level of acceptability from extremely acceptable to moderately acceptable was observed when the level of potato flour incorporation increasing from 0% to 30%. Control biscuits (0 percent potato flour) had the highest score for all the characteristics, however scores at 20 percent potato flour levels was found to be on a par with the control for all the sensory characteristics. But there is a significant drop in acceptable level was observed between 20% and 30% incorporation level for all the sensory attributes. Regarding the overall acceptability 53.3% of the respondent highly accepted the 20% potato flour incorporated biscuits while 20% and 13.3% of the respondent highly accepted the 10% and 30% potato flour incorporated biscuits. Scores of the other sensory attributes like flavor, texture and taste also revealed that acceptability level of the respondent was higher for the 20% incorporation level when compared to 10% and 30% level.

According to Khaliduzzaman *et al*. [16] biscuits made from five different proportions of composite flour of wheat and potato (0,15,20,25 and 30% potato flour) revealed that biscuits containing 25 % potato flour as a supplement secured the highest score in terms of all sensory attributes among others, though all samples are acceptable. Misra and Kulshrestha [4] formulated biscuits by incorporating potato flour in 6 different proportions to

replace wheat flour at levels of 0, 10, 20, 30, 40 and 50 percent. Results of the sensory evaluation revealed that until the 20% level, there was no significant difference observed in acceptability of the product and all three levels had similar sensory scores, being judged as good for appearance, taste and color and fair for flavor, texture and overall acceptability. According to a study conducted by Nazni *et al*. [19] potato flour incorporated biscuits have obtained highest scores for overall acceptability when compared to maize and green gram flour incorporated biscuits.

Nutrient Content of Biscuits: As shown in Table 4, the nutritional value of the biscuits (Crude protein, fat carbohydrate and ash) with the highest acceptable level of potato flour (20 percent) was similar to the wheat flour (control) biscuit. Twenty percent potato flour incorporated biscuit contained 6.1% protein, 25.8% fat, 1.7%, ash and 63.9% total carbohydrate. Nutrient content of 20 % potato flour incorporated biscuits were similar to those found by Khaliduzzaman *et al*. [16] in a similar analysis.

Moisture, Crude Fibre, Peroxide Value and Microbial Quality of Biscuits: Moisture and crude fibre content of 20% potato flour incorporated biscuits (4.9% and 2.5g/100 g) and control (5.0% and 2.1 g/100g) are almost similar. Peroxide value is an indicator of rancidity development during storage. There was no rancidity development observed in the formulated biscuits up to 60 days. The studies conducted by Aruna [20] also indicated that no rancidity development was observed during storage period up to 60 days.

Microbial load of biscuits was in the acceptable limit for a period of 60 days from manufacture. The bacterial count of all biscuits samples was lower than acceptable limit of $1x10^5$ CFU/g of sample The bacterial count for the fresh, 30 days and 60 days old 20 % potato flour incorporated biscuits samples was $3x10^3$ CFU/g, $4.5x10^3$ CFU/g and $6.5x10^3$ CFU/g respectively. Fungus growth was not observed in all three tested samples. Priya [21] was also observed similar results during the microbial examination sweet potato flour incorporated biscuits for a storage period of 60 days.

CONCLUSION

The study was conducted to find out the best proportion of refined wheat and potato flour to formulate the biscuit. Biscuit containing 20 % potato flour showed the best performance compared to other proportion of flour used. For the large-scale biscuit manufacture, potato flour can be incorporated up to 20 percent level, without affecting the sensory characteristics of biscuits as was accepted by the panelists. Moreover, nutritional value of potato flour incorporated biscuits was similar to the control (refined wheat flour) biscuits, thus not affecting its nutritional quality. Hence, potato flour may prove to be quite economical and acceptable to replace refined wheat flour in biscuit preparation. A substantial amount of potato is spoiled and wasted due to inadequate cold storage facilities and insufficient post harvest handling facilities. In addition to this smaller size potatoes (<25 cm) are difficult to handle and so fetch low price to the grower and are considered as waste. These unmarketable potatoes can also be utilized for the preparation of value added products. Minimization of post harvest losses of potato through proper handling and processing into value-added products is thus warranted in order to help attain food security at least to some extent in the world.

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