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Utilization of Corn Fibre and Pectin Gel for the Development of Low Calorie and High Fibre Biscuits

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Authors' contributions

This work was carried out in collaboration between all authors. Authors PPS and KB designed the study, wrote the protocol, and wrote the first draft of the manuscript. Authors KB and GS managed the analysis of the study and managed the literature searches. Author RSS designed the study and performed the statistical analysis. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Aim: The study was carried out to standardize low calorie-high fibre biscuits by using corn fibre and pectin gel.
Methodology: Corn fibre is a by-product of corn starch industry. It was used to replace refined wheat flour at 10 to 40% to level for the development of low calorie and high fibre biscuits. Pectin gel was used as a fat replacer in the corn fibre biscuits, the level of substitution of fat with pectin gel being 10 to 50%. The physical, sensory and nutritional characters of the biscuits were determined.
Results: The total dietary fibre (TDF) increased while carbohydrates and energy decreased significantly when corn fibre replaced the refined wheat flour at all the four levels. The colour, appearance, texture, taste, flavor and overall acceptability of the biscuits was similar to control upto 20% supplementation of corn fibre, however, a significant reduction in sensory characteristics was observed when the level of supplementation was 30 or 40%. No significant shrinkage as expresses

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by the spread ratio of the biscuits was observed when pectin gel substituted the fat upto 20% level. A significant reduction in fat content of high fibre corn biscuits can be achieved by replacing it with pectin gel. The product can provide double advantage to the consumers as it has higher fibre (7.85 g/100 g) but lesser fat (18.68 g/100 g).

Conclusion: Supplementation of refined wheat flour with corn fibre upto 20% is appropriate to prepare high quality biscuits with desirable functional and sensory attributes. Further, the fat can be replaced satisfactorily with pectin gel upto 20%.

Keywords: Corn fibre; pectin gel; high fibre; low calorie; biscuits.

1. INTRODUCTION

Corn bran contains abundant amount of fibre. It is composed of polysaccharides, oligosaccharides and their derivatives, which cannot be digested by human digestive enzymes in the upper alimentary tract, but are beneficial for maintenance of health and prevention of diseases [1]. Corn fibre can be employed in medical nutrition therapies for maintenance of gastrointestinal health, prevention of hyperlipidemia and colon cancer and regulation of calcium bioavailability and immunological system [2]. Traditionally, corn fibre is a by-product of corn starch industry which has received little attention as a marketable commodity for human consumption. It is mainly being used in cattle feed which is a low value product. In recent years, attention has been given to efficient recovery of potential foods from the food industry by-products. This by-product at moderate levels can be incorporated into food products without a significant detrimental effect on product quality like other cereal fibres [3].

Recently, the fruit pectin has been used as an effective fat replacer in the baked products [4-6]. The use of pectin in corn fibre supplemented biscuits may have a dual purpose of replacing a significant amount of fat and a valuable source of soluble fibre. The commercially available pectin is mainly extracted from fruit juice waste such as the peels of apple and citrus fruits. An application of pectin as a fat substitute in baked products also serves the purpose of waste utilization of fruit juice industry. The basis for the development of high fibre foods is related to a relationship of a generous intake of dietary fibre with reduced risk for developing cardiovascular diseases, stroke, hypertension, diabetes, obesity, colon cancer and certain gastro-intestinal disorders. Fibre enriched foods are usually designated as low Glycemic Index foods. High fibre foods are reported to improve serum lipid concentration; lower blood pressure; improve blood glucose; control in diabetes; promote regularity; aid in weight loss and improve immune function [7].

The change in lifestyle, food habits and public awareness about the health benefits of dietary fibre has increased the demand for high fibre foods. Though the enrichment of food products with the fibre obtained from various sources like cereal brans and fruit and vegetable waste has been reported [8-12]. However, high fibre and reduced fat in baked products have not been much studied. Addition of fibre as well as reduction of fat in baked products especially in biscuits present a challenge to food technologists for making the products with enhanced nutritional quality but without or minimally affecting the physical and sensory properties of the final product.

Biscuits have always been one of the most popular and appealing food products due to their sensorial and textural characteristics, compactness, convenience and cost competitiveness. They have lower moisture content than cakes and bread, so are generally safer from microbiological spoilage and have a longer shelf life [13]. Traditionally, biscuits are high in calories, low in proteins and low in fibre and hence, are not considered in healthy food category especially for aged, diabetic and obese people [14]. The high fibre biscuits available in the market carry a significant amount of fat. The study was carried out to standardize corn fibre enriched biscuits where a portion of fat was replaced by pectin gel. These low calorie-high fibre biscuits may be helpful to control obesity and metabolic disorders and at the same time, they may be acceptable to most marketers and consumers.

2. MATERIALS AND METHODS

2.1 Procurement of Food Ingredients

Corn fibre, which is a by-product of corn starch was procured from Bharat Starch Industries, Yamuna Nagar, Haryana, India. The corn fibre was ground to a fine powder using Borocil Grinder (Model: Silverline 600W) in the food

laboratory. The apple pectin with 68-70% degree of esterification was supplied by Foodchem International Corporation, China and was used as a fat replacer. All other ingredients used for the biscuit formulations were purchased in a single lot from the local market.

2.2 Functional and Nutritional Properties of Refined Wheat Flour and Corn Fibre

Water holding capacity (WHC) and oil holding capacity (OHC) were determined by the methods described by Sosulski et al. [15] Swelling capacity (SWC) was measured according to the method reported by Okaka and Potter [16]. The nutritional analysis included the estimation of moisture, ash, protein and fat according to the standard AOAC [17] methods. The protein was determined using Kelplus digestion system (Model: KES 12R) and Kelplus Automatic Nitrogen Distillation System (Model: Elite EX VA) supplied by Pelican Equipments, India. The fat was determined using Socsplus automatic solvent/fat extraction system (Model SCS 6 DLS) by Pelican Equipments, India. The total dietary fibre (TDF) was analyzed by enzymatic gravimetric method [17] using Fibretech (Model: Fibertec™ 1023) manufactured by FOSS Analytical Private Limited, India. Carbohydrates were determined by difference from the total moisture, crude protein, crude fat, ash, and crude fibre. The calorific value was estimated by multiplying the proportion of protein, fat and carbohydrates by their respective physiological energy values and then taking the sum of the products.

2.3 Pectin Gel Formulation

Pectin gel was prepared by dissolving pectin powder in distilled water at a concentration of 20% [5]. Butter as shortening was incorporated with pectin gel at 10, 20, 30, 40 and 50% for preparing the biscuits.

2.4 Biscuit Formulations and Preparation

Two experimental trials were conducted thrice. The first trial was to standardize high fibre biscuits by replacing refined wheat flour with corn fibre till at four levels i.e. 10 to 40%. Out of four corn fibre enriched biscuit formulations, the one with maximum physical and sensory attributes was selected for the second experimental trial where fat was replaced partially with pectin gel.

A total of ten biscuit formulations (One control and ten test formulations) were prepared as described in Table 1. Butter and sugar were mixed until creamy using electric mixer (Philips HR 1469, 300-Watt). The dried ingredients were sifted twice and were put into the mixture of butter and sugar. They were uniformly mixed to obtain consistent dough. The dough was rolled out to a height of 5 mm and cut into circular shape with diameter of 6 cm using a biscuit cutter. The biscuits were baked at 180ºC for 15 minutes in a bakery oven (Thermodyne Bakery and Industrial Equipments Pvt. Ltd. India). The biscuits were cooled at room temperature and sealed in the polythene bags for further measurements and analysis.

Table 1. Formulations of low calorie and high fibre biscuits

Ingredients (g)	Formulations†									
	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
Refined wheat flour	100	90	80	70	60	80	80	80	80	80
Corn fibre	0	10	20	30	40	20	20	20	20	20
Butter	50	50	50	50	50	45	40	35	30	25
Pectin gel	0	0	0	0	0	5	10	15	20	25
Sugar	50	50	50	50	50	50	50	50	50	50
Sodium bicarbonate	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Ammonium bicarbonate	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Baking powder	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Milk, ml	10	10	10	10	10	10	10	10	10	10

† T_0 refined wheat flour:corn flour is 100:0; T_1 refined wheat flour:corn flour is 90:10; T_2 refined wheat flour:corn flour is 80:20; T_3 refined wheat flour:corn flour is 70:30; T_4 refined wheat flour:corn flour is 60:40; T_5 refined wheat flour:corn flour is 80:20 & butter:pectin gel is 90:10; T_6 refined wheat flour:corn flour is 80:20 & butter:pectin gel is 90:10; T_7 refined wheat flour:corn flour is 80:20 & butter:pectin gel is 70:30; T_8 refined wheat flour:corn flour is 80:20 & butter:pectin gel is 90:10; T_9 refined wheat flour:corn flour is 80:20 & butter:pectin gel is 50:50.

2.5 Physical Characteristics of Biscuits

Physical characteristics of the biscuits i.e. diameter (D) and thickness (T) was studied. Five pieces of biscuits from each formulation were placed edge to edge and stacked one above the other to measure the diameter (D) and thickness (T), respectively. The average values of diameter (D) and thickness (T) were expressed in mm [18]. The spread ratio of biscuits was derived from diameter and width. Hardness of the biscuits was measured by Texture Analyzer (TA.HD Plus Texture Analyzer, US). The hardness was measured in terms of maximum force used to break the biscuits. The texture analyzer settings were fixed (pre-test speed 2.0 mm/sec, test speed 0.5 mm/sec, post-test speed 10 mm/sec, distance 4 mm/sec).

2.6 Sensory Evaluation

The sensory evaluation of the biscuits was carried out thrice in the Department of Food and Nutrition, Punjab Agricultural University, Ludhiana, India. The sensory evaluation of the two experimental trials was conducted on separate days. The sensory attributes of biscuits were evaluated in terms of appearance, colour, texture, taste and flavour by a semi-trained panel consisting of ten female faculty members in the age group of 40-50y. A nine point Hedonic scale was used having a score of 9-extreme liking, 8-like very much, 7-like moderately, 6-like slightly, 5-neither like nor dislike, 4-dislike slightly, 3-dislike moderately, 2-dislike very much and 1 for extreme disliking. The overall acceptability score was calculated as the average of the five parameters. The evaluation was carried out at 10.30 am each day. Samples were labeled with code numbers and presented in a random sequence to the members of the panel. The test was conducted in adequately lit individual booths. Before beginning of the evaluation, the panelists read and signed an informed consent form. The panelists were instructed to drink water after every sample and they were not allowed to comment during evaluation to prevent any peer-influence.

2.7 Statistical Analysis

The data obtained from two experimental trials performed three times each was presented as mean and standard deviations for various parameters. The analysis of variance was derived using MS Excel (2007) Statistical Analysis Tool Pak. Tukey's test was performed to compare the functional, nutritional and sensory characteristics of the biscuits using SAS software 9.1 version. The limit of probability fixed for the test of significance ($P \leq 0.05$) and least significance difference was calculated.

3. RESULTS AND DISCUSSION

3.1 Functional Properties and Nutritional Composition of Wheat Flour and Corn Fibre

Table 2 shows a comparison of functional properties and nutritional composition of corn fibre and refined wheat flour. A significantly higher Water Holding Capacity (WHC) and Oil Holding Capacity (OHC) of corn fibre was observed as compared to refined wheat flour. The relatively high OHC of corn fibre can be useful in bakery formulations where oil holding properties are required. The dietary fibres with high OHC allow the stabilization of high fat food products and emulsions [19]. Dietary fibres with high WHC can be used as a functional ingredient to modify the viscosity and texture of some formulated foods. The supplementation of young corn powder in biscuits was effectively used as a functional ingredient and a partial ingredient for substitution of wheat flour because of its ability to improve the nutritional quality of the final product without ignoring its palatability [20].

The results of the nutritional analysis revealed that the protein in corn fibre was comparable (11.5 vs. 10.9g/100g) while fat and carbohydrates were much lower i.e 3.1 vs. 0.8 and 20.9 vs. 79.1g/100g in comparison to refined wheat flour. Corn fibre was rich in total dietary fibre (58.6g/100g) while refined wheat flour had negligible amounts of dietary fibre. The results confirmed that supplementation of corn fibre in traditional biscuit formulation was appropriate to reduce fat and calories and to enhance fibre in the final product. Dietary fibre are not only desirable for their nutritional properties, but also for their functional and technological properties hence, they can be used to upgrade agricultural by-products for their use as food ingredients [21,13].

3.2 Physical Properties, Nutritional Composition and Sensory Characteristics of Corn Fibre Biscuits

The physical characteristics and nutritional composition of biscuits enriched with corn fibre at 0 to 40% level are presented in Table 3. The

Table 2. Functional properties and nutritional composition of wheat flour and corn fibre

Parameter	Corn fibre	Refined wheat flour
Water Absorption Capacity, g of water/g	4.7±0.1	1.2±0.1
Oil Holding Capacity, g of oil/g	2.8±0.2	1.1±0.1
Swelling Capacity	19.7±0.9	12.4±1.1
Moisture, g/100g	5.2±0.1	8.5±0.1
Protein, g/100g	11.5±0.3	10.9±0.3
Fat, g/100g	3.1±0.1	0.8±0.1
Ash, g/100g	0.7±0.1	0.3±0.1
Dietary fibre, g/100g	58.6±2.2	0.4±0.0
Insoluble	57.3±2.1	0.3±0.0
Soluble	1.0±0.1	0.1±0.0
Carbohydrates, g/100g	20.9±2.3	79.1±4.2
Energy, Kcal/100g	169.0±11.9	368.0±14.3

Values are presented as Mean ± SD

Table 3. Effect of corn fibre incorporation on physical properties and nutritional composition (per 100g) of biscuits

Characteristics	Formulations[†]				
	T_0	T_1	T_2	T_3	T_4
Physical properties					
Diameter, mm	66.4^{a}±0.3	65.5^{b}±0.4	65.5^{b}±0.2	65.3^{b}±0.1	64.4^{c}±0.5
Thickness, mm	6.2±0.1	6.3±0.1	6.4±0.5	6.5±0.1	6.5±0.1
Spread ratio	10.7^{a}±0.2	10.5^{a}±0.2	10.3^{ab}±0.8	10.1^{ab}±0.1	9.9^{b}±0.2
%Spread factor	100.0±0.0	97.6±2.7	95.5±8.9	93.8±2.6	91.9±0.9
Hardness, n	20.4^{a}±0.1	21.5^{b}±0.1	21.8^{c}±0.1	22.6^{d}±0.2	23.7^{e}±0.1
Nutritional composition					
Moisture, g	4.0^{a}±0.0	4.01^{b}±0.1	4.10^{b}±0.0	4.2^{c}±0.0	4.3^{d}±0.0
Protein, g	6.3^{a}±0.1	6.31^{a}±0.0	6.3^{a}±0.01	6.2^{b}±0.0	6.0^{c}±0.0
Fat, g	23.5^{a}±0.1	23.5^{a}±0.0	23.4^{b}±0.1	23.0^{c}±0.0	22.7^{d}±0.0
Ash, g	0.3±0.02	0.35±0.0	0.4±0.0	0.4±0.0	0.4±0.0
Total Dietary Fibre, g	0.2^{a}±0.03	3.5^{b}±0.1	6.7^{c}±0.2	9.8^{d}±0.1	12.5^{e}±0.1
Carbohydrates, g	65.7^{a}±0.1	62.3^{b}±0.1	59.2^{c}±0.2	56.4^{d}±0.1	54.2^{e}±0.1
Energy, Kcal	499^{a}±0.3	486^{b}±0.5	472^{c}±0.5	458^{d}±0.5	445^{e}±0.3

[†]***T_0** refined wheat flour:corn flour is 100:0; **T_1** refined wheat flour:corn flour is 90:10; **T_2** refined wheat flour:corn flour is 80:20; **T_3** refined wheat flour:corn flour is 70:30; **T_4** refined wheat flour:corn flour is 60:40*

Values are presented as Mean ± SD.

Superscripts with same alphabets imply non significant difference at 5% level of significance

Superscripts with different alphabets imply significant difference at 5% level of significance

diameter of the biscuits decreased significantly as the level of corn fibre enrichment increased in the biscuits. The spread ratio of the biscuits decreased significantly with 40% corn fibre enrichment. The results indicated that spread ratio of biscuits did not alter significantly upto 20% enrichment in comparison to control, respectively. Cookies with higher spread ratio are more desirable [22] as reported by Eissa et al. (2007). The influence of young corn powder on spread ratio of biscuits was found to be significant at 30% level of incorporation [20]. Artz et al. [23] found that the addition of 15% corn fiber did not significantly affect the cookie spread. Chen et al. [24] did not find any difference in cookie spread between the control and cookies containing lower fibre i.e. either 12% oat bran or 8% wheat bran. On the other hand, Khalil et al. [12] observed a significant decrease in diameter and spread ratio of biscuits with 10 to 30% oat bran supplementation. The hardness of corn fibre supplemented biscuits increased significantly at all the levels. Anis Jauharah et al. [20] found that hardness of biscuits increased in line with the level of incorporation of young corn powder. Artz et al. [22] found a significantly more hardness in cookies containing 15% corn fibre as compared to control. Silky and Tiwari [11] reported that the hardness of biscuits increased significantly by increasing wheat bran incorporation from 0 to 30%.

The moisture content of the biscuits increased significantly when corn fibre was supplemented at all the four levels in comparison to control while protein decreased significantly at 30 and 40% levels. Similarly, the fat content also decreased significantly on addition of corn fibre at 20 to 30%. The total dietary fibre (TDF) increased while carbohydrates and energy decreased significantly at all the levels (Table 3). The inclusion of wheat bran in refined wheat flour significantly increased the fat and crude fibre content and decreased the carbohydrates [11]. The substitution of wheat flour with young corn powder from 10 to 30% level in biscuits resulted in a significant decrease in fat and carbohydrates and an increase in the fibre content [12]. Similarly, Cheung et al. [3] also formulated high fibre chocolate chip cookies by substitution of all purpose flour with 2-50% of corn fibre. The results of the present study revealed that a significant increase in fibre and decrease in carbohydrates and energy make the corn fibre biscuits a healthy product for the consumers as it may impart beneficial health effects by reducing obesity and the risk of degenerative diseases.

The results of sensory evaluation as shown in Table 4 revealed that the colour of biscuits was darkened with the addition of corn fibre. The colour and appearance of corn fibre supplemented biscuits was comparable to control biscuits upto 20% of supplementation while 30 and 40% supplementation had significantly lowered the score for colour and appearance. The texture, taste, flavor and overall acceptability of the biscuits were similar to control upto 20% supplementation beyond that, a significant reduction in these characteristics was observed. Khalil et al. [12] also reported a significant decrease in overall acceptability of biscuits with an increase in the level of oat incorporation i.e. 0 to 30%, however, 10% oat bran incorporated biscuits obtained the highest rating as compared to other treatments. Silky and Tiwari [11] showed that the incorporation of wheat bran in refined wheat flour upto the level of 20% was found to be the most suitable for preparing high fibre biscuits. Similarly, El-Sharnouby et al. [25] reported that the use of wheat bran upto 30% in biscuits was acceptable. The use of multigrain premix upto 20% level was reported to be good enough to produce acceptable biscuits with high dietary fibre [26]. The incorporation of maize bran upto 50% in biscuit preparation without any appreciable change in colour, flavor and texture has also been reported [13]. The results of the present study indicated that a low calorie and high fibre biscuits can be made with substitution of corn fibre upto 20% without adversely affecting the sensory characteristics of the biscuits.

3.3 Physical Properties, Nutritional Composition and Sensory Characteristics of Corn Fibre Biscuits with Partial Replacement of Fat with Pectin Gel

Table 5 shows that there was no significant shrinkage in biscuits expressed by the spread ratio when the fat was substituted with pectin gel upto 20%, however, beyond this level, the shrinkage increased significantly with an increase in the level of pectin gel. A significant shrinkage in cookies was reported when fat was replaced with 30 to 50% of pectin obtained from orange by-products [6], but the replacement of fat by pectin upto 20% level did not significantly alter the spread ratio. In a study, when pectin enriched materials from apple pomace were

Table 4. Effect of corn fibre incorporation on sensory characteristics of biscuits

Sensory characteristics	Formulations[†]				
	T_0	T_1	T_2	T_3	T_4
Colour	8.4^{a}±0.5	8.3^{a}±0.7	8.1^{b}±0.7	7.6^{c}±0.5	7.2^{d}±0.8
Appearance	8.4^{a}±0.5	8.4^{a}±0.5	8.2^{b}±0.4	7.2^{c}±0.4	7.2^{d}±0.4
Texture	8.2^{a}±0.4	8.2^{a}±0.4	8.3^{b}±0.4	7.3^{c}±0.5	6.8^{d}±0.4
Taste	8.6^{a}±0.5	8.4^{b}±0.5	8.4^{b}±0.5	7.4^{c}±0.5	6.2^{d}±0.4
Flavour	8.2^{a}±0.4	8.2^{a}±0.4	8.2^{a}±0.4	6.6^{b}±0.5	6.2^{b}±0.4
Overall acceptability	8.4^{a}±0.5	8.3^{a}±0.5	8.2^{b}±0.5	7.2^{c}±0.6	6.7^{d}±0.7

[#]Values are the scores on 9 point hedonic scale

*[†]**T_0** refined wheat flour:corn flour is 100:0; **T_1** refined wheat flour:corn flour is 90:10; **T_2** refined wheat flour:corn flour is 80:20; **T_3** refined wheat flour:corn flour is 70:30; **T_4** refined wheat flour:corn flour is 60:40*

Values are presented as Mean ± SD.

Superscripts with same alphabets imply non significant difference at 5% level of significance

Superscripts with different alphabets imply significant difference at 5% level of significance

Table 5. Changes in physical properties and nutritional composition of corn fibre biscuits with partial replacement of fat with pectin gel

Characteristics	Formulations†					
	T_2	T_5	T_6	T_7	T_8	T_9
Physical properties						
Diameter, mm	65.5^{a}±0.2	65.2^{a}±0.2	63.8^{b}±0.7	62.4^{c}±0.1	61.9^{d}±0.4	61.1^{d}±0.6
Thickness, mm	6.4±0.5	6.4±0.0	6.5±0.1	6.7±0.0	6.7±0.2	6.7±0.3
Spread ratio	10.3^{a}±0.8	10.1^{a}±0.1	9.8^{ab}±0.2	9.5^{ab}±0.3	9.3^{b}±0.3	9.1^{b}±0.4
% Spread factor	100.0±0.0	98.7±8.4	99.6±3.0	98.2±6.7	90.4±8.2	90.0±4.1
Hardness, n	21.8^{a}±0.1	21.9^{b}±0.1	22.2^{c}±0.1	22.9^{cd}±0.1	23.5^{de}±0.2	24.8^{ef}±0.2
Nutritional composition						
Moisture, g	4.1^{a}±0.0	4.6^{b}±0.1	4.8^{c}±0.1	5.1^{d}±0.1	5.3^{e}±0.1	5.7^{f}±0.1
Protein, g	6.3a±0.0	6.3^{a}±0.1	6.2^{ab}±0.0	6.2^{b}±0.0	6.0^{c}±0.1	5.9^{c}±0.7
Fat, g	23.3^{a}±0.1	21.0^{b}±0.1	18.7^{c}±0.1	16.3^{d}±0.2	13.7^{e}±0.1	11.4^{f}±0.1
Ash, g	0.4±0.0	0.4±0.0	0.4±0.0	0.4±0.0	0.3±0.0	0.3±0.0
Total Dietary fibre,g	6.7^{a}±0.2	7.3^{b}±0.1	7.9^{c}±0.1	8.4^{d}±0.0	8.7^{e}±0.8	9.1^{f}±0.1
Carbohydrates, g	40.8^{a}±0.3	39.4^{b}±0.3	37.9^{c}±0.3	36.2^{d}±0.3	34.0^{e}±0.4	32.4^{f}±0.4
Energy, Kcal	398^{a}±1.8	372^{b}±2.1	345^{c}±1.8	316^{d}±2.7	283^{e}±3.2	255^{f}±2.8

†T_2 refined wheat flour:corn flour is 80:20; T_5 refined wheat flour:corn flour is 80:20 & butter:pectin gel is 90:10; T_6 refined wheat flour:corn flour is 80:20 & butter:pectin gel is 90:10; T_7 refined wheat flour:corn flour is 80:20 & butter:pectin gel is 70:30; T_8 refined wheat flour:corn flour is 80:20 & butter:pectin gel is 90:10; T_9 refined wheat flour:corn flour is 80:20 & butter:pectin gel is 50:50.

Values are presented as Mean ± SD.

Superscripts with same alphabets imply non significant difference at 5% level of significance

Superscripts with different alphabets imply significant difference at 5% level of significance

Table 6. Changes in sensory characteristics of corn fibre biscuits with partial replacement of fat with pectin gel

Sensory characteristics	Formulations†					
	T_2	T_5	T_6	T_7	T_8	T_9
Colour	8.1^{a}±0.8	8.0^{a}±0.7	8.0^{a}±0.7	7.6^{b}±0.5	5.0^{c}±0.7	5.0^{c}±0.7
Appearance	8.2^{a}±0.4	8.0^{a}±0.5	7.9^{ab}±0.6	7.4^{b}±0.5	6.2^{c}±0.8	5.4^{d}±0.5
Texture	8.4^{a}±0.5	8.2^{a}±0.8	8.1^{a}±0.7	7.4^{b}±0.5	4.6^{c}±0.8	4.4^{c}±0.5
Taste	8.4^{a}±0.5	8.2^{a}±0.4	8.2^{a}±0.6	7.4^{b}±0.5	5.2^{c}±0.4	3.8^{d}±0.8
Flavour	8.2^{a}±0.4	8.2^{a}±0.4	8.0^{a}±0.7	7.4^{b}±0.5	5.6^{c}±0.5	4.4^{d}±0.5
Overall acceptability	8.3^{a}±0.5	8.1^{b}±0.6	8.0^{b}±0.6	7.4^{c}±0.5	5.5^{d}±0.8	4.8^{e}±0.6

#Values are the scores on 9 point hedonic scale

†T_2 refined wheat flour:corn flour is 80:20; T_5 refined wheat flour:corn flour is 80:20 & butter:pectin gel is 90:10; T_6 refined wheat flour:corn flour is 80:20 & butter:pectin gel is 90:10; T_7 refined wheat flour:corn flour is 80:20 & butter:pectin gel is 70:30; T_8 refined wheat flour:corn flour is 80:20 & butter:pectin gel is 90:10; T_9 refined wheat flour:corn flour is 80:20 & butter:pectin gel is 50:50.

Values are presented as Mean ± SD.

Superscripts with same alphabets imply non significant difference at 5% level of significance

Superscripts with different alphabets imply significant difference at 5% level of significance

incorporated into cookie formulations in place of shortening up to 30% level, the cookie spread diameter was reduced and the moisture content was increased [4]. Hardness of the corn fibre biscuits also increased significantly when fat was replaced with pectin gel at all the levels. In a study by Lim et al. [5], the cakes containing pectin as a fat replacer exhibited increased textural hardness.

There was a significant increase in moisture and total dietary fibre but a decrease in fat, carbohydrates and energy content of biscuits was observed when there was an increase in the level of replacement of fat by the pectin gel. Besides, water as a main component of fat mimetic sample, the pectin itself is non-calorific because it is not digested or absorbed in the human digestive tract. Prihatin et al. [6] also found that there was an increase in moisture and a decrease in fat content when the level of fat replacers was increased in the cookies. The moisture content increased with addition of pectin due to high moisture content of fat

replacer preparation, which is a very typical characteristic of carbohydrate based fat replacers.

The evaluation of sensory characteristics (Table 6) which is the most crucial in overall acceptability of the final product revealed that the colour and appearance of the biscuits was comparable to control upto 30% of fat substitution by pectin gel but texture, taste, flavor and overall acceptability was at par with control when fat was substituted with pectin gel upto 20% level. Min et al. [4] observed that the replacement of shortening with pectin enriched materials from apple pomace contributed to a more tender texture and lighter surface color of the cookies.

4. CONCLUSIONS

The study concluded that corn fibre is suitable to enrich refined wheat flour due to its optimum functional, nutritional and sensory properties for the preparation of high fibre and low calorie biscuits. The supplementation of refined wheat flour with corn fibre upto 20% is appropriate to prepare high quality biscuits with desirable physic-chemical attributes. The fat can be replaced satisfactorily with pectin gel upto 20% to further reduce the fat content of fibre rich biscuits,. Therefore, a significant reduction in fat content of high fibre corn biscuits by replacing it with pectin gel can give double advantage to the consumers for a product which has higher fibre (7.85 g/100g) but lesser fat (18.68 g/100g), thus may offer protection from the risk of obesity and other metabolic disorders.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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