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Utilization of the Permeate as Replace Sugar to Improve Biscuits Quality

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ABSTRACT

Permeate is a byproduct of the manufacture of whey and milk protein concentrate. The aim of this study is to evaluate the effect of using permeate powder as natural by product to improve quality of biscuits. Permeate powder at levels (20% (B_1), 40% (B_2), 60 %(B_3), 80 %(B_4) and 100% (B_5) were used to substitute sugar in the production of biscuits. The results showed that the permeate powder had the highest values of ash, lactose and minerals content, (especially, sodium, calcium, phosphorus, and potassium).On the other hand, the additions of permeate powder in the various biscuit formulations contributed to the increase in their minerals and moisture content compared with the control while slight decreased in spread ratio. All biscuits gave good accepted score. There are no significant between control, B_1, B_2 and B_3 in taste. Also, it was more acceptable among the panelists. From these results, it can be concluded that permeate powder improve the quality and significantly increase the nutritional values of the biscuits with reducing the amount of sugar.

Key words: Permeate-biscuits-lactose- nutritional value

Introduction

Food supplementation defined as the addition of one or more nutrients to a food to improve its quality for the people who consume it, usually with the goal of reducing or controlling nutrient deficiency (Mahamoud *et al.,* 2012).

Permeate is an important byproduct of ultra-filtration process in cheese industry. Meanwhile, substances of lower molecular weight, such as lactose and minerals, in addition to water-soluble vitamins and salts pass through the filter. Therefore, permeate can be considered as a solution of nutritious significance (Murad *et al.,* 2011 and Marhamatizadeh *et al.,* 2012).

Permeate is a byproduct of the manufacture of whey and milk protein concentrate or isolate. Minerals and lactose removed during membrane fractionation are found in permeate. The approximate dry weight composition of permeate is 65 to 85% lactose, 8 to 20% ash or minerals, 3 to 8% protein, and less than 1.5% fat (US Dairy Export Council, 2011). Permeate contains bioavailable calcium, phosphorus, magnesium and potassium, which are minerals important for growth (Drewnowski *et al*., 2012).

(Hattem *et al*., 2011) In this respect, ultrafiltration of milk produces a large quantity of permeate as byproduct. It contains lactose as the major constituent in addition to water soluble vitamins and salts of milk. Therefore, permeate can be considered as a solution of nutritious significance. Renner and Abd El-Salam (1991) reported that permeate appears as a crystal clear, greenish fluid. Besides lactose, minerals and vitamins are fractioned between the retentate and permeate. The permeate would contain about 80% of the original lactose, whilst the other components would pass into the permeate in various proportions. Concerning the use of permeate in food industry, there are several procedures may be applied to obtain products which are modified in some properties to be better usable.

Besides lactose as the major constituent, permeate contains salts and water-soluble vitamins which would affect the flavor and nutritive value of permeate powder. Milk salts were reported to have a significant role in the flavor characteristics of whey powder (Helbig *et al.,* 1978 and Higgins and Lorimer, 1982) and their levels in permeate would affect the flavor of the resultant product.

Abrams *et al.* (2002) reported that lactose is the most abundant carbohydrate of mammalian milk and milk is the only known natural source of significant amounts of lactose. Human milk contains approx. 7 % of lactose and cow's milk contains approx. 4.6% of lactose. In exclusively breast fed infants lactose constitutes about 40% of the daily energy consumption.

Golden, (2009) showed that the processing of milk to whey and whey permeate changes the absolute and relative composition of minerals present. Whole milk is a good source of calcium, magnesium, phosphorus, potassium, selenium and zinc. A great proportion of the calcium, magnesium and phosphorus present in milk are however bound to the casein fraction of milk, and the mineral content in whey and

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whey permeate is therefore lower than in whole milk. Potassium, sodium and calcium are present as diffusible salts in whole milk and are transferred to whey permeate without any major changes.

Biscuits are one of the most popular bakery items consumed nearly by all levels of society; this is mainly due to its ready to eat nature, good nutritional quality, and availability in different varieties and affordable cost (Sudha *et al*. 2007). Among cereal-based products, biscuits are characterized by their enrichment with two major ingredients, sugars and fats, and by their low final water content 1–5 % (Chevallier *et al*. 2000). Sucrose is the main sugar used in short dough biscuit formula, and it plays an important role in the biscuit manufacturing as well as in the biscuits final quality. Sugar inhibits gluten development during dough mixing by competing with the flour for the recipe water, resulting in less tough and more crumbly biscuits. Sugar affects flavor, dimensions, color, hardness and surface finish (Gallagher *et al*., 2003). Nowadays, however, such high sugar levels are considered undesirable for several health reasons such as dental problems, obesity, type II diabetes, high blood cholesterol, and coronary disease (Pareyt *et al*., 2009). Decreasing the amount of sugar added to biscuits is a good way to obtain a healthier and lower-calorie product (Drewnowski *et al*., 1998).

Gallagher *et al*. (2003) used an oligosaccharide, Raftlose to replace 20–30 % of the sugar resulting in softer biscuits and different surface color attributes. Biscuits with the highest level of sugar replacement showed different surface color attributes.

Moreover, biscuits have only about 6–7% protein (Agarwal 1990). Also, they are high in carbohydrates, fat and calorie but low in fiber, vitamin, and mineral which make it unhealthy for daily use. However, biscuits are probably a better vehicle of fortification with protein because of their popularity, high nutrient density and long shelf-life because they are very low in moisture (Sudha *et al.,* 2007).

Protein energy malnutrition (PEM) is one of the most serious health problems in many part of country especially in developing countries FAO, (2007). High protein soya bakery product reduce incidence of malnutrition (Whitehead *et al.,* 1986) and encourage the farmers to grow more soybean due to increasing demand in the market (Islam *et al*., 2007).

Farzana and Mohajan, (2015) indicate that good quality biscuits can be prepared by substituting wheat flour with 15% soy flour and addition of mushroom powders may affect the backing quality. Fortification of wheat biscuits with 20% isolated soy protein (Mohsen *et al.,* 2009) or 20% defatted soy flour DSF (Singh *et al.,* 2000) increased protein content to 20% and 10%, respectively. Mishra and Chandra (2012) showed that, supplementation of soy flour and rice bran at 15% level each for biscuits, would improve the nutritional quality without adversely affecting the sensory parameters. Also, (Singh *et al*., 2000) found that enrichment of defatted soya flour up to 20% improves the nutritional quality of bakery products like biscuit, bread, muffins without affecting its taste, textural and overall acceptability of product.

The main objective from this investigation was to feasibility of the use it as sugar replacer on short dough biscuits to create the best suitable product.

Materials and Methods

Materials:

Wheat flour (72% extraction) was obtained from El-Haram Milling Company, Giza. Permeate used in the biscuits making was obtained from Al-Alamia for Modern Industries Co., 1st industry area, building 43, October, Giza, Egypt. Low fat soy flour was obtained from Food Technology Research Institute, Agricultural Research Center Giza, Egypt. All other ingredients like sugar, butter, baking powder, eggs and vanilla were obtained from local market.

Methods:

Procedure for preparation of biscuits:

The base formulation to develop the biscuits was made according to the standard procedure for sweet biscuit at BiscoMisr Co., Cairo. The formulae of biscuits were made as follows according to the Wade (1988) with some modification. Six samples were developed, listed in Table (1) with partial replacement of sugar by permeate powder: first sample with no permeate (control), 20% (B_1), 40% (B_2), 60 % (B_3), 80 % (B_4) and 100% of the sugar by permeate powder (B_5). All blends of biscuit were added 20% of low fat soy flour.

Table 1: Formulae of the biscuits

Ingredients (%)	Control	B_1	B_2	B_3	B_4	B_5
Wheat flour (72%)	80	80	80	80	80	80
Low fat soy flour	20	20	20	20	20	20
Sugar	30	24	18	12	6	0
Permeate powder	0	6	12	18	24	30
Butter	20	20	20	20	20	20
Eggs (whole, fresh)	24	24	24	24	24	24
Vanilla	1	1	1	1	1	1
Baking powder	1	1	1	1	1	1

B_1: biscuits with 20% sugar reduction; B_2: biscuits with 40% sugar reduction; B_3: biscuits with 60% sugar reduction; B_4: biscuits with 80% sugar reduction; B_5: biscuits with 100% sugarreduction.

Chemical analysis:

Moisture, protein, ash, crude fiber and fat content were determined according to the methods described in A.O.A.C. (2010). Total carbohydrates were calculated by difference. Minerals content, i.e., Na, Ca, Mg, P and K were determined in the diluted solution of ash samples by using the atomic absorption spectrophotometer (3300 Perkin-Elmer) as described in A.O.A.C. (2010). Lactose were determined in permeate powder by high perphormance liquid chromatography (HPLC) Hewlett Packard 1040A HPLC detection system as described by Jeon *et al.,*(1984).

Quality evaluation of biscuits:

The biscuits were evaluated for thickness, weight, diameter and spread ratio content as described by Gaines, (1991).Six biscuits edge-to-edge, were used for the evaluation and the average was noted. Diameter and thickness were measured using a Vernier Caliper. Spread ratio was calculated from the ratio of diameter to thickness and calculated using the following equation:

Spread ratio = Diameter / Thickness

Texture Profile Analysis (TPA) of biscuits:

Biscuits texture (hardness) was determined using Texture Profile Analyzer (TPA) according to (Bourne, 2003). Texture was determined by universal testing machine (Conetech, B type, Taiwan) provided with software.

Sensory evaluation of biscuits:

The10 panelists from the staff of Bread and Pastry, Res. Dept., Food Tech. Res. Institute., Agric. Res. Center, Giza were requested to assign score for characteristics appearance, color, texture, flavor, taste and overall acceptability of biscuit according to the method of Sudha *et al*. (2007).

Statistical analysis:

The data obtained from sensory evaluations were statistically analyzed by the least significant differences value (L.S.D) at 0.05 levels probability procedure to Snedecor and Cochran (1980).

Results and Discussion

Chemical composition of raw materials:

The obtained results in Table (2) indicated that the permeate powder contained the highest values of ash and lactose (7.92 and 82 %, respectively), while low fatted soy flour had highest protein and fiber content (46.71 and 4.39% respectively). Also, from the same table, it can be seen that, permeate powder had the highest value of Na, Ca, P and K (981, 430, 720 and 2157mg/100 g, respectively) compared with low fat soy and wheat flour (72%).While low fat soy flour contained the highest values Mg content (209.00 mg/100g). These results are in agreement with those reported by Abd EL-Salam *et al.* (1985) reported that the ash content in the range 7.16- 7.81% , protein content in the range 3.75-4.69% and lactose content in the range 86.1-88.3%. The permeate powder contents of Na, Ca, Mg, P and K (981, 430, 99.87,

720 and 2157 mg/100 g, respectively).Higgins and Lorimer, (1982) reported that the Ca content ranged from 380 to 620 mg/100 g for permeate powder and Mg content ranged from 70.6-109.4 mg/100 g. The Na content of permeate powder ranged from 0.92-1.38% and the K content of ranged from 1.99-2.77% (Higgins and Lorimer, 1982).

Table 2: Chemical Characteristics of raw materialson dry weight basis

Parameter (%)	Permeate powder	Low fat soy flour	Wheat flour (72%)
Protein	5.00	46.71	10.15
Ash	7.92	5.72	0.48
Fat	0.013	5.67	0.87
Crude fiber	0.012	4.39	0.47
Carbohydrate	87.055	37.51	88.03
Lactose	82	--	--
Minerals(mg/100g)			
Na	981	28.30	31.82
Ca	430	192.00	28.34
Mg	99.87	209.00	30.56
P	720	360.00	128.22
K	2157	350.00	132.45

Chemical composition of biscuits:

Chemical composition of biscuits with 20% of low fat soy flour were prepared by replacing sugar with different levels of permeate powder are presented in Table (3).The results showed that, the biscuit with 100% permeate powder had the highest value of protein, ash, fat, fiber and lowest value of total carbohydrate (20.42%, 18.99%, 3.19%, 1.85%, and 55.55% respectively) compared with the control. All samples of biscuits (except the control) had protein content ranged from 16.25-20.42%, ash 2.21-3.19%, fat 18.90-18.99%, crude fiber 1.80-1.87% and total carbohydrate 55.55-60.61 %.

Also the results presented in Table (3), show that higher in protein, ash and mineral due to add of 20% soy flour and different levels of permeate powder had the highest values in minerals content (i.e., sodium, calcium, manganese, phosphors and potassium) compared with control biscuits. The addition of permeate powder to biscuit formulation contributed to the increase in their mineral content, especially calcium, magnesium, phosphorus and potassium due to their higher amounts in permeate powder (Marhamatizadeh *et al.,* 2012 and Udovicic *et al.,* 2013). Also addition of 20% defatted soy flour to all blends of biscuit were found to be nutritionally preferable have higher protein, fat crude fiber content and minerals content (Alam *et al.* 2013and Singh *et al*., 2000).

Table 3: Chemical composition of produced biscuits on dry weight

	Biscuits samples					
Parameter (%)	Control	B_1	B_2	B_3	B_4	B_5
Protein	9.51	16.25	16.99	17.85	19.05	20.42
Ash	1.41	2.21	2.48	2.84	2.96	3.19
Crude Fat	18.11	18.90	18.84	18.98	18.93	18.99
Crude fiber	1.25	1.86	1.84	1.87	1.80	1.85
Total carbohydrate	69.74	60.61	59.85	58.46	57.26	55.55
Minerals(mg/100g)						
Na	2.93	44.98	83.61	121.65	159.71	197.73
Ca	27.76	85.87	116.59	151.82	178.94	208.49
Mg	18.47	55.08	60.88	65.63	70.80	76.18
P	88.05	122.98	166.18	185.19	220.24	261.61
K	115.99	150.62	182.89	200.01	217.46	234.96

B_1: biscuits with 20% sugar reduction; B_2: biscuits with 40% sugar reduction; B_3: biscuits with 60% sugar reduction; B_4: biscuits with 80% sugar reduction; B_5: biscuits with 100% sugar free reduction.

Physical properties of produced biscuits:

Physical properties of biscuits are important for both manufacturers and consumers. Table (4) showed that the all samples of biscuits which had higher moisture content, ranged from 3.93 to 4.39% than the control (3.89%). Such increase in moisture may be due to the levels of substitution of permeate powder which absorb more water and could be due to the fact that soy flour absorb moisture in baked product Mishra and Chandra (2012). The weights of biscuits were slightly increased by increasing whey permeate

powder substitution resulted from the increased water absorption by the higher level of permeate powder. Also, the changes in diameter and thickness were reflected in spread ratio of biscuits. Data in the same table showed that, spread ratio in all samples of biscuits resultant slight decreased by increasing flour substitution permeate powder. The hardness of the biscuits was increased and spread ratio was decreased by increasing addition levels of permeate powder compared to the control sample. Reduced spread ratios of biscuits were attributed to the non-wheat high protein flour or any other ingredient which absorbs water during dough mixing will reduce the spread ratio may be caused the water available in such system would be insufficient to dissolve sugar during baking, increasing the viscosity and resulting in lower spread ratio (Kissell and Yamazaki, 1975). Hooda and Jood (2005) explained the rapid partitioning of free water of these hydrophilic sites occurred during dough mixing and increased dough viscosity, thereby limiting cookie spread and top grain formation during baking.

Karaoğlu and Kotancilar (2009) reported that hardness is the most important in evaluation of baked goods, because of its close association with human perception of freshness.

Table 4: Physical properties of produced Biscuits.

Biscuits	Moisture content %	Weight (g)	Diameter (D) (mm)	Thickness (T) (mm)	Spread ratio D/T	Hardness (N)
Control	3.89	4.20	45.60	5.20	8.77	23.35
B_1	3.93	4.25	45.20	5.20	8.69	24.49
B_2	3.99	4.36	44.20	5.20	8.50	24.65
B_3	4.18	4.41	44.10	5.20	8.48	25.68
B_4	4.25	4.47	44.00	5.20	8.46	27.45
B_5	4.39	4.53	43.70	5.20	8.40	28.49

B_1: biscuits with 20% sugar reduction; B_2: biscuits with 40% sugar reduction; B_3: biscuits with 60% sugar reduction; B_4: biscuits with 80% sugar reduction; B_5: biscuits with 100% sugar reduction.

Sensory evaluation of the produced biscuits:

The sensory evaluation scores for the biscuits are presented in Table (5).Statistical analysis of sensory scores indicated that the best in all parameter attribute of the resulting biscuits can be obtained in biscuits which contain 20% permeate powder. There are no significant between control, B_1, B_2 and B_3 in taste. This results may be due to the sodium and potassium contents of permeate powder represent the highest mineral content in permeate powder and are probably responsible for its salty taste.

The color of biscuits had high score as a result of increasing the level of permeate powder. Ndife *et al.*, 2011 explained that the browning may have resulted from Millard reactions or caramelization. While Hu *et al.* (2007) reported a direct relation between the fiber content and browning.

The results showed that, such as enhancing surface browning and which not only improve appearance but also imparts a pleasant caramelized flavor, moisture retention and development of a tender crumb structure. Whereas, Lactose content dictates permeates ability to improve the texture of baked products, affect their appearance and color. Its unique volatile flavor-binding and enhancing properties are particularly useful in bakery products with delicate flavors. Because lactose binds volatile flavor components, there is less flavor loss during processing and storage. (Marhamatizadeh *et al.,* 2012 and Udovicic *et al.,* 2013).

Table 5: Sensory evaluation of the produced biscuits

Samples	Appearance (10)	Color (10)	Flavor (10)	Texture (10)	Taste (10)	Overall acceptability (10)
Control	9.85^{a}	9.00^{b}	10.00^{a}	9.00^{b}	10.00^{a}	9.80^{a}
B_1	9.85^{a}	9.50^{ab}	9.34^{b}	9.13^{ab}	9.80^{ab}	9.78^{a}
B_2	9.90^{a}	9.50^{ab}	9.50^{ab}	9.22^{ab}	9.80^{ab}	9.73^{a}
B_3	9.95^{a}	9.50^{ab}	9.80^{a}	9.24^{ab}	9.75^{ab}	9.65^{ab}
B_4	9.95^{a}	9.70^{ab}	9.80^{a}	9.33^{ab}	9.50^{b}	9.55^{ab}
B_5	10.00^{a}	9.90^{a}	9.99^{a}	9.83^{a}	8.67^{b}	9.25^{b}

B_1: biscuits with 20% sugar reduction; B_2: biscuits with 40% sugar reduction; B_3: biscuits with 60% sugar reduction; B_4: biscuits with 80% sugar reduction; B_5: biscuits with 100% sugar reduction.

Conclusion

It is concluded that permeate powder is a cheap source for moderately malnourished children. Permeate powder as replacer sugar at different levels to improve biscuits nutrition and quality.

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