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Drying of Sweet Whey using Drum Dryer Technique and Utilization of the Produced Powder in French-type Bread and Butter Cookies

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Abstract: The objective of this study was to dry sweet liquid whey using drum dryer and to utilize the whey powder in French-type bread and cookies as a sugar substitute. The sweet whey powder was characterized chemically for ash, moisture, water activity, protein, salt, acidity and lactose contents. Optimization parameters including drying temperature, drum speed and starch addition for whey drying by drum dryer were tested to produce the best powder characteristics. The optimum temperature was 140°C at a drum speed of 20 rpm with a corn starch level of 2% (weight per weight). Sweet whey powder produced was used as a sugar replacer in French-type bread and butter cookies at substitution levels of 25, 50 and 75% of total sugars. The developed products were analyzed chemically and sensorially. The two developed products were relatively high in protein, ash, lactose and salts compared to the control samples. Regarding the sensory evaluation, the results showed that the sugar substitution of 25 and 50% in bread and cookies were significantly ($p<0.05$) better than the control. It can be concluded that sweet whey powder can significantly improve the quality of the studied bakery items.

Key words: Sweet whey powder, drum dryer butter cookies, french-type bread, sensory evaluation

INTRODUCTION

Cheese whey is the liquid that remains after the precipitation and removal of milk casein during cheese-making (Gonzalez, 1996). Whey is classified into two types; sweet and acid. Sweet whey is the liquid that separates from the cheese curd when starter cultures and rennet are applied to milk during the manufacture of cheese like Cheddar and Mozzarella. Whereas acid whey results from the production of cottage, quark and other fresh cheeses as well as labneh manufacturing (Ozer *et al*., 1998; Shon and Haque, 2007; Alsaed *et al*., 2013).

The sweet whey produced from Nabulsi cheese represents about 25% of the total whey produced annually in the Jordanian dairy industry (Alsaed *et al*., 2013). Only less than 1% of which is used in Jordanian food industry especially in beverages, whereas the reminder is usually disposed in the public sewer system causing environmental problems due to its high biological oxygen demand (BOD) (Yousif *et al*., 1997). Whey total solids can be used in food industry to develop new food products as it undergoes suitable treatments such as drying, concentration and hydrolysis of lactose (Wail-Alomari *et al*., 2012).

Dried whey can contribute a desirable slight fermented flavor due to its high lactose content (63.0-75.0% in dried sweet whey and 61.0-70.0% in dried acid whey) (ADPI, 1992). Lactose content in condensed sweet whey is about 32.0-43.0, depending on total solids in the condensed whey (Kosikowski, 1979).

Drum dryers were developed to dry many food products before spray dryers came into use (Patel *et al*., 2009). Jack and Wasson (1940) were the first to dry the sweet whey powder using the atmospheric drum dryer. Many problems were interfered while drying the sweet whey, for instance the whey burning, browning and the loss of flow ability. Accordingly, they added starchy compounds, like wheat and corn starch, in different percentages to delay the burn of whey during drying.

Jordanian imports of dried milk and other concentrated sugar syrup, is estimated to reach about 60 million Jordanian Dinar per year (DOS, 2009). Whey can be converted to nutritious valuable by-products by using different techniques such as concentration, drying and hydrolysis; hence whey products have many functional properties in bakery production (Boutin, 2010). In addition, disposing sweet whey in the public sewer system lead to environmental problems due to their high BOD. The objectives of this study were to investigate using drum drier technique for whey drying. The utilization of the produced dried whey in two local bakery

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products, namely French-type bread and butter cookies, as a sugar substitute was also converted.

MATERIALS AND METHODS

Sample collection and handling: Sweet whey samples were collected from Nabulsi cheese processed at the dairy pilot plant at Faculty of Agriculture, the University of Jordan from. Whey collected was tested chemically. The content of the liquid whey used was: Fat (0.96%), lactose (3.55%), protein (0.82%) and solids non-fat (6.68%). Commercial corn starch was added to sweet whey at two concentrations (1 and 2% w/w) to prevent the browning of whey lactose (Friedman, 1996). Starch was added in two different ways. Initially it was added directly to the whey and stirred well to prevent it from being precipitated. It was also tried to pre-gelatinize the starch by adding it to warm whey and then heat the mix until boiling. After mixing, whey samples were introduced into drum drier.

Drying by drum drier: Samples mixed with corn starch were dried using drum drier (Simon® twin cylinder dryer, UK) at various temperatures and drum speeds to standardize the drying conditions suitable to produce the desired characteristics of whey flakes. Samples without starch shrunk immediately and turned to brown color after addition on the drum drier. Samples of 1 and 2% starch were dried at a temperature of 150 and 140°C and a speed of 15 and 20 rpm. The addition of pre-gelatinized starch before drying produced wet and non-flowable product; the starch bounded the water molecules in whey and prevented it from being evaporated. The collected whey flakes were grinded using porcelain mortar and stored in dark closed glass containers at room temperature (about 20°C) until used.

Chemical analysis of sweet whey powder: Moisture, ash titrable acidity, salt content and crude protein were determined following the Association of Official Analytical Chemists (AOAC, 1995) on fresh weight basis. Lactose content was determined according to ISO 5765-2 (2002) method. Fat content in the sweet whey powder was determined using Roese-Gottlieb method (AOAC, 1995). Water activity (a_w) was measured by using Novasina instrument (Axier Ltd, Type: TH200, Switzerland) according to the manufacture instructions; the temperature was calibrated to reach 25°C for 15 min. Whey powder sample was put in plastic plate then placed in a specified chamber.

Substitution of sugar with sweet whey powder

Butter cookies production: Butter cookies were produced in the Department of Restaurants and Cafeterias, the University of Jordan. Table 1 shows the ingredients used to butter cookies production with 25, 50 and 75% of sugar substitution with sweet whey powder. The dough was mixed by a mixer until a complete homogenization obtained, then was cut into small cookies pieces, manually moulded and baked in a conventional oven at 170°C for 15 min until a golden brownish color obtained, then samples allowed to cool in the pans for 10 min before de panning.

Table 1: Ingredients used for butter cookies production with 25, 50 and 75% of sugar substitution with sweet whey powder

Ingredients	Control	25% replacement	50% replacement	75% replacement
Flour (kg)	1.5	1.5	1.5	1.5
Eggs	5.0	5.0	5.0	5.0
Butter (kg)	1.0	1.0	1.0	1.0
Powdered sugar (g)	500.0	375.0	250.0	143.0
Sweet whey powder (g)	--	143.0	250.0	375.0

Table 2: Ingredients used for french-type bread production with 25, 50 and 75% of sugar substitution with sweet whey powder

Ingredients	Control	25% replacement	50% replacement	75% replacement
Flour (kg)	1.0	1.0	1.0	1.0
Salt (g)	20.0	20.0	20.0	20.0
Compressed yeast (g)	30.0	30.0	30.0	30.0
Improver (g)	4.5	4.5	4.5	4.5
Fat (g)	10.0	10.0	10.0	10.0
Water (mL)	500.0	500.0	750.0	900.0
White sugar (g)	60.0	45.0	30.0	15.0
Sweet whey powder (g)	-	15.0	30.0	45.0

French-type bread production: The production of French-type bread was carried out at Al-Sofara Bakery (Amman, Jordan). Three experimental bread dough were prepared by using 25, 50 and 75% actual weight sugar replacement. Table 2 shows the ingredients added to each of the treatments. Dough was mixed until proper development is achieved. Dough was first proofed for 5-10 min, then cut into 100 g pieces, moulded manually, panned, then proofed at 45°C and relative humidity about 85 until a suitable height was attended, then the loaves were baked in rotary oven at 220°C for 10 min then allowed to cool for 10 min before depanning.

Sensory evaluation: Products were evaluated after 2 h of production by a Panel of assessors (16 semi-trained subjects) from the Faculty of Agriculture, the University of Jordan. French-type bread and butter cookies were evaluated for the overall acceptability using a multiple comparison test. It was indicated that the control sample is the reference marked with R and the other samples were tested whether they were better than, equal to or inferior to the reference. The score of 1 means "inferior extremely" and 9 means "better extremely". The sensory evaluation for the products was conducted twice during 1 week (Ogunrinola *et al*., 1988; Yousif *et al*., 1990).

Chemical analysis of products: Butter cookies and French-type bread samples were chemically tested. Moisture, ash, titrable acidity and protein, salt content and water activity were tested as mentioned before in whey powder analysis on fresh weight basis. Fructose, glucose, sucrose, galactose and lactose were determined by High-pressure Liquid Chromatography (HPLC) according to AACC method 80-04.01 (AACC, 2000).

Statistical analysis: The Analysis of Variance (ANOVA) was undertaken using mixed procedure (Proc Mixed) to perform a Repeated Measure Analysis Model where time was considered as a repeated factor. Differences between the treatment means were found using Least Significant Difference (LSD) test at $p<0.05$. All statistical analyses were conducted using the SAS software, version 9 (SAS Institute, 1997).

RESULTS AND DISCUSSION

Optimization of sweet whey drying using drum-dryer: Different parameters were tested with regard to the drying process using drum-dryer; these parameters included temperature, drum speed and corn starch addition level. Regarding the addition of corn starch, it was used as a filler to prevent lactose caramelization and stickiness during drying. Samples without starch were dark brown in color when dried using the drum drier. The trial to use gelatinized starch in the feed revealed a substational delay of the drying process. This is due to the fact that water became bound as water of hydration requiring higher energy to evaporate (Wootton and Bamunuarachchi, 1978). In contrast, it seems that in case of adding native starch as it was adopted in this research, the free water was evaporated just before gelatinization of starch took place on the surface of the drum. The sample containing 1% starch was dried at 150 and 140°C and a drum speed of 15 and 20 rpm. The same conditions were used for the samples containing 2% starch.

Regarding temperature, drying at 150°C produced whey powder with brownish color, indicating lactose caramelization and Millard reaction; such defect did not occur in the trials using 140°C. As a result, temperature of 140°C was used for drying the sweet whey for further studies. Regarding drum speed, it was observed that speed at 20 rpm (the highest speed in the dryer) gave a light color of whey flakes but at drum speed of 15 rpm, the product became very dark. This result shows the effect of retention time on the browning reactions during drying of sweet whey.

According to the USDEC standards (USDEC, 2011), the optimum color of sweet whey powder varies from off-white to creamy. Since lactose is a reducing sugar, exposing whey to high temperature during drying may result in browning due to Millard reaction. This problem may become more acute during improper storage of whey powders as the reaction rate is known to be accelerated at low a_w (Dattatreya *et al*., 2007). Corn starch was used as a filling material by Jack and Wasson (1940) to prevent lactose browning and stickiness during drying using drum-dryer and it was added at 3 and gave a good characteristic whey powder. Yousif *et al*. (1997) dried sweet and acid whey using the hot surface rotary plate using a mixture composed of 16: 3:1 of liquid sweet whey, wheat flour and corn starch consecutively and the resulted powder had a good flowability and stability.

The findings of the current study show that the best conditions to dry whey using drum dryer were at 140°C, using a drum speed of 20 rpm and adding starch level of 2% to the whey, which give a white yellowish sweet whey powder with no stickiness upon storage in sealed containers.

Chemical analysis of whey powder: Water activity, moisture, protein, ash, salt, lactose contents and acidity of sweet whey powder are presented in Table 3. The addition of starch to the sweet whey at a concentration of 2% increased the total solids in the liquid from about 7-9%; this means that the starch content after drying will be 22% (by estimation) and the other total solids will be lower than those reported in other studies on the commercial sweet whey powder.

It is clear from data in Table 3 that lactose level reached to 44.4% (as a fresh weight basis). Guo *et al*. (2010) who worked with sweet whey drying using a spray dryer and reported higher figures (>70% lactose content). JISM (2008) dictates that lactose content in sweet whey powder should not be less than 65%. As shown in Table 3, the protein content was about 7.9%. Baer *et al*. (1983) found that the protein content in sweet whey powder ranged from 9.0-11.0%.

According to the JISM (2008), the protein content should not be less than 11%; the level of protein in the produced whey powders was lower than those mentioned

Table 3: Chemical composition of the sweet whey powder produced using drum drying technique with 2% (w\w) starch

Test	Value±SD* (%)
Water activity	0.39±0.02
Moisture (%)	3.5±0.130
Ash (%)	5.4±0.020
Acidity (% lactic acid)	0.21±0.04
NaCl (%)	2.7±0.240
Crude protein (%)	7.9±0.500
Lactose (%)	44.4±3.200
Fat (%)	11.5±0.110

*SD means the standard deviations of the value in the local standards for sweet whey powder because of addition of starch and increasing the total solids in the liquid whey. The amount of proteins in whey are affected in many factors like seasonal changes that could affect on α-lactoglobulin, β-lactalbumin, glycomacropeptide and casein contents in whey (Regester and Smithers, 1991). Many factors could affect the protein content like whey source and composition, cheese manufacturing conditions, heat treatment conditions, storage conditions, overall sanitation conditions and techniques used for functionality evaluation (Schmidt *et al*., 1984).

The acidity of sweet whey powder expressed as lactic acid was found to be about 0.21%. Lactic acid in whey is produced through natural fermentation. Mahajan *et al.* (2004) found that the acidity of sweet whey powder was less than 0.30%. JISM (2008) reported that the acidity of sweet whey powder (as lactic acid%); the results obtained in this study agree with those reported in the local standards.

The ash content in the produced whey sample was 5.4%. The minerals in whey are only a small part of the liquid whey and are overshadowed by the whey's larger constituents of lactose, casein, whey proteins and water. The principal minerals in whey are as follows: Potassium, calcium, chloride, phosphorus and sodium (Cashman, 2006). JISM (2008) dictated that ash content should not be higher than 8.5 and according to the USDEC (2011), the ash content of sweet whey powder ranges between 8.2-8.8%. Also, Sawyer (2010) studied the ash content in SWP and it was found to be 8.27%. The salt content (NaCl) in sweet whey powder was found to be 2.7%. The source of this salt is coming from addition of sodium chloride to cheese during processing. Whey contains approximately 10% salts of the dry matter, either as a natural component originating from the milk, or salts added during cheese processing ($CaCl_2$ and/or NaCl). The NaCl% was found to be from 2.5-4.0% in sweet whey powder (El-Desoki, 2009).

As shown in Table 3, moisture content in SWP was 3.5%. It is in agreement with USDEC (2011) studies and the Jordanian Standards that dictates the moisture content should not exceed 5%. The figures obtained in this study agree with those in previous studies and the local standards. Water activity of the SWP in this study was found to be 0.39. Domian and Wlodarska (2007) studied the water adsorption in whey powders and found that aw ranges from 0.3-0.4 in whey powders. At this low water activity, the microbial growth would be low. Water activity affects the physical characteristics of the product such as caking, caramelization and browning reactions (Saltmarch and Labuza, 1980).

Fat content in SWP was found to be about 11.5%; such high figure occurred due to the high fat content in the liquid sweet whey (about 1%). Nowadays many studies concentrate on the whey powder demineralization; where the fresh whey is clarified and defatted before at least 90% demineralization, prior to evaporation and drying. According to CODEX STAN 289 (1995), the typical butterfat content in sweet whey powder is about 1.5%.

Chemical analysis of products: Figure 1-4 show the chemical composition of both French-type bread and butter cookies.

Findings show that ash content was not significantly different (p<0.0001) from control sample in French-bread at 25% SWP replacement; it increased from (2.63%) to (2.76%). At 50 and 75% replacement treatments, the ash content was significantly different from the control; it

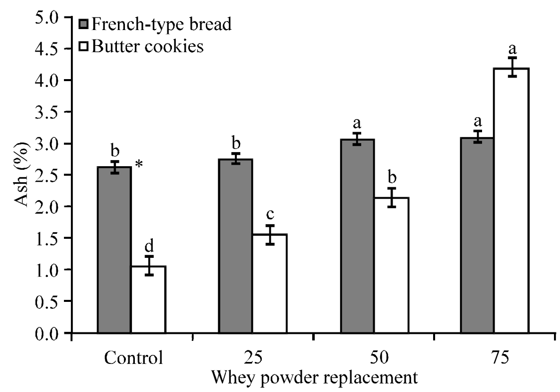

Fig. 1: Ash content in french-type bread and butter cookies produced with different concentrations of whey powder

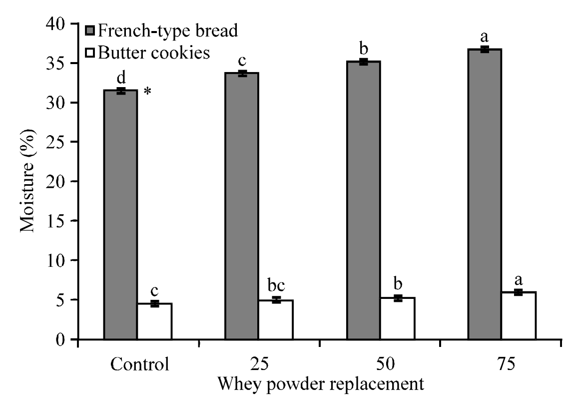

Fig. 2: Moisture content in french-type bread and butter cookies produced with different concentrations of whey powder

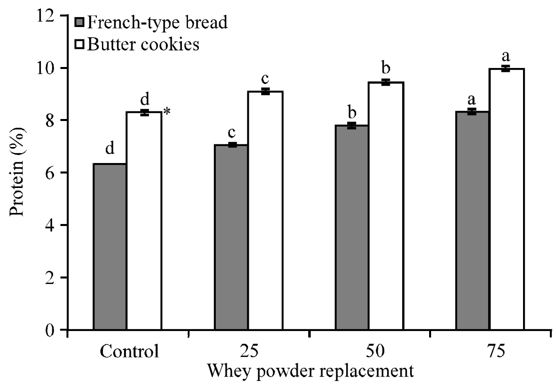

Fig. 3: Protein content in french-type bread and butter cookies produced with different concentrations of whey powder

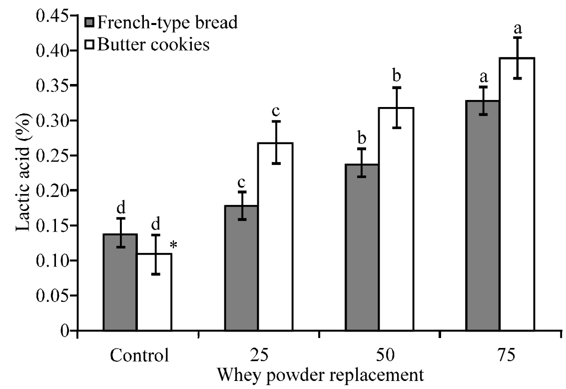

Fig. 4: Acidity (expressed as lactic acid) in french-type bread and butter cookies produced with different concentrations of whey powder

increased form (3.08-3.12%). These results were almost similar with those reported for butter cookies in this study. A clear significant effect ($p<0.0001$) of SWP replacement regarding the ash content can be noticed from data in Table 3, the ash percentage increased significantly by increasing the SWP replacement in butter cookies. The obtained ash results agree with those reported by Erdogdu-Arnoczky *et al*. (1996) who found that addition of acid whey powder to wheat flour could increase the ash level in bread samples. Such results were expected since whey contains different amounts of minerals like calcium, sodium, magnesium and phosphorus.

Regarding the moisture content, there was a significant effect ($p<0.0001$) of SWP replacement in both butter cookies and French-bread. The moisture content was increased gradually by increasing the SWP replacement. Yousif *et al*. (1997) and Erdogdu-Arnoczky *et al*. (1996) found that there were no significant effects of whey powders addition on the moisture content of Arabic-bread. In this study, after whey addition to the dough, it became much tough and stiff than the control one, so some additional water were added to the dough to be easily cut and reformed in moulds in both cookies and bread production. This might explain why the moisture content increased significantly when increasing SWP replacement.

The titrable acidity (as lactic acid%) of French-bread samples were significantly different from the control sample ($p<0.0001$) at 25, 50 and 75% replacements. There were no significant differences between the 25 and 50% replacement. For butter cookies samples, there were no significance ($p>0.8102$) between samples but the acidity was increased by increasing the level of SWP replacement. Such results were expected since SWP had high lactic acid content.

Regarding salt content (NaCl), in French-bread there were significant differences ($p<0.0001$) between the control sample and the other developed products. There were no significant differences between the 25 (1.58%) and 50% (1.59%) replacement, whereas in butter cookies, there were a high significant difference ($p>0.0057$) between the control sample and the other treatments, with no significant difference between the treatments. Salt content was gradually increased by increasing the SWP replacements. However, such results were expected due to the high salt content of the SWP.

Due to the low water activity of the bread, the 75% replacement level could had a better stability or shelf life than other treatments, its water activity was (0.52) compared to (0.55) for the control. However, the water activity of samples with 25, 50 and 75% replacements and the control sample were less than (0.6) indicating a good stability for the products (Yousif and Alghzawi, 2000). This may indicate the possibility of longer storage of bread at ambient temperature without deterioration. Regarding the water activity of cookies, results show a significant increase ($p<0.0001$) in water activity as the sugar replacement level increased.

It was clear from data in Fig. 3 that protein content increased significantly ($p<0.0001$) as sugar replacement increased; it increased from 6.33% in the control sample to 8.28% in the 75% replacement in bread. On the other hand, protein content ranged from 8.25% in the control sample to 9.93% in the 75% replacement in butter cookies. The obtained results confirm those results of

Jooyandeh *et al.* (2009); they reported that supplementation of flour by WPC at 25, 50, 75 and 100% levels increased the bread content of protein, ash and fat and the values of these components increased with increasing the level of whey substitution.

It is well known that physical, chemical and biological changes occur during dough baking process of bread and cookies; including water evaporation, formation of porous structure, increasing volume, protein denaturation, crust formation, which may affect the chemical and the physical properties of bread and cookies samples (Mondal and Datta, 2008).

Sugar analysis results: Fructose, glucose, sucrose, galactose and lactose contents of the developed products (bread and cookies) were determined and the results are shown in Fig. 5-8.

Regarding sugar content of the developed products shown in Fig. 7, the fructose percentage of the (p>0.0017) french-type bread treatments were significantly different from the control sample. The fructose level increased from (0.79%) in the control bread sample to reach (2.76%) in the 75% replacement bread sample. The increased level of fructose can be due to the sucrose hydrolysis into fructose and glucose during the baking process. Sucrose starts hydrolysis at a temperature of 180°C with the presence of water (Quintas *et al.*, 2007). The baking process was conducted at a temperature of 220°C for 10 min and this could explain the hydrolysis of sucrose. In addition, these results were in agreement with other findings (Yousif and Alghzawi, 2000; Calixto and Canellas, 1982). Yousif and Alghzawi (2000) reported that roasting of carob powder caused some reduction in sugar content due to Millard reaction and caramelization. During baking at temperature above 160°C, sugar undergoes a

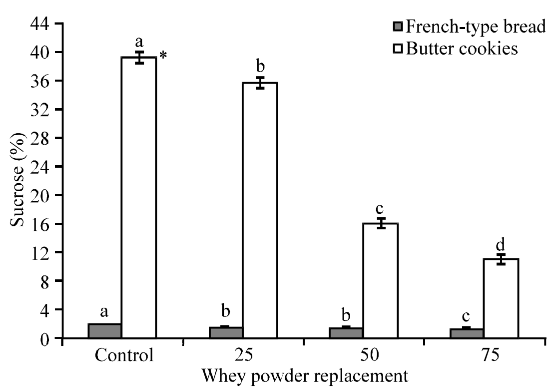

Fig. 5: Sucrose content in french-type bread and butter cookies produced with different concentrations of whey powder

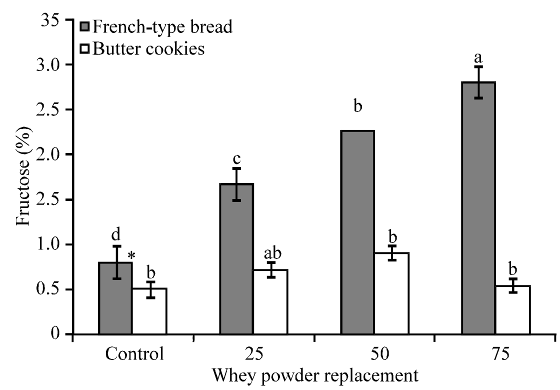

Fig. 7: Fructose content in french-type bread and butter cookies produced with different concentrations of whey powder

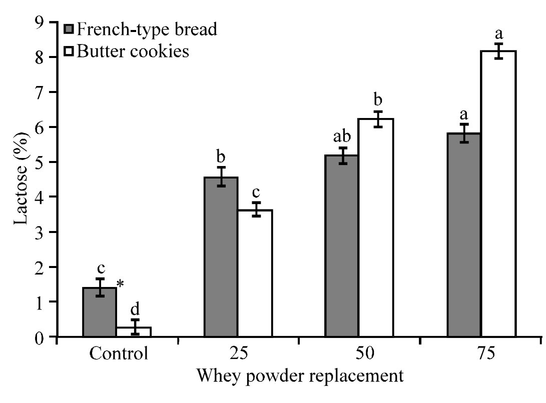

Fig. 6: Lactose content in french-type bread and butter cookies produced with different concentrations of whey powder

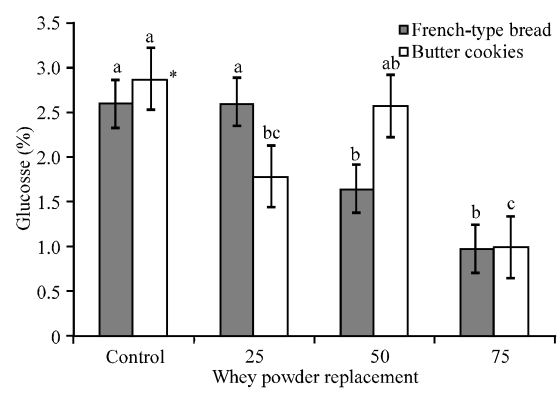

Fig. 8: Glucose content in french-type bread and butter cookies produced with different concentrations of whey powder

Table 4: Sensory analysis score for the french-type bread samples produced with different concentrations of sweet whey powder

	Treatment (%)		
Panelists	25	50	75
1	7.5	4.5	5.5
2	6.0	6.0	4.0
3	6.0	8.5	5.5
4	7.0	6.0	5.0
5	7.5	6.0	6.5
6	4.5	7.5	5.0
7	6.5	5.5	3.5
8	7.5	4.5	4.5
9	8.0	7.0	4.5
10	8.5	5.0	4.5
11	8.0	7.0	4.5
12	7.0	5.0	5.0
13	6.5	6.0	5.5
14	7.0	6.0	3.5
15	7.0	5.0	5.0
16	7.0	5.0	6.5
Totals	159.52	96.00	76.96
Means	6.97 A	6.00 B	4.81 C
SD	1.20	1.20	1.20
CV	20.30	20.30	20.30

Duncan's critical range: 0.69-0.72

Table 5: Sensory analysis score for the butter cockies samples produced with different concentrations of sweet whey powder

	Treatment (%)		
Panelists	25	50	75
1	5.5	4.0	7.0
2	5.0	7.0	5.5
3	4.5	6.5	3.5
4	5.5	6.0	4.0
5	6.0	6.0	4.5
6	7.5	8.5	5.0
7	4.0	7.0	4.5
8	7.5	4.5	5.0
9	7.0	6.5	3.0
10	6.0	7.5	5.0
11	5.0	6.0	5.0
12	4.0	7.5	3.5
13	6.5	7.5	5.5
14	6.0	6.0	3.5
15	7.5	8.0	5.5
16	6.5	6.5	6.0
Total	94.08	104.96	74.08
Means	5.88 A	6.56 A	4.63 B
SD	1.67	1.67	1.67
CV	29.27	29.27	

Duncan's critical range: 0.79-0.84

series of complex browning reactions. The products of such reactions form the brown crust of many baked goods, these reactions are known as Millard reaction (Czeronohorsky and Hooker, 2010). On the other hand, yeast fermentation in the dough might cause many changes in the sugar content; the yeast grows optimally in the presence of sucrose as a carbon source by the aid of invertase enzyme which breakdowns sucrose into glucose and fructose (Gobbetti *et al*., 1994). Data obtained in this study show that sucrose and glucose percentage decreased due to substitution with whey and as a result of the yeast activity.

Lactose content in both bread and butter cookies was significantly different ($p>0.0002$) from the control samples. Furthermore, it was found that lactose is responsible for the improved crust color and for flavor development in bakery products when a dairy ingredient is used, as it combines with amino acids in Millard reaction (Hugunin, 1980; Guy, 1978).

It was found that galactose was not present in high percentages in the control samples of bread and cookies compared to the 75% replacement level (2.87% in bread and 3.53% in butter cookies). This confirms that lactose may be hydrolyzed into glucose and galactose during whey drying or within baking process due to the high temperatures of baking.

Sensory evaluation results: Table 4 and 5 show that there were significant differences ($p<0.05$) between the new developed products and the control samples. The sensory evaluation results of French-type bread showed that bread prepared at 25% sugar replacement level was moderately better than the control sample (the score achieved was 6.97). In addition, the 50% sugar replacement level was slightly better than the control bread sample, with a score of (6.00). On the other hand, the 75% sugar replacement level was slightly inferior to the control sample with a score of (4.81). This might be due to the relatively low sweetness of the added sugar. It is known that sucrose has a high level of sweetness (100) compared to only (30) for lactose. In addition, the whey powder gives a salty taste due to NaCl content in whey powder that was added during cheese making and acidic taste due to lactic acid content in the SWP added to the bread.

As shown in Table 5, sensory results revealed that there were no significant differences between the 25 and 50% sugar replacement level (with score of 5.8 and 6.5, respectively) in the butter cookies as compared with the control. Nevertheless, 50% replacement level in butter cookies was slightly better than the control, whereas the 75% replacement level (with a score of 4.6) sample was slightly inferior to the control. It seems that panelists favored the moderate sweetness taste of butter cookies.

CONCLUSION

The findings of the current study provide evidence that drying of sweet whey by drum dryer can be successfully used to obtain the whey powder. Drying of sweet whey using drum dryer technique was achieved by optimization of temperature at 140°C, drum speed at 20 rpm and the concentration of starch at 2% added to the liquid sweet whey before drying.

The chemical composition of the produced whey powder was nearly conforming to the local standards of the sweet whey powder, except the protein contents which were lower than standards. The results of the tests carried out on the developed products proved that it is possible to obtain improved food products that are almost the same or better than that of the control. Since no harmful effect on the quality was detected during this study, these results will encourage the usage of sweet whey powder in the formulating of food products. This also can reduce the amount of the whey disposed off by utilization of whey and whey components in many Jordanian food industries.

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