International Journal of Science, Environment and Technology, Vol. 6, No 4, 2017, 2343 – 2352

ISSN 2278-3687 (O)
2277-663X (P)

DEVELOPMENT OF EGG-LESS CAKE USING WHEY PROTEIN CONCENTRATE AS EGG SUBSTITUTE

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Abstract: Studies were conducted to replace eggs in cake with whey protein concentrate (WPC) to develop eggless cake. WPC 60 having protein content of 62.50 was obtained by ultrafiltration technique. Cakes were prepared with WPC 60 as egg substitute and the physical and sensory attributes were studied. Highest porosity and specific volume (2.75 cc/g) were observed in cake containing WPC 60 when compared to control cake containing eggs. From the studies, it was found that for the preparation of good quality of WPC 60 cake the optimum levels of major ingredients are: 7 % WPC, 17 % hydrogenated fat, 27 % refined wheat flour, 24 % sugar, 2.4 % baking powder, 21 % milk and 0.80% flavor.

Keywords: Whey protein concentrate, Eggless cake, Bakery products.

Introduction

The increasing demand for convenience foods may be traced to the developments like changes in demographic, social and economic patterns; increasing participation of women in the workforce; changes in meal patterns and existing food habits; altered attitudes to leisure activities and time spent in conventional 'baking'; rising real income and disposable income and increased interest in 'healthy eating' and low calorie foods. Bakery products are increasingly becoming popular in India as indicated over 250% increase in their production during the last decade. The popularity of the products is due to their ready-to-eat convenience nature, unique taste and ready availability at reasonable cost in different parts of the country, including remote rural areas. Among the bakery products, cakes are important. Keeping in view their good keeping quality and comparatively better nutritive value, baked products including cakes could serve as a carrier of nutrition. The conventional process for cake making uses eggs as an essential ingredient owing to its ability to increase the number of air cells, thereby contributing to the desired leavening of the product. But sometimes the presence of egg is a deterrent to its consumption, due to its typical flavour which is offensive to those who are not accustomed to eggs.

Whey – a byproduct of cheese and paneer industry contains valuable whey proteins and large amount of whey is available as a byproduct of the dairy industry in India every year. This

*Received June 21, 2017 * Published Aug 2, 2017 * www.ijset.net*

whey contains about 65 million kg's of nutritious whey solids. Unfortunately, most of this is being drained and thus a precious nutritive material is lost. Whey protein concentrates (WPC) prepared from whey by physical separation techniques like ultrafiltration, have excellent functional properties, especially foaming or whipping ability. Thus, whey from the dairy industry could be used as an ingredient in bakery products and could serve as a potential substitute for eggs because of its excellent functional properties. Therefore, a detailed investigation was undertaken to concentrate whey by membrane processing and subsequent drying to obtain whey protein concentrate (WPC). WPC was used in cake formulation as a substitute for eggs in cake preparation.

Materials and Methods

Buffalo Milk Cheddar Cheese Whey: Whey was obtained from the preparation of buffalo milk Cheddar cheese as per the method of Kanawjia (1987)[1] being followed in the Experimental Dairy of NDRI, Karnal. Buffalo milk was standardized to casein/fat ratio of 0.70, pasteurized at 63^0C for 30 min, cooled to 28^0C and an active starter culture (*S. lactis* and *S. cremoris*) was added to the standardized milk at the rate of 2% along with 0.5% *L.casei* 300 to milk. After 30 min. Meito rennet was added at the rate of 1.5 g/100 l of milk with thorough mixing. After setting (30 min), the curd was cut. After 10-15 min of cutting, stirring was started and the curd was cooked to 36^0C for 40-45 min. The cooked curd was left undisturbed in the whey for 5-10 min. Then, the whey was drained, pasteurized to 72^0C/15 s and cooled to 10^0C and collected for subsequent experiments.

Cake Ingredients

Refined Wheat Flour

'Trupti' brand refined wheat flour (maida) manufactured by NEPC Agro Limited, Muzaffar Nagar, was used for making cake.

Vegetable Fat

'Dalda' vegetable fat (vanaspati) manufactured by Brooke Bond Lipton (India) Ltd. was used

Sugar

Commercial grade cane sugar procured from the Experimental Dairy of the Institute was used after grinding to a powder.

Baking Powder

'WeikField' baking powder (WeikField Products Co. (India) Pvt. Ltd; Pune) was used as a chemical leavening agent in the preparation of cakes.

Emuslifier and Stabilizer

Tween 80 (polyoxyethylenesorbitan mono-oleate) emulsifier and carboxy methyl cellulose (CMC) stabilizer were obtained from HiMedia Laboratories Pvt. Ltd. Mumbai.

Eggs

Fresh eggs were procured from the local market

Milk

Buffalo milk from Experimental Dairy was used for cake making.

Chemicals

All the chemicals used in this investigation were of AR grade, unless mentioned otherwise.

Equipment

Mixer

Hobart Mixer and Blender manufactured by Hobart Corporation, USA was used to blend, whip and mix the cake batter.

Oven

BPL Microwave and convection heating oven of 40 l capacity was used to bake the cake batter.

Moulds

Borosil crystallizing dishes of size 100 x 50 mm were used as moulds for the preparation of cakes by both convection and microwave baking.

Packaging material

Metalized Polyester Pouches

Pouches (12 x 15cm) of metalized polyester with the following specifications were used for packaging cake mixes and dried milk byproducts:

Metalized polyester low density polyethylene – 350 guage

Moisture vapour transmission rate (38^0C/90% RH/24 h) – 14-20 g/m^2

Oxygen permeability (at atmospheric temperature) – 85-95 ml/m^2

Grease resistance – Very good

Methods

Manufacture of whey protein concentrate by ultrafiltration

Cheddar cheese whey was used for the production of whey protein concentrate using UF. UF was carried out as outlined by Patel *et al*. (1991)[2] using a pilot-scale hollow fibre membrane plant (Romicon, membrane type PM 50), supplied by Alfa-Laval, Denmark. Whey was pumped by a feed pump from the holding tank into the vertical membrane module. A

circulation loop provided with recirculation pump permitted partial recycling of the retentate. The part of the retentate being returned to the feed tank was recycled through the feed pump. The discharge pressure of the feed pump was 0.5 bar whereas that of the recirculation pump 1.8 bar. The process was continued until required concentration was reached for all the three byproducts.

Manufacture of spray dried WPC

The whey protein concentrate prepared by UF were spray dried using Anhydro (Denmark) spray drier, 35 kg water evaporation capacity per hour by maintaining 185^0C inlet and 90^0C outlet air temperature, to get respective powders.

Cake Preparation

Process standardization for the preparation of egg-containing cake

Method was standardized for preparation of cake containing whole egg, refined wheat flour, vegetable fat, sugar and baking powder. The mixture with required quantities of refined wheat flour and baking powder were sifted 8-10 times so as to ensure thorough mixing. Known quantities of sugar and vegetable fat were whipped for 10 min in Hobart blender employing whipping attachment at medium speed. When the beaten mixture attained light whitish yellow colour, liquid whole eggs were added and whipping continued for further 7 min to give a liquid cake batter. The cake batter thus obtained was put into pre-greased glass moulds for baking.

Process standardization for WPC cake preparation

WPC was used as source of protein in lieu of eggs in cake preparation. The byproduct powders were individually mixed with milk and whipped for 10 min. The whipped product was then mixed with previously beaten sugar and vegetable fat mixture and whipped further for 10 min. Known quantity of sifted refined wheat flour was slowly added and mixed properly to get liquid uniform cake batter. The cake batter was put into pre-greased mould for baking.

Convection cake baking

The time-temperature combination for cake baking was standardized for convection oven.

Microwave-convection combination cake baking

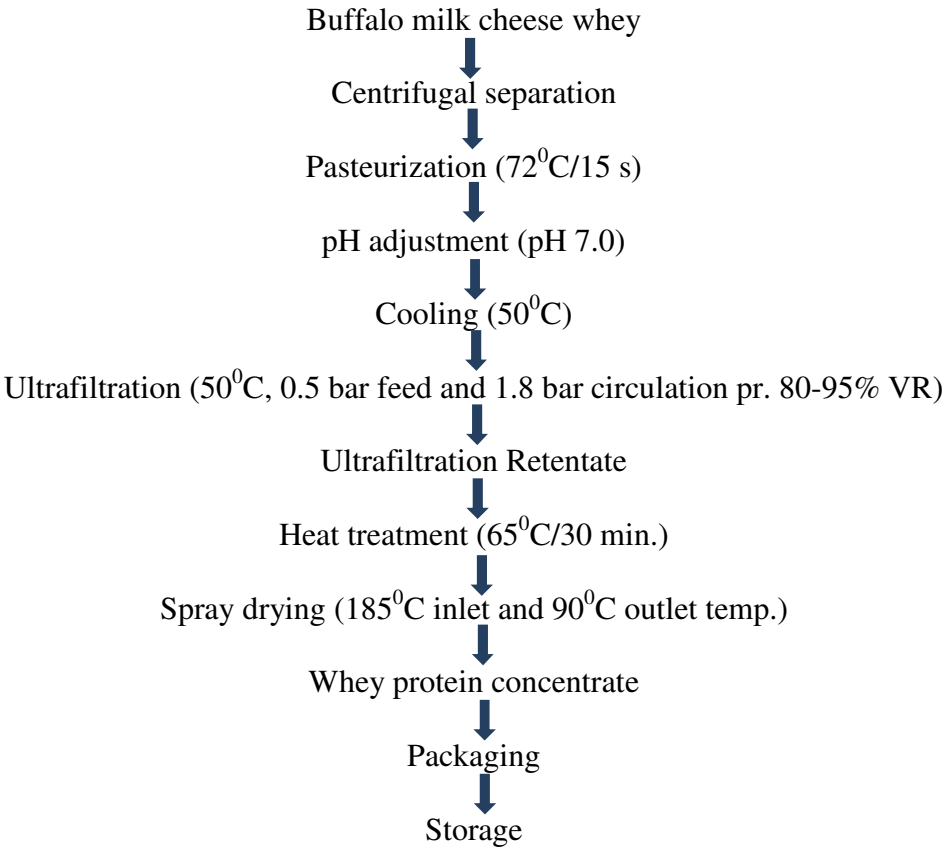
Baking quality of cake was studied at different levels of microwave power and time in a microwave cum convention oven. Method was also standardized for baking the cake using the combination of both, viz., microwave and convection in the same oven.

Results and Discussion

Standardization of the Procedure for Cake Making

In the present study cakes were prepared in the laboratory using egg as well as WPC for standardizing the procedure. The egg containing cakes were considered as control for comparison of physical and sensory characteristics. Since the main aim of the study was to substitute eggs in cake preparation with WPC, based on the results of the functional properties, WPC was substituted for egg in cake with suitable modification in the formulation. As found in preliminary studies among WPCs, WPC 60 was preferable when compared with other WPCs (WPC 50 and WPC 35). The resulting cake batters were baked in both convection and micro-convection combination oven. The time-temperature combination for cake baking was also standardized.

Fig. 1.Flow Diagram for the Manufacture of Whey Protein Concentrate (WPC)



Effect of level ingredients on the quality of WPC – 60 containing cake

As can be seen from the Table 2, increasing the level of WPC from 5 to 7 per cent resulted in increased cake height, but upon further rise in the WPC 60 level to 9 per cent the height remained unchanged (6.20 cm), the hardness of cake also increased with the increasing WPC 60 level. This was contradictory to what was observed in egg cake where the hardness

decreased with the increasing egg level (Table 2), thus indicating the air cell lamellae in the egg cake tended to become weaker with increasing egg concentration, whereas it became tougher with increasing WPC in the batter. With regard to sensory evaluation highest scores were obtained at the 7% level. The 9% level resulted in intermediate scores between those with 5 and 7 % level. Thus WPC 60 at 7 % was found optimum. Similar observation with regard to complete replacement of eggs in cakes with a fat-WPC deWit (1984)[3] has replaced eggs completely with a fat-WPC emulsion in cake making and observed that eggs can be replaced in cake making with a fat-WPC emulsions containing the same amounts of fat and protein.

Table 2 further shows that of the three fat levels viz., 13, 17 and 21 percent, the 13 percent level resulted in cake with a hard crust and crumb; the product lacked glossiness, typical flavor and taste. With 21 % fat, the cake was oily and too moist. These results corresponded with the low sensory scores. Maximum sensory scores were obtained at 17 % fat level.

With the increasing level of refined wheat flour from 23 to 27 %, the cake height increased perceptibly, but raising the level to 31 % had no further impact (Table 18). The hardness of the product did not exhibit any definite trend with the change in the flour level; the 27 % level resulted in a product that was softer than that with either the higher or lower level. The sensory scores obtained at 27 % level were ideal and hence chosen for further studies.

As seen earlier with the egg-containing cake the increasing sugar content (from 20 to 28%) caused decreased cake height and hardness of the WPC 60 cake (Table 1). As could be expected, the intermediate sugar level yielded a cake with most desirable sensory quality.

Table 1: Effect of level of major ingredients on the quality of egg-containing cake

Ingredient level (%)	Physical Properties S (%) (N)	HT (cm)	H	Sensory Rating Flavour	B & T	Colour	Porosity
Whole Egg							
23	-	4.8	1.74	6.0	7.0	8.0	7.5
27	-	5.5	1.60	8.2	8.3	8.3	8.5
31	-	5.5	1.58	5.0	7.8	7.8	8.4
Hydrogenated Fat							
11	-	5.0	1.84	6.0	6.9	7.0	7.6
16	-	5.5	1.60	8.3	8.4	8.3	8.4
21	-	5.1	1.48	6.1	6.8	7.5	7.7
Refined Wheat Flour							
23	-	5.0	1.38	8.1	7.8	8.0	7.8
27	-	5.5	1.60	8.2	8.3	8.4	8.4

31	-	5.1	1.82	8.1	8.0	8.0	8.2
Sugar							
23	-	5.5	1.77	7.6	7.5	7.2	7.9
27	-	5.0	1.60	8.2	8.2	8.3	8.5
31	-	4.5	1.48	7.8	8.0	6.9	8.0
Baking Powder							
1.3	-	4.7	1.88	6.5	6.2	6.9	7.2
2.6	-	5.5	1.60	8.2	8.3	8.4	8.5
3.9	-	5.6	1.39	5.9	8.2	7.5	8.4

S = Shrinkage, HT = Mean cake height, H = Hardness measured in Instron, B & T = Body and texture

Compared to 1.2 % level, the 2.4 % level of baking powder gave a substantially improved cake height, which was the same as that observed with the 3.6 % level. 1.2 % level, the cake was hard, less porous and had a pale crust colour, whereas with 3.6 % baking powder the cake had an off-flavour and crumbly texture. The intermediate level gave the highest sensory scores. The product became softer with the increasing baking powder addition.

At the 17% level of addition of milk, the cake obtained was dry and hard as also indicated by Instron hardness (1.88 N), whereas, at 25% level the cake was too soggy which adversely affected the porosity. The sensory scores obtained for 21 % milk content were the highest (Table 2) and the physical quality of cake was also good and hence this level was considered most suitable.

Hence for the preparation of good quality of WPC 60 cake the optimum levels of major ingredients were found to be: 7 % WPC, 17 % hydrogenated fat, 27 % refined wheat flour, 24 % sugar, 2.4 % baking powder and 21 % milk apart from flavor.

Table 2: Effect of level of major ingredients on the quality of WPC 60-containing cake

Ingredient level (%)	Physical Properties S (%)	HT (cm)	H (N)	Sensory Rating Flavour	B & T	Colour	Porosity
WPC							
5	-	5.0	1.28	7.0	7.1	6.7	6.0
6	-	6.2	1.73	7.9	8.2	7.8	8.5
7	-	6.2	1.86	7.3	7.5	7.2	8.2
Hydrogenated Fat							
13	-	5.4	1.85	6.1	6.3	6.8	6.1
17	-	6.2	1.70	7.8	7.8	7.6	8.3
21	-	6.1	1.40	6.0	6.2	6.8	7.1
Refined Wheat Flour							
23	-	5.3	1.96	7.1	6.3	7.0	7.1
27	-	6.1	1.72	7.7	8.1	7.7	8.4
31	-	6.1	1.85	7.3	6.5	7.3	7.2

Sugar							
20	-	6.1	1.92	6.2	7.0	7.0	7.8
24	-	5.8	1.73	8.0	8.0	7.9	8.3
28	-	5.2	1.40	6.9	7.1	6.0	7.9
Baking Powder							
1.2	-	5.2	1.87	6.7	6.1	6.5	6.2
2.4	-	6.2	1.71	7.8	8.3	7.9	8.5
3.6	-	6.2	1.42	5.1	7.0	6.0	8.4
Milk							
17	-	5.4	1.88	7.4	6.9	7.7	6.5
21	-	6.2	1.73	7.7	8.3	7.8	8.4
25	-	6.1	1.55	7.6	7.0	7.8	6.1

S = Shrinkage, HT = Mean cake height, H = Hardness measured in Instron, B & T = Body and texture

Standardization of time-temperature combination for cake baking

In order to achieve proper baking, the time-temperature combination of cake baking was standardized for both convection and micro-convection combination baking.

Convection baking

Time and temperature of baking are important to the quality of cake made by convection baking system. As shown in Table 3, generally lower baking temperature and shorter baking time resulted in underbaking as indicated by doughy and moist or soggy texture and light colour, whereas higher temperature and longer time imparted darker colour to the cake crust. The least intense time-temperature combination (170^0C/20 min) resulted in the most overdone cake. The best time-temperature combination appeared to be 180^0C/25-30 min. as it resulted in a cake that had golden brown crust and without any doughiness. The product was rated the most acceptable.

Micro-convection combination baking

In order to save the time required for baking, microwave-convection combination baking was employed and studies were conducted to optimize the baking conditions in terms of the power level and residence time. The cake batter was first baked by microwave heating followed by convection heating (180^0C/5 min). The results obtained on the product quality are presented in Table 4.

At low microwave power level (50), the cake obtained was doughy and moist irrespective of the residence time, whereas at high power (70), the cake had a hard body at all residence times. At medium power (60) with 2.5 min residence time, a cake of acceptable quality with uniform body and texture was obtained.

Table 3: Effect of time-temperature of convection baking on the sensory characteristics of cake

Time (min)	Temperature (^{o}C)		
	170	180	190
20	Doughy, improper baking	Slightly doughy, improper baking	Slightly doughy, moist and improper baking
25	Slightly doughy and moist	Golden brown crust and crumb colour with proper baking	Dark brown crust and crumb colour, dark specks in crumb
30	Moist, dark brown crust and crumb colour	Slightly dark brown crust and crumb colour with proper baking	Very dark brown colour, not acceptable cake

Table 4: Effect of microwave baking on the sensory characteristics of cake

Residence time (min)	Microwave power level*		
	50	60	70
2.0	Highly doughy and soggy	Slightly doughy and moist	Uniform baking but slightly hard body and texture
2.5	Doughy and moist	Uniform baking with acceptable body and texture	Hard body and texture, not acceptable
3.0	Slightly doughy and moist	Uniform baking but slightly hard body and texture	Very hard body and texture

Conclusion

In the preparation of cake sometimes the presence of egg, which is nearly an essential ingredient owing to its ability to increase the number of air cells, thereby contributing to the desired leavening of the product, is a deterrent to its consumption, as it imparts a typical flavor which is offensive to those who are not accustomed to eggs. Hence an attempt was made to prepare eggless cake using whey protein concentrate as egg substitute. Cakes were prepared with WPC 60 as egg substitute and the physical and sensory attributes were studied. Highest porosity and specific volume (2.75 cc/g) were observed in cake containing WPC 60 when compared to control cake containing eggs. From the studies, it was found that good quality eggless cake can be prepared using whey protein concentrate as egg substitute with the formulation as7 % WPC, 17 % hydrogenated fat, 27 % refined wheat flour, 24 % sugar, 2.4 % baking powder, 21 % milk and 0.80% flavor.

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