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Effect of Modified Whey Protein Concentrates on Instrumental Texture Analysis of Frozen Dough

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Abstract: Modified whey protein concentrate (mWPC) is an important functional ingredient having wide range of application in food products. Important functional properties of the whey protein are hydrophilic, swelling and water retention capacity and its ability to absorb and bind water is useful in connection with frozen doughs which are mixed, formed and then held in frozen storage for some length of time before being thawed, proofed and baked. Major objective was to determine the effect of modified whey protein concentrates on instrumental texture profile analysis (TPA) of frozen doughs made from flour with different protein contents. Three commercial wheat flours of protein contents 9.2, 12.7 and 14.2% were studied for making frozen dough. Flours with 9.2 and 14.2% protein contents were fortified with 5% mWPC while 12.7% protein contents flour with 2.5% mWPC. Doughs were prepared by mixing all the ingredients in the dough mixer and after resting divided into different pieces and stored in the walk in freezer at -4^{o}F. The values of texture profile analysis of the frozen doughs after thawing for hardness, cohesiveness, gumminess, adhesiveness and springiness were determined with LFRA Texture Analyzer. TPA of dough samples was performed on fresh i.e. zero day and then after 15, 30 and 60 days to study the effect of storage and mWPC treatments on TPA parameters of frozen dough. Values of instrumental texture parameters of frozen dough were affected significantly by the addition of mWPC treatments and a significant decrease in the values of hardness, cohesiveness, gumminess and springiness were observed with its addition in dough samples. Results also represent significant effect of different storage periods on TPA parameters of frozen dough showing upward trends in the values of hardness and gumminess while decreasing values of cohesiveness, adhesiveness and springiness were recorded with the increasing storage periods.

Key words: Frozen dough, TPA, texture, dough storage, modified whey protein concentrates

Introduction

Freezing technology is commonly being employed for the storage of different food products in the developed countries. The production of frozen dough has increased tremendously because of its direct sales to the consumers and rapid growth in number of in-store bakeries. The demand for quick and convenient food has also increased manifolds because of the change in daily life styles.

Rheologic behavior of food materials is important for new product development, equipment design, process improvement and food quality control. Thus, it is desirable that foods be characterized through experimental values or parameters obtained in the determination of their rheologic properties. Because of the simplicity of operation and the requirement of a rather simple texture-measuring instrument, texture profile analysis (TPA) and stress-relaxation tests are two textural methods used to determine the behavior of food products (Yadav *et al.*, 2006).

The frozen dough product segment has been considered to be the third largest in the baking industry in the developed countries. The fast developing frozen dough industry is becoming an easy and feasible alternative to the traditional bakery products. The consumers demand breads from frozen dough that possess a desirable quality and sensory characteristics comparable to the traditional fresh breads.

Frozen dough has attained an important position in the world market and has huge potential of growth due to its high market potential and current lack of competition. The total market for frozen dough products covers retail grocery sales and food service but due to increase in the demand of frozen dough products, several major industrial groups have entered into this business. The trend for more meals prepared outside of the home has also reflected rapid growth in frozen dough (Schroeder, 1999).

The frozen dough production and utilization may confront certain problems that can be overcome by the use of certain additives. These compounds interact with water and can affect the quality of the end bakery product. These compounds also possess water binding and gelling properties. The proteins from dairy sources, like whey proteins, have been reported to be safe and natural food additives that exhibit the capability of thickening functions similar to the hydrocolloids, starches and other thickeners in food systems (Hudson, 2000).

Incorporation of dairy ingredients into the frozen dough system improves the baking quality and can be more beneficial than chemical additives. It will also help to improve the nutritional value of the product. The whey proteins after modification possess several functional properties such as hydrophilic, water retention capacity and gelling capacity (Morr, 1992; Zayas, 1997). The whey protein is widely used as a dough-enhancing additive, conferring a protective effect on the gluten network in the frozen dough system (Jacobson, 1997).

Frozen doughs with the addition of heat treated whey protein concentrates as functional ingredients have shown the improvement in gluten network and baking performance (Kenny *et al.*, 2001). This improvement has attributed to its ability to counteract the rheological changes that occur in frozen storage (Wolt and D'Appolonia, 1984).

The rheological properties of dough are primarily used as quality indicators for the production of final products. These properties are measured in the past few decades through a variety of instruments, empirical, fundamental and dynamic rheometery (Steffe, 1996). Fundamental rheometery describes the physical properties of a material over a wide range of strains and strain rates. Direct comparison of results obtained by various testing instruments and researchers can be carried out by the use of this technique (Weipert, 1990).

Knowledge of the rheological behavior of wheat flour dough is important in the bread making process and to produce better quality cereal products (Letang *et al.*, 1999). Wheat flour dough is a viscoelastic material and its characteristics mainly depend on the properties and composition of the flour and the quantity of water added. Rheological testing has been used to follow the changes in dough systems to determine fundamental dynamic properties. (Huang and Kaletunc, 2003). The objective of this research work was to determine the effect of modified whey protein concentrates on the instrumental texture profile analysis of frozen dough.

Materials and Methods

Procurement of raw material: The commercial wheat flours of three different protein contents, baker's special superfine castor sugar, baker's salt and ascorbic acid were procured from The King Arthur Flour Company, Inc., Norwich, Vermont. Saf-instant yeast manufactured by SAFMEX for: LESAFFRE Yeast Corporation Milwaukee, Wisconsin and Crisco, all-vegetable shortening manufactured by The J.M. Smucker Company, Orrville, OH, were purchased from a local supermarket in USA.

Production of modified whey protein concentrates: Modified whey protein concentrates (mWPC) used in this study as frozen dough functional ingredients were produced by following the procedure of Resch and Daubert (2002).

Preparation of dough: Doughs were prepared from three different wheat flours with and without the addition of mWPC as shown in the following Table 1.

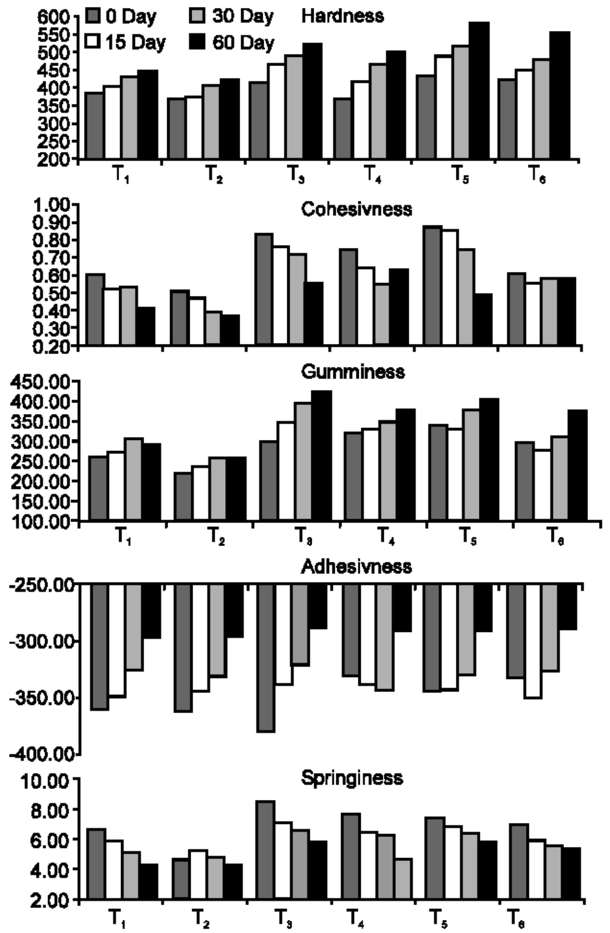
Texture profile analysis of frozen dough: The frozen doughs after thawing were evaluated for their textural properties with the Brookfield LFRA Texture Analyzer. The dough samples were cut with a cylindrical die to get the uniform size of 20mm width and 25mm height. A round disk probe of 30mm diameter was used to exert the force in the middle of the each dough sample. The dough samples were tested in TPA mode consisting of two cycles with a recovery time of 10 seconds. The probe speed was 10mm/sec and the distance of the probe was 75% of the products height. The data were processed with Brookfield Texture Prolite Version 1.0 software package provided by Brookfield Engineering Laboratories, Inc. USA. The parameters such as hardness, cohesiveness and adhesiveness of dough were determined using the method of Bourne (1978); Manohar and Rao (1999).

Statistical analyses and software: Data for texture analysis of the dough were processed with Brookfield Texture Prolite version 1.0 software package provided by Brookfield Engineering Laboratories, Inc. USA and it was subjected to statistical analyses to determine the level of significance between texture parameters of different treatments by using completely randomized design and means were compared according to the appropriate methods described by Steel and Torrie (1997).

Results and Discussion

In this study, TPA parameters were used to verify the changes of the textural attributes of frozen dough made from the wheat flours of different protein contents and with different treatments of modified whey protein concentrates according to the treatments as shown in Table 1. The textural parameters of food products have been established using the TPA methodology, which gives excellent correlations with the results of organoleptic analysis (Bourne, 2002). For this study, a sensory analysis was not included.

There are two methods to evaluate food texture, namely sensory and instrumental methods. The sensory method of developing a texture profile utilizes a human taste panel and provides the ultimate test, which cannot be completely duplicated by any instrumental procedure. Texture profile analysis (TPA) method is widely used for texture evaluation of food products. Human eating action normally consists of several bites. In order to better describe the eating actions of humans, the TPA method was presented by Peleg (1976). The TPA test performs



T_1 (9.2% protein contents flour), T_2 (T_1 Flour + 5% mWPC), T_3 (12.7% protein contents flour), T_4 (T_3 Flour + 2.5% mWPC),T_5 (14.2% protein contents flour), T_6 (T_5 Flour + 5% mWPC).

Fig. 1: Texture Profile Analysis of frozen dough.

two bites; every bite includes compression and decompression cycles. The results pertaining the analysis of variance and mean sum of squares of instrumental texture parameters of frozen dough are shown in Table 2.

Hardness: The analysis of variance for the hardness of frozen dough prepared from different treatments is shown in Table 2. The analysis of variance showed that the effect of different treatment and storage was highly significant whereas interaction between treatment and storage was found to be non significant on the hardness of frozen dough.

Statistical means for the hardness of frozen dough of different treatments have been presented in Fig. 1. The mean score for the hardness of frozen dough ranged from 412.33-503.23. It is evident from the results that lowest values for the hardness of frozen dough were recorded from the wheat flour with 9.2% protein contents (T_1) and higher values of frozen dough were recorded made from T_3 and T_5 with 12.7 and 14.2% protein contents wheat flours respectively for the hardness measurement in TPA instrument. This trend showed that with the increase in protein contents of wheat flours an increase in the values of the hardness of frozen dough were observed. The results also indicated that addition of mWPC in wheat flours resulted in the lowering values of hardness of the frozen dough in all treatment, which means that addition of mWPC induces a softening effect on the dough system.

The results for the values of hardness varied from 396.33-500.94 during different storage periods. The results also represent a steady increase in the values of hardness with the increasing frozen storage periods of time up to 60 days.

The results found in this study are in close agreements to the findings of Gambaro *et al.* (2002, 2004, 2006) as they previously conducted texture profile studies on frozen dough and they found a significant increase in the values of hardness of dough with the increasing storage periods.

Cohesiveness: The results pertaining to the analysis of variance for cohesiveness of frozen dough with different mWPC treatments at different storage intervals revealed that cohesiveness was affected significantly by different treatments as well as storage periods. The interaction between the treatments and storage periods did not affect significantly the cohesiveness of frozen dough.

Values of means for the cohesiveness of frozen dough ranged from 0.41 for (T_2) to 0.74 (T_5) for the dough made from 14.2% protein contents wheat flour among different treatment as shown in Fig. 1. The results also represent that with the increasing protein contents in the wheat flours, the values of cohesiveness increased in the frozen dough which could be seen as lower cohesiveness values in T_1 and significantly higher ones in T_3 and T_5, respectively. A decreasing trend in the values of cohesiveness was observed with the addition of mWPC treatments in the frozen dough.

Results shown in Fig. 1 also represent that the statistical mean values of cohesiveness from zero to 60 days varied from 0.50-0.69 across different storage intervals. The values were maximum at zero days and then significantly decreased values of cohesiveness of the frozen dough were observed with the increasing storage periods. The results found in this study are in close agreement to the findings of Gambaro *et al.* (2006). According to them, increase in the frozen storage periods resulted in a decrease in the cohesiveness of dough samples.

Gumminess: The results pertaining to the analysis of variance for the gumminess of frozen dough with

Table 1: Experimental design of flour samples

Modified whey protein concentrates addition	Wheat flour with 9.2% protein contents (Type 1 = PF)	Wheat flour with 12.7% protein contents (Type 2 = BF)	Wheat flour 14.2% protein contents (Type 3 = HF)
0.00%	PF (T_1)	BF (T_3)	HF (T_5)
2.50%	-	BFW (T_4)	-
5.00%	PFW (T_2)	-	HFW (T_6)

Table 2: Mean Sum of squares for the instrumental texture analysis of frozen dough

SOV	df	Hardness	Cohesiveness	Gumminess	Adhesiveness	Springiness
Treatments (T)	5	21218.456**	0.173**	28713.581**	236.158^{NS}	8.141**
Storage intervals (S)	3	35416.778**	0.120**	17267.162**	13817.940**	11.309**
T x S	15	929.589^{NS}	0.014^{NS}	1192.995^{NS}	473.106^{NS}	0.616^{NS}
Error	48	553.403	0.007	654.986	263.472	0.348

** = Highly Significant, ($P \leq 0.01$), $^{N.S}$ = Non Significant

different mWPC treatments and at different storage intervals showed that gumminess of frozen dough was affected significantly both by different treatments as well as by different storage periods. The interaction between the different treatments and different storage periods was found to be non significant for the gumminess of the frozen dough.

The mean values for the gumminess of frozen dough ranged from 240.83-364.25 among different treatments. However the gumminess mean values varied from 286.06-352.33 across different storage intervals as shown in Fig. 1. A significant decrease in the mean values of gumminess were observed with the addition of mWPC treatments in frozen dough as significantly lower values of gumminess have been observed in T_2, T_4 and T_6 when compared with the T_1, T_3 and T_5, respectively.

The results also described that gumminess of frozen dough increased with the increase of storage period and it was significantly lower at 0 day and it increased significantly by increasing frozen storage periods.

Adhesiveness: The results regarding the analysis of variance for the adhesiveness of frozen dough prepared with different treatments showed no significant differences among different mWPC added treatments of frozen dough while it was affected significantly by the different storage periods. Results also indicate a non-significant interaction among treatments and storage periods.

The statistical means for the adhesiveness of frozen dough measured with TPA instrument ranged between -294 and -357 and results shown in Fig.1 represent a significant increase in the values of adhesiveness with the increase of storage periods.

Springiness: The results for the springiness of frozen dough prepared from different mWPC treatments and at different frozen storage intervals have been given in Table 2 which illustrated the significant effect of different treatments and storage periods. It was also found that the interaction between treatments and storage periods was found to be non significant for the springiness values of frozen dough measured by TPA instrument.

Values of the statistical means for the springiness of frozen dough ranged from 4.62-6.92 among different treatments as shown in Fig. 1. The results also represent that a decreasing trend in the values of cohesiveness was observed with the addition of mWPC treatments in the frozen dough.

The statistical mean values of springiness from zero to 60 days varied from 4.95-6.84 across different storage intervals. The results shown in Fig. 1. also represent a significant decrease in the values of springiness with the increasing storage periods. The values were significantly maximum at zero day and then a significantly gradual decrease in the values of springiness were observed with the increasing storage periods in the frozen dough.

Conclusion: The instrumental texture analysis study of frozen dough showed that addition of mWPC significantly decreased the values of hardness, cohesiveness, gumminess and springiness. The storage increased the hardness, gumminess and adhesiveness while a decrease in the values of cohesiveness and springiness was recorded. The lack of significant interaction shows that the mWPC addition did not eliminate the changes in frozen bread dough caused by storage.

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