PAPER

BREAD QUALITY SUBSTITUTED BY POTATO STARCH INSTEAD OF WHEAT FLOUR

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ABSTRACT

Wheat bread constitutes the most regularly consumed food in the World, the international market for wheat undergoes strong pressure and prices are unceasingly increasing. The aim of this study is to substitute wheat flour by potato starch in bread preparation. Mixtures flours were characterized for composition, damaged starch, and Alveograph properties. According to the results of alveograph parameters, they decrease with the rate of incorporation of potato starch. This decrease can be corrected by adding vital gluten. The results of physicochemical analysis showed a decrease in protein levels, an increase in moisture content (about 2%) and carbohydrates levels due to the composition of potato starch. However, sensory analysis ($p \leq 0.05$) showed that the addition 80% of potato starch leads to bread with better characteristics: taste, colour and odour, based on that, it is highly advisable as an ingredient in the standard preparation of wheat bread.

- Keywords: bread, flour, potato starch, wheat -

INTRODUCTION

Bread is an important component of the Algerian diet, while wheat production in the country is insufficient. Therefore, substantial quantities of this cereal must be imported every year. Making bread by partial substitution of wheat is not a new idea and it is worthwhile to reveal some of the efforts made in the past to make bread from local materials, such as cereal flour or root starches. Potato occupies the fourth place in the World list of food crops, after wheat, rice and corn, with an annual World production of approximately 300 million Mg (CIP, 2008). The country now produces enough potatoes and its price is also within affordable limits of average people. So potato appears to be one of the most promising substitutes in bread making in order to help reduce dependence on wheat flour.

Potato starch is an important raw material in the food industry because its properties and their proportions vary according to the environment and genotypes of potato (VASANTHAN *et al.*, 1999; KAUR *et al.*, 2002; ZAIDUL *et al.*, 2007). Potato starch is largely used in food and non-food fields (paper, cardboard, textiles, mining, drilling, adhesives, etc.). Originally, it was produced for baking by adding it to cereal flour (ROUSSEL *et al.*, 1996; SINGH *et al.*, 2003). The addition of modest amounts of potato starch helps preserve the freshness of bread and it also confers a distinctive character and a pleasant flavor (YANEZ *et al.*, 1981; WILLARD and HIX, 1987).

The aim of this work is to evaluate the possibility of substituting wheat flour for high percentages of potato starch in bread making process and to evaluate the physical, chemical, nutritional and sensory properties of the produced bread.

MATERIAL AND METHODS

Raw material

Algerian wheat flour was obtained from NEKHLA mill, Algeria. Ingredients like sugar, salt, instant active dry yeast and shortening were purchased from the local market, while Potato starch was obtained from Michel Come, Rambouillet, France.

Methods

Physical and chemical composition

Moisture content

The moisture content of samples was determined according to the AACC Official Methods 46-30, where a sample of 5 g is weighed and placed in a moisture dish. The sample is warmed to 130°C in an air oven during 2 hours; then the residue is cooled to room temperature and weighed (AFNOR, 1991).

Ash content

It was determined according to the AACC Official Methods 08-01 (AACC, 1995). Where a sample of 3-5 g is weighed and placed in an ash cup, then the sample is heated at 900°C in an ash oven until complete combustion of the organic matter, and the residue is cooled to room temperature and then weighed (AACC, 1995).

Protein content

Protein content is determined by the Kjeldahl distillation method (by analyzing total nitrogen contents). Two grams of dry sample are weighed and placed with hot concentrated sulfuric acid. The ammonia liberated from the resulting ammonium sulphate, after adding sodium hydroxide was distilled into 1 M boric acid then titrated with 0.1 M HCl. The nitrogen value estimated was multiplied by 5.7 (protein factor) to obtain the value of crud protein. This is expressed as the percentage of dry sample mass (AACC, 1995).

Fat content

According to UGRINOVITS *et al.* (2004) the crude fats were determined by the Soxhlet method. They are extracted from 10 g of each sample using a Soxhlet apparatus with low boiling point petroleum ether (40-60°C) as solvent. A rotary-evaporator was used to evaporate the solvent after each extraction.

Falling Number Test

The level of enzyme activity was measured by the Falling Number Test (standard method AACC 56-81B), and this is to evaluate the α-amylase activity of the flour by measuring the consistency of the gelatinized starch.

Seven grams of the sample is weighed and combined with 25 mL of distilled water in a glass falling number tube with a stirrer and shaken to form a slurry. Then, it is placed in the falling number instrument (AACC, 1995).

Alveograph characteristics

An amount of 250 g of the sample with salty solution was mixed in the alveograph mixer. After 8 minutes of kneading, the passage was opened and the extraction began. The dough patty was cut as soon as it arrived at a mark on the extraction plate. The dough patty was rolled and cut with the cutter and then was placed in the oven of the dough pieces at 25.5°C. After 28 minutes, each dough patty was inflated with air and its individual characteristics (P, L, W) were measured (AACC, 1995).

Table 1- Bread mix formula.

Formula	
Wheat flour	500 g
Salt	10 g
Sugar	5 g
Yeast	10 g
Water	300 mL
Dough improver	0.1 g

W: The work of the deformation energy (baking strength);
L: The length of the curve (Extensibility);
P: Maximum height (Tenacity);
P / L: Ratio curve configuration.

Bread making

The conventional straight-dough method for pan bread was performed according to the procedure developed by AACC. The formula used to make bread is given in Table 1. The level of substitution of wheat flour by potato starch was 80%.

To make bread, the dry ingredients were manually mixed and then added to a mix containing water. The components were thoroughly kneaded with the mixer for 5 min at low speed. The mixing speed was then changed to high speed for 5 min. The dough was divided into pieces of 100 g, rounded by hand and allowed to relax for 25 min. The dough was moulded then panned and fermented for 90 min at 30°C in a fermentation cabin.

Gas retention during fermentation was evaluated using an indicator of growth containing 25 g of dough which was subjected to fermentation in the same conditions as the dough.

The bread was baked at 220°C/20 min in an electric oven. Subsequently, the baked bread samples were then depanned and cooled to evaluate their external and internal properties by a 1h at room temperature, packed in polyethylene bags used for further analyses.

Bread evaluation

Loaves were organoleptically evaluated for their external and internal properties by a jury of twenty tasters. The method of 5 point score (in a hedonistic qualification scale) was used (AMERINE *et al.*, 1973). The panel members were asked to score for crust colour, crumb colour, texture, flavour and overall acceptability.

Statistical analysis

In this study, all experiments were performed in triplicate. Statistical analysis was performed using XLSTAT program to compare the results. The level of significance was considered at $p \leq 0.05$.

RESULTS AND DISCUSSION

Physical and chemical composition

The result of proximate composition analysis of wheat flour and potato starch is as shown in Table 2. The wheat flour protein content used in this study was about 10%, this result is similar to that reported by LINDAHL and ELIASSON (1992). According to UGRINOVITS *et al.* (2004) the strength of the flour is partially determined by its wet gluten content.

The wet gluten content of potato starch is about 1.72% where as wet gluten content of wheat flour is 30.08%, which is a normal level, potato starch contained lower proteins (trace) and higher carbohydrate than wheat flour. However this value of wet gluten, added to the vital gluten in the mixture allows compensating for the deficit of protein potato starch (32.77%).

The results of baking test show that potato starch alone is not enough to produce bread, and the same result was found for the mixture with high level. It might be due to the value of gluten that is lower. Therefore, it is necessary to add a percentage of vital gluten.

However, the value of the falling number of the

Table 2 - Physical and chemical characteristics of mixtures.

Parameter\Product	100%	100% S.P	20% F 80% S.P	
			Wh.G	G
Moisture (%)	15.80±0.026	17.80±0.035	17.60±0.011	16.21±0.015
Mineral (Ash) (%)	0.53±0.025	0.18±0.02	0.19±0.0152	0.27±0.01
Wet Gluten (%)	30.10±0.155	/	1.72±0.092	32.77±0.196
Falling number (s)	312	220	181	126
Protein content (%)	10	Trace	/	/
Fat content (%)	0.9	Trace	/	/

F: Wheat Flour; S.P: Potato Starch; Wh.G: Without Gluten; G: With Gluten.

Table 3 - Rheological characteristics of the flours (with and without addition of vital gluten).

Rheological characteristics		Rate of incorporation of the potato starch		
		0%	80% without gluten	80% with gluten
Alveographic measurements	P (mm)	81	20	99
	G (cm)	19.1	06.7	14.8
	P/L	01.09	06.68	02.25
	W (10^{-4} J)	210	10	193

mix is lower (220) than that of wheat flour and also lower than the optimal standards for bread which is 200 to 300 seconds (GODON and LOISEL, 1997). This might be due to the decreased resistance of potato starch to enzymatic degradation. Also, the fact that the gelatinization temperature is lower than that of wheat flour can be considered as another reason.

Alveograph characteristics

The results of Alveograph Test, summarized in Table 3, make it possible to predict baker quality of flour. This test is an interesting practice which is very appreciated by professionals of the second transformation, due to the fact that it reflects through alveographic parameters measured the ability of flour to be managed according to its baking strength for a specific purpose (ROUSSEL and CHIRON, 2002).

The Alveograph parameters of wheat flour and mixtures (with 80% of potato starch) showed (Table 3), that overpressure (P), a measure of dough tenacity, which is an indicator of gas retention by the dough as indicated by WANG *et al.* (2002), varied from 58 to 150 mm.

The measure of Alveograph dough extensibility (L), ranged from 45 to 116 mm. The values for curve configuration ratio, indicating the configuration ratio of the Alveograph curve, varied from 1.09 to 2.25. The index of swelling (G) varied from 6.9 to 19.10 cm and the baking strength representing the energy necessary to inflate the dough bubble to the point of rupture ranged from 10 to 210*10^{-4} J. These differences of results are due to the addition of gluten which controls these parameters, where the P value increases to 99mm H_2O. It is higher than the limit of 80 mm.

These results show that the composite potato starch and wheat flour lead to dough which is less resistant to deformation and low extensibility for rate incorporation of 80%.

Mixed baking test

In order to know the influence of the substitution of wheat flour by potato starch (20/80), several tests were carried out in the laboratory and other tests at the bakery with the assistance of a French expert in bakery (J. PRODHOMME).

The experimental baking studies showed that the concentration of 80% potato starch with the addition of gluten did not affect the handling of dough except for some defects of extensibility during shaping. This similarity in results is due to the role of the added gluten; the essential element for baking (especially during kneading and shaping), which plays a very significant role in increasing the uptake of water and the resistance of the dough. A significant criterion observed during almost all stages of baking, is the stickiness of the dough.

In a similar vein, the properties of gas retention within the composite dough are followed by measurement of the volume of the dough during fermentation using the indicator of growth containing 25g of dough subjected to fermentation under the same conditions as the loaves of bread. The results obtained are highly significant ($p \leq 0.05$), they show that the pastes incorporate up to 80 % of potato starch, which experience less raising during fermentation, but remain comparable with those obtained with 100 % of wheat flour (Fig. 1).

External and internal aspects of breads obtained are shown in Figs. 2 and 3. The incorporation of potato starch at levels of 80% gives breads with optimal characteristics.

The breads resulting from the potato starch have a good appearance, presenting regular and smooth crusts similar to the breads resulting from wheat flour.

As for the coloration of the crust, bread with potato starch presents a less dark coloring compared to bread with wheat flour. DUPIN *et al.* (1992) and BOYACIOGLU and D'APPOLONIA (1994) showed that the dark coloration of bread is influenced by the rise of the rate of both damaged starch and total sugars present in flour, which were highest in starch potato.

Concerning the appearance of the crumb related to (Fig. 2), bread has aired cells, badly dispersed and not homogeneous. That can be explained by the irregular distribution or the incorporation of α-amylases.

As for the appearance of crumbs (Fig. 3), bread has aired cells, poorly dispersed and not homogeneous. Again, that can be explained by the bad distribution or the incorporation of α-amylases.

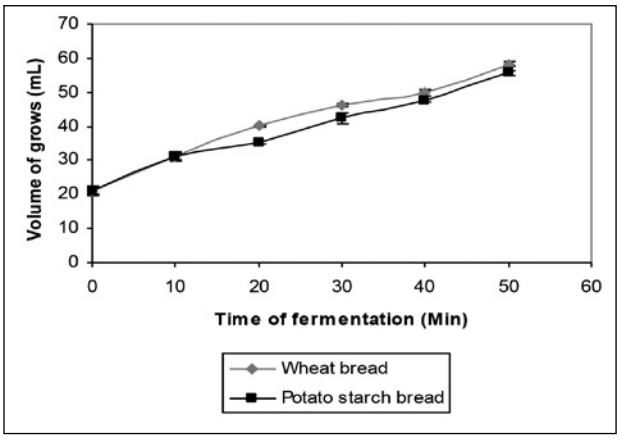

Fig. 1 - Influence incorporation of potato starch on the profiles of gas retention.

Fig. 2 - Appearance of the crust of potato starch bread (80%).

Fig. 3 - Appearance of the crumb of potato starch bread (80%).

Bread evaluation

The approximate composition of bread made from potato starch and wheat flour is shown in Table 4.

The control bread obtained shows a protein rate of 10.5 %, a rate 60.4% of sugar of and 0.9 % of fat. These values are similar to the values given by CABROL (2006).

However, bread prepared containing potato starch 80% present a reduction in proteins (6.87%) and fat (0.37%). This result might be due to the composition of potato starch that, in fact, is rich in sugar and low in fat and proteins.

The sensory quality statistics reveal that potato starch influences the crumb of bread (Fig. 4). Bread with potato starch 80% acquires a very white coloration, and therefore receives the highest score compared to control bread. Meanwhile, the texture of bread is more developed than that of the control bread.

However, we observed that there is significant difference ($p \leq 0.05$) in the P value therefore stating the sensory characteristics of potato starch bread 80% are not affected.

CONCLUSIONS

The aim of this study was to analyze samples of bread at 80% of potato starch and compared with control bread produced from wheat flour under the same conditions for their nutritional, physicochemical and sensory characteristics. The formulation of our bread was made as follows: potato starch, wheat flour, gluten, yeast, salt and a dough improver. The results show that the loaves can be prepared by potato starch even at high percentage (80%) and gluten. Breads obtained by this formula were nutritionally, physically, chemically and at the

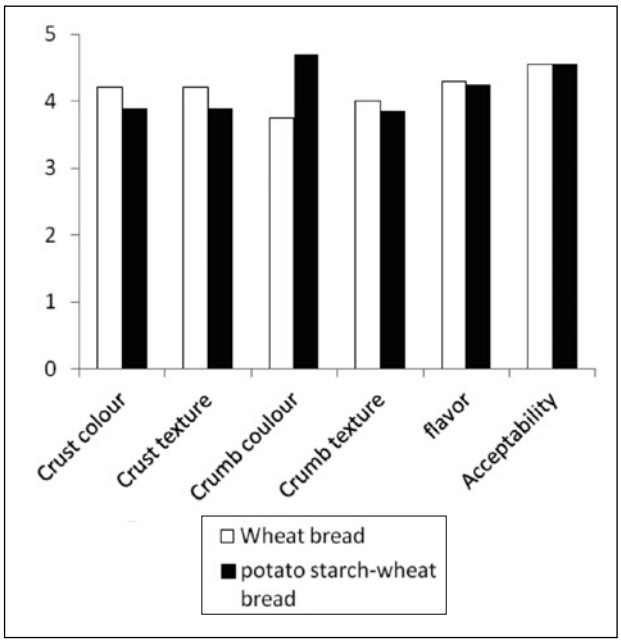

Fig. 4 - Evaluation of some characters of quality of the potato starch bread 80% and wheat bread prepared in bakery.

Table 4 - Nutritional composition of breads.

Products	Humidity %	Glucids (%)	Protein (%)	Fat (%)	Fibre (%)
Wheat bread	28.20	60.4	10.5	0.9	-
Potato starch bread	31.33	61.36	6.87	0.37	0.07

sensorial level comparable to the control bread. A high percentage of consumers said they saw no difference.

These results support the partial substitution of wheat flour by potato starch in wheat-based food products to minimize costs. Future studies are needed to investigate the pasting properties of mixtures of wheat flour and potato starch (by RVA), to determine the interaction between wheat flour and potato starch and also to interpret their rheological properties by differential scanning calorimeter and rheometer.

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