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EFFECT OF FAT REPLACERS AND HULL-LESS BARLEY FLOUR ON LOW-FAT CROISSANT QUALITY

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The aim of this study was to evaluate corn maltodextrins and pectin as fat replacers to be used for the production of low-fat (low calorie) croissants and to study the effect of partial replacement of wheat flour with barley flour on croissant quality. Twenty four formulas of croissant dough were prepared using maltodextrin or pectin as fat replacers. Wheat flour was replaced using hull-less barley flour at two levels (20 and 30%). Fat was replaced at three levels (25, 50 and 100%). Rheological properties of dough were evaluated. Moisture content, baking quality, color attributes, firmness and organoleptic properties of the final product were evaluated. The results obtained revealed that replacing fat or wheat flour using fat replacers or barley flour affected croissants quality. Most of organoleptic properties were adversely affected as a function of increasing levels of fat replacers or barley flour. Acceptable low-fat croissants could be produced when fat would be replaced up to 50% using maltodextrin or pectin. In addition, wheat flour could be replaced up to 20% to produce acceptable croissants under investigated conditions.

INTRODUCTION

The baking industry has responded to the demands of consumers by developing low- or reduced-fat products, defined as those foods that have at least one-third fewer calories than an equivalent serving of a normal counterpart. The reduced-calorie product, however, must not be nutritionally inferior to the similar standard product. One option for reducing fat or calories in commercial products is to replace a part of fat with carbohydrate-based fat substitutes like maltodextrins, modified food starches, or polydextrose compounds [Vetter, 1991].

To produce high-quality acceptable reduced-calorie products, more consideration must be given to the effects of the substitutes on the sensory properties of the finished products [Setser & Racette, 1992]. Fat replacers provide one alternative to lower fat content in baked products. The type and amount of fat used in a baked product influences its flavor, texture and appearance [Pyler, 1988].

Most reduced-fat or low-fat products rely on a combination of ingredients to replace the fat [Giese, 1996]. Carbohydrate-based fat substitutes incorporate water in a fat like gel; the resulting lubricant and flow properties are similar to fats. Water content of products formulated with these fat replacers increases as the percentage of fat replacement increases [Inglett *et al.*, 1994]. Normally, increased levels of water are needed to replace high levels of fat, and a means of stabilizing the extra water is necessary [Jackel, 1990].

The primary function of fat is to create more tender products and shorter doughs. Fat lubricates the structure by being dispersed in the dough or batter during mixing and helps preventing the starch and protein from forming a continuous network [Sanchez *et al.*, 1995]. The sensation of a fatty mouth feel is formed by a combination of several poorly defined or quantitated parameters including viscosity, absorption, cohesiveness and waxiness [Glicksman, 1991].

Barley, one of the earliest cultivated cereals in the world, is now gaining renewal as a food component because of its soluble dietary fiber and β-glucan content in particular [Marconi *et al.*, 2000]. Compared with other cereals, barley has a relatively high level of β-glucans reaching 2–11 g/100 g (wb) [Mac-Gregor & Fincher, 1993].

In Egypt, breeding programmes address hull-less barley as an important crop as it is characterized by high yield production, is suitable for arid and semi-arid areas. Hull-less barley flour can be used in combination with wheat flour for many food uses where Egypt is suffering from wheat shortage.

Hull-less (naked) barley generally contains more protein and starch compared to hulled barley. This is due to the removal of fibrous hull which has a dilution effect on these components [Bhatty, 1999]. In hull-less barley, grain protein varies from 13 to 17% [Edney *et al.*, 1992], whereas limiting amino acids, lysine and threonine, occur in higher concentrations compared to wheat or hulled barley [Edney *et al.*,

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1992; Boros *et al.*, 1996]. Hull-less barley like oat contains high concentrations of β-glucan, a major component of total dietary fiber (TDF) and soluble fiber (SF). β-Glucan forms 22 and 38% of TDF and SF of bran and 20 and 27% of flour, respectively. Hull-less barley flour 70% extraction contains 7.7, 2.7 and 4.5% of total dietary fiber, soluble fiber and β-glucan, respectively [Bhatty, 1993]. Barley, barley bran and barley flour display a hypocholesterolemic effect as they contain β-glucans and tocols [Wang *et al.*, 1993; Peterson, 1994; Lupton *et al.*, 1994; Ikegami *et al.*, 1996].

The aim of this study was to evaluate corn maltodextrins and pectin as fat replacers to be used for the production of low-fat (low calorie) croissants and to determine the joint effect of replacing wheat flour with hull-less barley flour and introducing fat replacers on the quality of croissants produced, regarding rheological properties, moisture content, baking quality and sensory evaluation of the final product.

MATERIALS AND METHODS

Materials

Wheat flour (72%), fat (vegetable shortening), salt (NaCL), sucrose, active dry yeast, and improver were obtained from local markets, Cairo, Egypt. Barley flour 70% extraction was obtained from hull-less barley cultivar Giza (129), which was obtained from the Ministry of Agriculture, Cairo, Egypt. Corn maltodextrin (13 dextrose equivalent, 5% moisture, 0.5% ash and pH=4.5) was obtained from the National Company for Maize Products, Cairo, Egypt. Pectin of citrus peels was obtained from Fluka Company, Germany.

Croissants composition and preparation

Control. For 100 g flour, 60 g fat, 1 g active dry yeast, 0.5 g salt, 1 g sucrose, 1 g improver and 50 mL water were added in all formulas.

Croissants with fat replacers and barely flour. Two fat replacers (corn maltodextrin and pectin) were used to replace fat at levels of 0, 25, 50 and 100%. In addition, barley flour was used to replace wheat flour at levels of 20 and 30%. Replacements and numbers of samples are presented in Table 1.

Flour, salt, yeast, sugar, improver and water were mixed. Dough was left for 15 min, and then fat was added. The dough was left in a refrigerator for one hour (4°C), then divided (100 g) and left for two hours for fermentation. Baking was performed at 200°C for 20 min. Croissants were left for 2 h before evaluation.

Methods

Moisture content was determined according to AOAC method [1995]. Firmness was evaluated using a firmness tester, Chotllon, New York, USA. Colour attributes were determined as described by Bhatty & Rossnagel [1998] using a spectrocolorimeter (Hunterlab colour-Quest--Hunter Assoc. Laboratiories, Reston, VA). Water absorption, arrival time, dough development time, stability and weakening of dough were evaluated with a Farinograph, whereas dough extensibility, resistance to extension and energy were evaluated with an Extensograph according to AACC methods [1983]. Specific volume was calculated as: volume (cm^3) / weight (g).

Sensory evaluation. Sensory evaluation of croissants was performed by 15 panelists – members of the Food Technology Department, National Research Center – as described by Armbrister & Setser [1994] with some modifications as follows: General appearance (20), Color (10), Texture (20), Surface roughness (10), Cell size (10), Taste (20), and Mouth feel (10).

Statistical analysis. Data of a sensory evaluation were elaborated statistically with an analysis of variance using randomized complete design. Least significant difference (LSD) was also calculated as described by Snedecor & Cochran [1980].

RESULTS AND DISCUSSION

Rheological properties

Data presented in Table 2 revealed that the addition of barley flour to wheat flour slightly affected rheological properties of doughs as measured by a farinograph and an extensograph. Water absorption, arrival time, dough development time and stability increased as barley flour addition increased.

TABLE 1. Maltodextrin- or pectin-replaced croissant samples (100 g sample).

Wheat flour (g)	Barely flour (g)	Fat (g)	Replacer: maltodextrin or pectin (g)	Water (mL)	Fat replacement (%)
			Control		
100	0	60	-	-	0
100	0	45	3.5	11.5	25
100	0	30	7.0	23.0	50
100	0	0	14.0	46.0	100
			20%barley flour		
80	20	60	-	-	0
80	20	45	3.5	11.5	25
80	20	30	7.0	23.0	50
80	20	0	14.0	46.0	100
			30% barley flour		
70	30	60	-	-	0
70	30	45	3.5	11.5	25
70	30	30	7.0	23.0	50
70	30	0	14.0	46.0	100

TABLE 2. Rheological properties of dough as affected by barley flour.

	Control	20% Barely flour	30% Barely flour
	Farinograph		
Water absorption (%)	61	62	64
Arrival time (min)	1.5	2	2
Dough development time (min)	2.5	3	3
Stability (min)	5.5	12.5	16.5
Weakening (BU)	40	20	20
	Extensograph		
Extensibility (mm)	110	100	90
Resistance to extension (BU)	800	720	640
Energy (cm^2)	118	106	128

These effects may be referred to the presence of β-glucan in barley flour. Wheat flour contains a lower content of β-glucan than barley flour [Bhatty, 1993]. Extensibility, resistance to extension and energy decreased as barley flour level increased (up to 30%). These effects were attributed mainly to the dilution of gluten by the presence of barley flour.

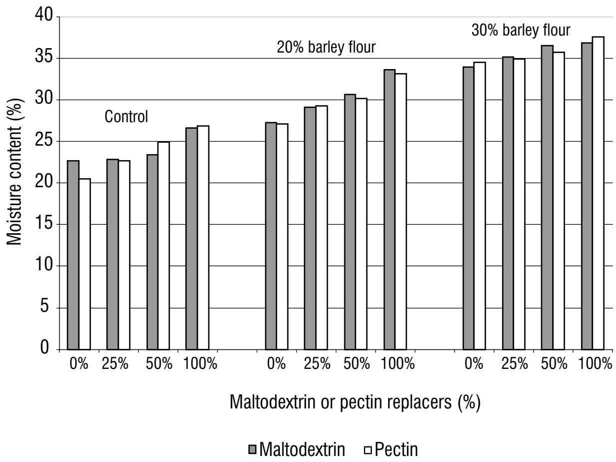

FIGURE 1. Moisture content of croissants as affected by fat replacers or barley flour.

Moisture content of croissants

As shown in Figure 1, moisture content of croissants was affected by fat replacers and barley flour; it increased as the levels of fat replacer increased. The trend was observed in both maltodextrin- and pectin-replaced samples. Fat replacers (maltodextrin and pectin), are characterized by a high water binding capacity, thus maltodextrin- or pectin--replaced samples retain more water than the control samples. Rice maltodextrin-replaced cookies had higher moisture content than the control samples [Sanchez *et al*., 1995]. In addition, samples containing barley flour had higher moisture content than those of wheat flour samples. Therefore, samples containing barley flour and fat replacers had a higher moisture content than those of wheat flour and fat.

Baking quality of croissants

Both maltodextrin- and pectin-replaced croissants had a higher specific volume than the control samples. As shown in Table 3, the volume and weight of croissants increased as the replacement level increased. This tendency was observed in both barley-containing samples and control ones. Maltodextrin and pectin bind more water, hence the weight of croissants was observed to increase. What is more, maltodextrin and pectin may enhance gluten network and increase viscosity [Deis, 1994], consequently, the volume of croissants increased. That effect slightly decreased in barley-containing croissants. Barley flour has no gluten, therefore the gluten network was adversely affected as replacing ratio increased, consequently, the volume of croissants with wheat flour and fat replacers increased more than those of wheat-barley and fat replacers under the same conditions.

Colour attributes of croissants

Lightness (L-value) increased as fat replacement increased (Table 4), still it decreased as barley flour level increased. A slight increase in the L-value was observed as a result of the presence of potato maltodextrins or pectin

TABLE 3. Baking quality of croissants as affected by fat replacers and barley flour.

Fat replacement (%)	Maltodextrin Volume (cm^3)	Maltodextrin Weight (g)	Maltodextrin Specific volume (cm^3/g)	Pectin Volume (cm^3)	Pectin Weight (g)	Pectin Specific volume (cm^3/g)
			Control			
0%	250	84.78	2.95	240	127.16	1.89
25%	380	117.8	3.23	260	142.08	1.83
50%	400	121.48	3.29	340	145.49	2.34
100%	500	127.33	3.93	390	152.69	2.55
			20% barley flour			
0%	250	122.06	2.05	250	121.35	2.06
25%	290	130.55	2.22	265	143.31	1.85
50%	342	135.08	2.53	300	144.97	2.07
100%	420	139.2	3.02	320	156.71	2.04
			30% barley flour			
0%	230	109.87	2.09	250	132.09	1.89
25%	255	129.04	1.98	280	143.69	1.95
50%	365	130.72	2.79	282	144.99	1.94
100%	400	145.41	2.75	285	159.89	1.78

TABLE 4. Color attributes of croissants as affected by fat replacers and barley flour.

Fat replacement (%)	Maltodextrin			Pectin		
	L	a	b	L	a	b
			Control			
0%	52.26	16.03	35.15	58.50	10.50	33.42
25%	53.50	15.50	31.50	59.15	11.75	29.75
50%	53.75	14.50	29.15	60.70	12.54	27.50
100%	53.95	14.15	28.07	60.75	13.50	26.75
			20% barley flour			
0%	51.50	14.07	32.50	60.50	8.55	29.50
25%	51.75	16.50	31.01	60.75	9.15	30.75
50%	52.15	16.75	29.55	61.15	12.75	31.50
100%	52.70	16.80	26.25	61.48	16.15	31.82
			30% barley flour			
0%	50.25	11.55	32.50	60.55	12.50	31.75
25%	50.50	12.50	32.75	60.50	12.55	31.87
50%	51.15	13.65	33.14	61.75	13.10	33.75
100%	51.90	14.70	35.35	62.35	13.50	35.50

used instead of fat in cookies [Armbrister & Setser, 1994], but L-value increased as oatrim level increased [Swanson *et al.*, 1999]. While a-value decreased as maltodextrin or pectin level increased, barley flour addition led to an increase in a-values. In the case of the b-value, it is clear that fat replacers (maltodextrin or pectin) affected it. In addition the b-value decreased as barley flour level increased.

Pectin is more effective than maltodextrin regarding its effect on colour attributes. Bhatty [1993] reported that L-value of wheat flour was higher than that of barley flour. Also, Kunckles *et al.* [1997] pointed out that the L-value decreased as barley flour level increased in wheat-barley bread. Such findings were also reported by Bhatty [1986].

Firmness of croissants

Data presented in Figure 2 show the firmness of croissants as affected by fat replacers (maltodextrin or pectin) and barley flour. Both fat replacers and barley flour affected texture characteristics of croissants. As fat replacement increased, the firmness increased. This tendency was observed in maltodextrin- and pectin-replaced samples. Still, the presence of barley flour decreased the firmness of croissants compared to wheat flour samples. This is likely to be due to the fact that barely contains more β-glucan which affects the rheological properties of dough (Table 2). It could be noticed that pectin-replaced samples were more hard than those in which maltodextrin was used as a replacer (Figure 2).

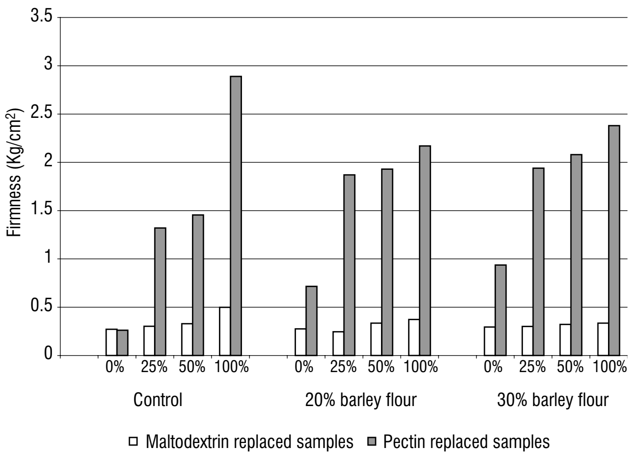

FIGURE 2. Firmness of croissants as affected by fat replacers or barley flour.

Rice maltodextrin increased breaking force of cookies, and firmness increased as a result of the absence of fat which is very important for tenderness and mechanical handling [Sanchez *et al.*, 1995].

On the other hand, the presence of barley flour reduced the firmness of croissants, for example the formula containing 100% wheat flour, 0% fat and maltodextrin and the formula containing 30% barley, 0% fat and maltodextrin demonstrated the firmness values of 0.449 and 0.335 kg/cm^2, respectively. Also, the formula containing 100% wheat flour, 0% fat and pectin and the formula containing 30% barley, 0% fat and pectin had the firmness values of 2.890 and 2.380 kg/cm^2, respectively. This trend was observed in all tested samples regardless of the fat replacer type applied. That effect may be due to the presence of β-glucan in barley flour.

Sensory evaluation of croissants

Data presented in Table 5 show the sensory evaluation of croissants as a function of fat replacers (maltodextrin or pectin) and barley flour. Regarding general appearance, it could be noticed that acceptable croissants could be produced when fat was replaced with maltodextrin or pectin up to 50% (fat weight basis). Significant differences were observed when wheat flour was replaced with barley flour. As the replacement level increased the general appearance score decreased.

Regarding colour, it is clear that the presence of fat replacers (maltodextrin or pectin) slightly affected the colour of croissants, while the presence of barley flour strongly affected colour, as shown in Table 5. That trend was observed in all the samples tested.

TABLE 5. Sensory evaluation of croissants as affected by fat replacers (maltodextrin and pectin) and barley flour (mean values).

Fat replacement (%)	General appearance (20)	Color (10)	Texture (20)	Surface roughness (10)	Cell size (10)	Taste (20)	Mouthfeel (10)
				Maltodextrin			
				Control			
0%	14.4^{bc}	7.5^{ab}	14.0^{abc}	7.2^{bc}	6.6^{bc}	15.1^{ab}	7.2^{ab}
25%	16.1^{ab}	7.6^{ab}	15.0^{abc}	7.5^{abc}	7.0^{ab}	15.4^{ab}	7.3^{ab}
50%	16.6^{a}	8.3^{a}	17.0^{a}	8.3^{ab}	7.8^{a}	17.1^{a}	7.9^{a}
100%	15.6^{ab}	7.4^{abc}	15.4^{ab}	8.9^{a}	6.9^{ab}	15.4^{ab}	7.3^{ab}
				20% barley flour			
0%	12.5^{c}	6.3^{bcde}	13.1^{bcde}	7.1^{bc}	6.4^{bc}	14.3^{b}	6.8^{abc}
25%	13.1^{c}	6.7^{bcd}	12.6^{cdef}	6.6^{cd}	6.4^{bc}	13.9^{bc}	6.7^{abc}
50%	15.6^{ab}	7.2^{abcd}	14.6^{abc}	8.3^{ab}	7.3^{ab}	13.9^{bc}	6.8^{abc}
100%	14.6^{abc}	7.0^{abcd}	13.2^{bcde}	8.0^{abc}	7.0^{ab}	13.1^{bcd}	6.3^{bcd}
				30% barley flour			
0%	9.3^{d}	4.9^{f}	10.2^{fg}	5.1^{de}	4.7^{d}	10.9^{d}	5.0^{d}
25%	9.4^{d}	5.1^{ef}	9.7^{g}	4.9^{e}	4.8^{d}	10.8^{d}	5.2^{d}
50%	12.4^{c}	6.0^{def}	10.9^{efg}	6.8^{bc}	5.5^{cd}	11.6^{cd}	5.7^{cd}
100%	12.9^{c}	6.0^{cdef}	11.6^{defg}	6.6^{cd}	5.1^{d}	11.4^{cd}	5.5^{cd}
LSD* $_{0.05}$	2.20	1.33	2.78	1.51	1.12	2.57	1.13
				Pectin			
				Control			
0%	16.7^{a}	8.7^{a}	16.6^{a}	7.9	8.3^{a}	16.5^{a}	7.9^{a}
25%	14.2^{abc}	7.2^{bc}	14.2^{ab}	7.3	7.3^{ab}	13.8^{ab}	7.3^{a}
50%	15.7^{ab}	8.3^{ab}	13.7^{bc}	7.2	6.7^{bc}	13.5^{bc}	7.1^{ab}
100%	11.1^{d}	6.0^{de}	9.9^{d}	6.7	5.1^{d}	9.4^{d}	4.8^{c}
				20% barley flour			
0 %	12.5^{cd}	6.9^{cd}	10.8^{d}	6.8	5.4^{d}	10.1^{d}	5.4^{c}
25%	13.2^{bcd}	6.4^{cde}	12.8^{bcd}	6.8	5.8^{cd}	10.9^{cd}	5.5^{c}
50%	12.2^{cd}	6.3^{cde}	11.3^{cd}	6.4	5.8^{cd}	11.4^{bcd}	5.8^{bc}
100%	12.2^{cd}	6.8^{cd}	11.4^{cd}	6.1	5.8^{cd}	9.8^{d}	5.2^{c}
				30% barley flour			
0 %	11.3^{d}	6.4^{cde}	11.2^{cd}	6.5	6.1^{cd}	11.0^{bcd}	5.3^{c}
25%	12.0^{cd}	6.3^{cde}	10.7^{d}	6.4	5.8^{cd}	11.4^{bcd}	5.7^{bc}
50%	10.7^{c}	5.4^{e}	10.2^{d}	6.3	5.6^{cd}	10.3^{d}	4.9^{c}
100%	12.7^{cd}	6.5^{cde}	11.3^{cd}	6.2	5.7^{cd}	9.6^{d}	4.6^{c}
LSD*$_{0.05}$	2.59	1.16	2.69	N.S	1.10	2.80	1.35

* $LSD_{0.05}$: Least Significant Difference; values with different superscipts (in each column) are significantly different

The results obtained indicate that the texture and surface roughness were affected by the presence of tested fat replacers or barley flour. Both fat replacers and barley flour adversely affected the texture and surface roughness of croissants. The same trend was also observed in cell size of croissants. In addition, the results obtained revealed that the control samples were superior samples regarding taste and mouth feel properties. This may be because control samples have no fat replacers or barley flour.

CONCLUSIONS

Finally, it could be concluded that acceptable low-fat croissants could be produced using maltodextrin or pectin as fat replacers up to 50% replacing level (fat weight basis), but croissants containing pectin were more hard. Therefore, maltodextrin is better than pectin to be used as a fat replacer under investigated conditions. Also, wheat flour could be replaced with barley flour up to 20% to produce acceptable croissants. Increasing levels of tested fat replacers or barley flour led to a low quality of croissants produced.

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