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Effect of pregelatinized corn and rice flour on specific volume of gluten-free traditional Algerian bread «*KhobzEddar*» using central composite design

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In the present study, the effect of addition of pregelatinized corn and rice flour on specific volume of gluten-free traditional Algerian bread *Khobz Eddar* was studied. The gluten-free breads were made from corn and rice/field bean formula in ratio 2/1 (w/w) and pregelatinized corn and rice flour were made by adding water to flour on the basis of 5/1 (w/w) and heated until 65°C. Response Surface Methodology (RSM) was used to optimize the gluten-free *Khobz Eddar* bread with the specific volume as the only response. The effect of hydration and pregelatinized corn and rice flour on specific volume of the two formula of gluten-free *Khobz Eddar* bread was studied. The optimum points were characterized by specific volume and image analysis as compared to a control bread based on durum wheat semolina. The optimum formulation for corn/field bean bread contained 115 g/100 g of water and 7.05 g of pregelatinzed corn (dry basic) with a specific volume of 2.39 cm^3/g and for rice/field bean bread the optimum was found by addition of 105 g/100 g of water and 6.3 g of pregelatinized rice (dry basic) with a specific volume of 2.24 cm^3/g. Specific volume of corn/field bean bread showed a higher value as compared to rice/field bean bread (*p<0.05*), for both breads, the specific volume was lower (*p<0.05*) than control wheat bread (3.64 cm^3/g). The image analysis by software Image J showed that the number of cells in both formula was greater than that of *Khobz Eddar* control bread.

Key words: Gluten-free *Khobz Eddar*, optimization, pregelatinized flour, rice, corn, specific volume.

INTRODUCTION

Khobz Eddar is a traditional leavened bread consumed in Algeria during major celebrations such as weddings and religious feasts. It is prepared from durum wheat semolina with added salt, oil, yeast, water, and whole egg.

Bread may be prepared by the use of gluten-free ingredients such as rice, corn, buckwheat, potato and sorghum flours (Arendt and Dal Bello, 2008). To present an acceptable gluten-free bread, the proposed loaves must have quality characteristics that are similar to those of wheat bread. Bread with rice or corn flour has a lower loaf volume than wheat flour bread; it is related to the

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absence of gluten, where the glutenin wheat dough is responsible for the dough's resistance to extension and it has the ability to retain gases produced during the yeast fermentation process (Hamada et al., 2013; Hoseney, 1994; Turabi et al., 2008). To solve this problem, different additives can be suggested to improve bread volume.

The pregelatinized flours and starches obtained by heating in the presence of water are widely used for their technological properties such as solubility in hot or cold water, high viscosity and smooth texture and they can be used in the treatment of foods whenever thickening is required (Lai, 2001). The addition of gelatinized rice flour or rice porridge to prepare gluten-free bread has been studied limitedly (Chang et al., 2014). The gelatinized rice can replace the gluten and affect the texture or physical properties of bread and give a higher dough expansion (Shibataa et al., 2011; Miyazaki et al., 2006).

Tang Zhong or pregelatinized flour is indeed a kind of 'flour paste,' a thick flour mixture was made by adding water to corn or rice flour on the basis of 5/1 (w/w) at 65°C (149°F) (Delcourt and Lefief, 2013; Herberth, 2013; Paquette, 2016; Yvonne, 2007). Pongjaruvat et al. (2014) reported that the starch has a potential to improve viscoelastic properties of the dough to efficiently trap and retain carbon dioxide gas bubbles produced during fermentation. The onset of viscosity of starch begins in excess water at about 65°C when amylopectin crystals begin to melt and proteins to hydrate (Fitzgerald and Reinke, 2006). On cooling, the dough becomes more viscous and amylose aggregates and forms a gel (Sindic, 2009).

The aim of this work was to investigate the effect of addition of pregelatinized corn flour or pregelatinized rice flour on the quality of gluten-free traditional Algerian *Khobz Eddar* bread and to optimize water and pregelatinized flour (corn or rice) addition for a better expansion by applying Response Surface Methodology (RSM).

MATERIALS AND METHODS

Raw materials

Sample preparation for gluten-free Khobz Eddar making

For control, durum wheat semolina was obtained from a local market in Benhamadi, Algeria (14.20± 0.00% moisture, 0.83±0.00% ash, 0.67±0.01% lipid, and 13.93±0.00% protein).

For gluten-free *Khobz Eddar*, rice (Basmati) was obtained from Thaïland (10.30±0.14% moisture, 1.66±0.23% ash, 0.06±0.04% lipid, and 9.42±0.10% protein), corn grain from Alicampo (Argentina) (6.66±0.00% moisture, 1.40±0.01% ash, 1.14±0.1% lipid, and 9.77±0.00% protein) and field bean seeds from Alamir company (Egypte) (10.00±0.8% moisture, 2.66±0.00% ash, 1.03±0.00% lipid, and 30.86±0.55% protein). They were milled using a laboratory mill and sifted. All semolina used in gluten-free *Khobz Eddar* had particle sizes between 200 and 500 µm.

Additional ingredients used were salt (ENAsel, Algeria), instant dry yeast (Saf-instant, France), commercial sunflower oil "Elio" from Cevital (Algeria) and fresh eggs. They were purchased from an Algerian local market.

For pregelatinized formulation

Rice flour (Basmati, Thaïland) had 10.66±0.47% moisture, 1.33±0.00% ash, 0.36±0.07% lipid and 6.04±0.38% protein and corn flour (Alicampo, Argentina) had 8.33±0.46% moisture, 1.40±0.01% ash, 3.97±0.23% lipid and 8.74±0.00% protein.

Hydration properties of corn and rice flours

Water absorption index (WAI), water solubility index (WSI) and swelling power (SP) of both flours (corn and rice) were determined.

The SP was determined using the method of Mccormock et al. (1991), as amended by Tang et al. (2002), while WAI and WSI were determined by the method of Li and Yeh (2001). A sample of 0.25 g of flour was weighed into a centrifuge tube with coated screw cap to which 5 ml of a 0.1% $AgNO_3$ solution was added. The suspensions obtained were mixed for 10 s using a Vortex mixer. The tubes were placed in shaking water bath at 70°C for 10 min and then transferred into a boiling water bath for 10 min. After the tubes were cooled in cold water (20°C) for 5 min and centrifuged at 1700 × g for 4 min. The supernatant was poured out from the tube and was dried in air oven at 105°C for 24 h and weighed (W1) (Tang et al., 2002). The sediment adhered to the wall of centrifuge tube was weighed (Ws). WAI, WSI and SP were calculated as follows (Anderson et al.,1969; Li and Yeh, 2001; Mccormick et al., 1991):

$$WSI=[W1/0.25] \times 100\%$$

$$SP=Ws / [0.25 (100\% - WSI)] (g/g)$$

$$WAI=Ws / 0.25$$

Pregelatinized flour process

Two types of pregelatinized flour were prepared with rice flour or corn flour. Pregelatinized rice flour was added to dough made with rice/field bean semolina and pregelatinizedcorn flour was added to dough made with corn/field bean semolina.

The pregelatinized flour was made by adding the water to flour on the basis of 5/1 (w/w). The mixture was then heated with stirring by using spatula until the temperature reaches 65°C (149°F). The pregelatinized flours were then cooled 1 h at room temperature and kept for 24 h at 4°C. They were mixed with other ingredients after maintaining it at room temperature for 1 h. The process flow diagram of pregelatinized flours is as shown in Figure 1.

Gluten-free *Khobz Eddar* formulation

The gluten-free formulations studied in this work were based on a mixture of cereal and leguminous in a ratio of 2:1 (w/w), aiming to offer a better nutritional balance in amino-acids (Benatallah et al., 2012; Micard et al., 2010). Two formulations were prepared based on corn/field bean semolina (CFBS) or rice/field bean semolina (RFBS). The hydration level was determined for each formula by preliminary experiments. Intervals of water and pregelatinized flour amount used were, respectively 51 to 115 ml of water and 0 to 14.10 g (dry basis) of pregelatinized flour corn for 100 g CFBS ingredients and 45 to 105 ml water and 0 to 12.60 g (dry basis) pregelatinized flour rice for 100 g of RFBS. The water contained in the eggs is not taken into account in the total water added. Preliminary tests on the control bread made with wheat semolina showed a specific volume (3.64±0.03 cm3/g) of Khobz Eddar with an optimal hydration rate of 55 g of water per 100 g of durum wheat semolina.

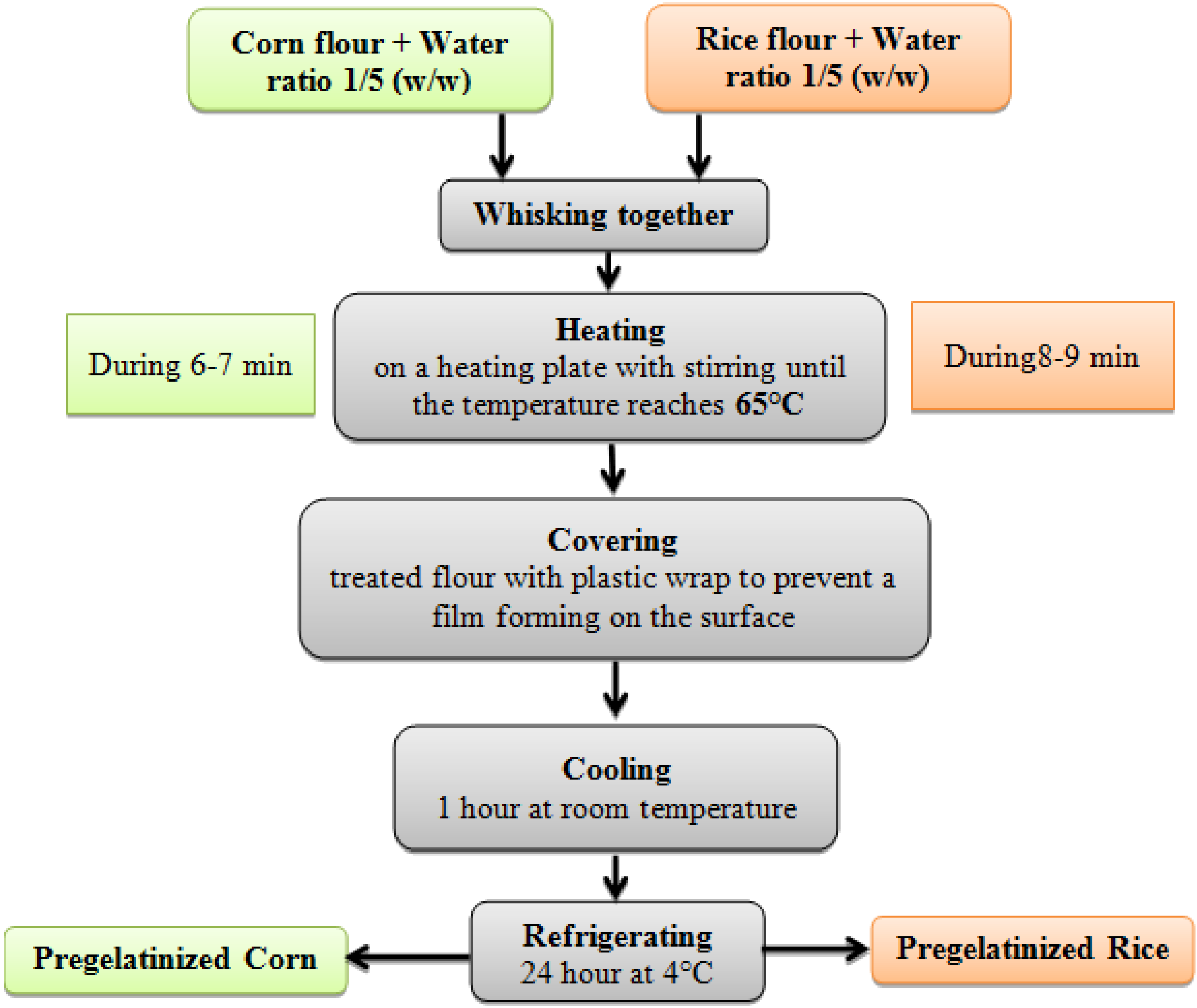

Figure 1. Flow diagram illustrating the formulation steps of the two type of pregelatinized flour.

Table 1. Coded and actual levels of the factors water and pregelatinized corn and rice in the central composite design..

Code value	Real values (g)			
	CFBS formula		RFBS formula	
	Water	Pregelatinized corn	Water	Pregelatinized rice
	X_1	X_2	X'_1	X'_2
-1.41421	51.00	0.00	45.00	0.00
-1	60.37	2.06	53.78	1.84
0	83.00	7.05	75.00	6.30
+1	105.62	12.03	96.21	10.75
+1.41421	115.00	14.10	105.00	12.60

CFBS: Corn/Field bean semolina; RFBS: rice/field bean semolina.

Experimental design

A central composite design of 2 factors was used to study the effects of water (X_1 for CFBS, X'_1 for RFBS) and pregelatinized flour level [X_2 for corn flour (CF), X'_2 for rice flour (RF)] on the specific volume of gluten-free bread (Y for CFBS, Y′ for RFBS). Each of the factors was tested at five levels (Table 1). The matrix of central composite design for CFBS and RFBS is shown in Table 1. The

Table 2. Central composite design arrangement, experimental data and the main resulting dough of corn/field bean semolina formula.

Run	Coded X_1	Coded X_2	Compositon of CFBS formula					
			Uncoded water (g)	Total water	Treated corn	Semolina	Water	
				Uncoded CFg in 100 g crude ingredients	CSg in 100 g crude ingredients	FBS g in 100g crude ingredients	g in mixed treated corn*	g added to 100 g of crude ingredients**
1	+1.41421	0	115.00	7.05	59.62	33.33	35.25	79.75
2	-1.41421	0	51.00	7.05	59.62	33.33	35.25	15.75
3	0	+1.41421	83.00	14.10	52.57	33.33	70.50	12.50
4	-1	+1	60.37	12.03	54.63	33.33	60.17	0.00
5	+1	-1	105.62	2.06	64.60	33.33	10.32	95.30
6	+1	+1	105.62	12.03	54.63	33.33	60.17	45.45
7	-1	-1	60.37	2.06	64.60	33.33	10.32	50.04
8	0	-1.41421	83.00	0.00	66.67	33.33	0.00	83.00
9	0	0	83.00	7.05	59.62	33.33	35.25	47.75
10	0	0	83.00	7.05	59.62	33.33	35.25	47.75
11	0	0	83.00	7.05	59.62	33.33	35.25	47.75
12	0	0	83.00	7.05	59.62	33.33	35.25	47.75
13	0	0	83.00	7.05	59.62	33.33	35.25	47.75

CFBS: Corn/field bean semolina formula, CS: corn semolina, FBS: field bean semolina, CF: corn flour. ***Water weight in mixed pregelatinizedcorn = CF weight × 5. **Water weight added to crude ingredients = Total water weight – (CFweight × 5).

factorial section is a 2^2 test; the star section includes four tests. Five replicates (runs 9, 10, 11, 12, and 13) at the center of the design were used to allow for estimation of the pure error at the sum of square, for a total of $2^2+2^2+5=13$ runs.

Bread making process

The formulations used in the preparation of experimental *Khobz Eddar* bread and the composition of CFBS and RFBS are shown in Tables 2 and 3, respectively.

The basic bread recipe consisted of rice or corn/field bean semolina, 2% of salt, 2% of instant dry yeast, 10 g powder egg, 10 mL of sunflower oil and the amount of water defined according to experimental design (Tables 2 and 3). The making procedure involved manual premixing of dry ingredients, with the exception of whole egg and then water was added. When pregelatinized rice and corn flour were added, the corresponding amount of rice or corn semolina and water were replaced. The mixture was left to rest for 10 min, then the fresh whole egg and the rest of water were added and mixed for 10 min and sunflower oil was added and mixed for additional 5 min. The resulting dough was divided in lumps (70 g) and put into mold and proofed for 45 min at 37°C in a fermentation cabinet. The baking tests were carried out at 230°C for 30 min into an electric oven. The process flow diagram is as shown in Figure 2.

Bread evaluation

The analyzed bread characteristics included specific volume (V*sp*) and image analysis for optimums proceded 1 h post-baking.

Specific volume

Specific volume (V*sp*) of the gluten-free *Khobz Eddar* bread was determined at room temperature, using the formula: Specific volume (cm^3/g) = Volume of bread (cm^3) / Bread weight (g). The volume of the samples was measured by the method of displacement of small particles of 0.67 cm^3/g in specific volume.

Image processing

Three samples *of Khobz Eddar* bread (control, CFBS optimum, and RFBB optimum) were sliced transversely (1 cm) and scanned using a flatbed scanner (Epson Stylus SX105). The scanned images were analyzed using the software Image J 1.48. The acquired color images were firstly saved in TIFF format. Using bars of known lengths, pixel values are converted into distance units. The center of each image was cropped to a square of 20×20 mm^2 and converted to gray scale (8 bits). A threshold method was used for differentiating gas cells and non-cells (conversion to a binaryimage). The black parts of the binary image

Table 3. Central composite design arrangement, experimental data and the main resulting dough of rice/field bean semolina formula.

Run	Coded X′1	Coded X′2	Compositon of RFBS formula					
			Uncoded Water (g)	Total water	Treated corn	Semolina	Water	
				Uncoded RFg in 100 g crude ingredients	RS g in 100 g crude ingredients	FBS g in 100 g crude ingredients	g in Mixed Treated rice*	g added to 100 g of crude ingredients**
1	+1.41421	0	105.00	6.30	60.37	33.33	31.50	73.50
2	-1.41421	0	45.00	6.30	60.37	33.33	31.50	13.50
3	0	+1.41421	75.00	12.60	54.07	33.33	63.00	12.00
4	-1	+1	53.78	10.75	55.91	33.33	53.77	0.00
5	+1	-1	96.21	1.84	64.82	33.33	9.22	86.98
6	+1	+1	96.21	10.75	55.91	33.33	53.77	42.43
7	-1	-1	53.78	1.84	64.82	33.33	9.22	44.56
8	0	-1.41421	75.00	0.00	66.67	33.33	0.00	75.00
9	0	0	75.00	6.30	60.37	33.33	31.50	43.50
10	0	0	75.00	6.30	60.37	33.33	31.50	43.50
11	0	0	75.00	6.30	60.37	33.33	31.50	43.50
12	0	0	75.00	6.30	60.37	33.33	31.50	43.50
13	0	0	75.00	6.30	60.37	33.33	31.50	43.50

RFBS: Rice/Field bean semolina formula, RS: rice semolina, FBS: field bean semolina, RF: rice flour. ***Water weight in mixed pregelatinized rice **=** RF weight × 5. ****Water weight added to crude ingredients = total water weight – (RF weight × 5).

were regarded as air bubbles (Rubel et al., 2015).

As a result, the surface plots and four air-bubble parameters of the bread samples were calculated: number of cells, average size, area fraction and circularity. A perfect circle has a shape factor of 1 (Rounds pores) and a line has a shape factor approaching 0.

Statistical analysis

The computational work, including the surface-contour graphical presentations of the response surface models, was performed using the statistical software JMP (Version 11.2, SAS Institute Inc., Cary, NC, USA). Multiple regression analysis was performed to fit second order model to the dependent variable by using Minitab Release 17 (Minitab Inc., State College PA, USA). The model was used to optimum conditions. These conditions were determined by using response optimizer in Minitab release 17 software. One way analysis of variance (ANOVA) was applied to compare the effects of water (X_1, $X`_1$) and pregelatinized flours ($X_2$,$X`_2$) on the dependent variable (Specific volume Y_1, Y_2). The significance level was set at 0.05. The model proposed for each response was:

$$Y = b_0 + b_1 X_1 + b_2 X_2 + b_{11} X_1^2 + b_{22} X_2^2 + b_{12} X_1 X_2$$

where b_0 is the value of the fitted response at the center point of the design, that is, point (0,0); b_1 and b_2 are the linear regression terms; b_{11} and b_{22} are the quadratic regression terms; and b_{12} is the cross-product regression term (Montgomery, 1991).

RESULTS AND DISCUSSION

Hydration properties of corn and rice flours

Table 4 shows WAI, WSI, and SP results of the corn and rice flours. WAI can be used to give an indication of cold paste viscosity, which correlates with the cooking degree and WSI can be used as an indication of the degree of molecular damage (Bryant et al., 2000; Yağci and Göğüş, 2008). Flour with high WSI and low WAI would be ideal for use in a sport drink because of the high solubility. Further, flour with high WAI and low WSI could be used in a product such as a low fat soup where the main concern is a high viscosity (Bryant et al., 2001).

Corn flour presented the highest values of SP (0.14±0.00 g/g) and WAI (12.48±0.28 g/g). Cornejo and Rosell (2015) have found that there is a positive correlation parameter between SP and WAI. According to Han et al. (2010), the SP and WAI increase when the size of the particles

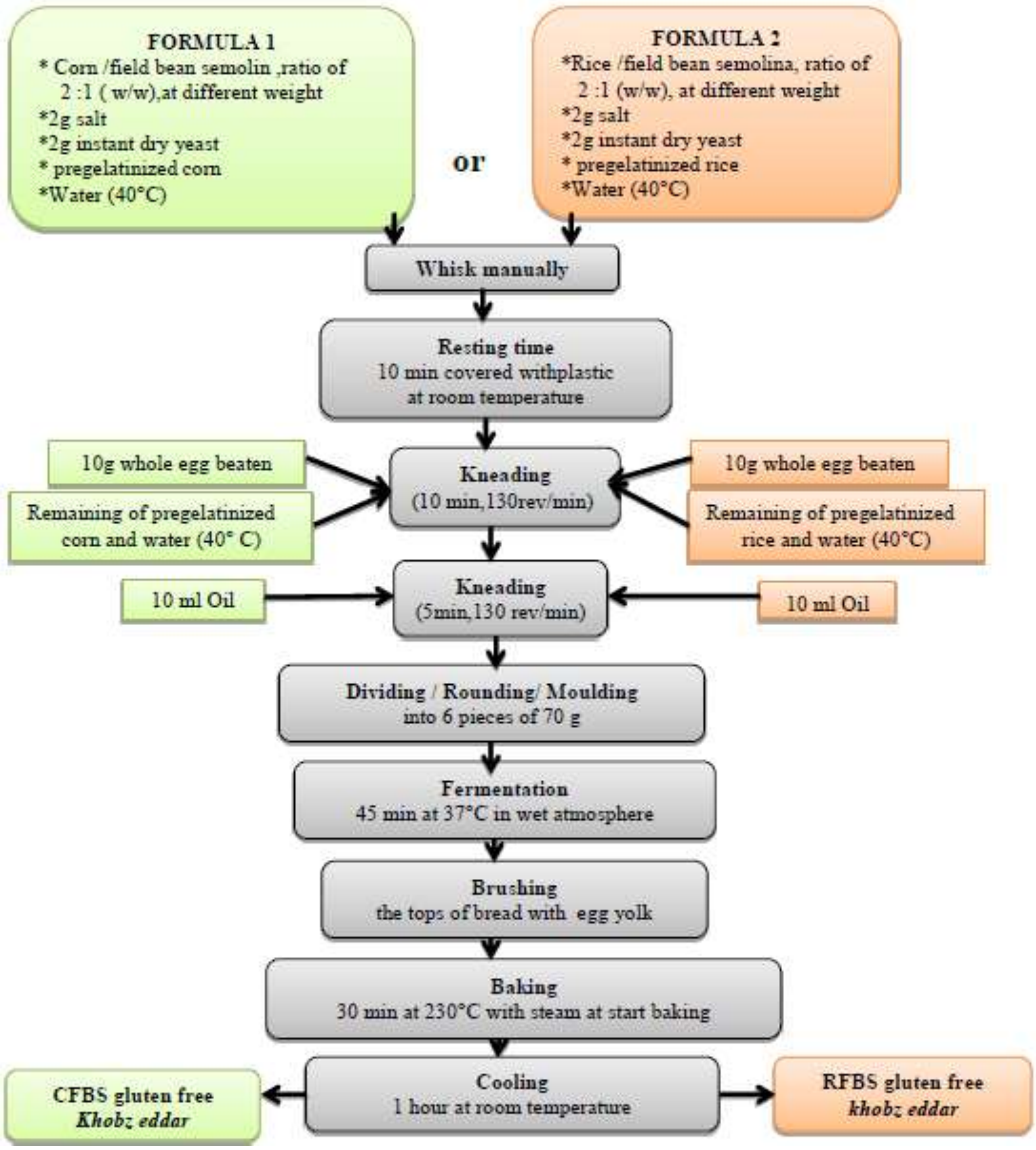

Figure 2. Flow diagram illustrating the formulation steps of two gluten-free breads.

Table 4. Hydration properties of corn and rice flour.

Parameter	WAI (g/g)	WSI (g/100 g)	SP (g/g)
Rice flour	8.60±0.62 [a]	26±2.82[a]	0.11±0.00 [a]
Corn flour	12.48±0.28 [b]	12±0.00 [b]	0.14±0.00 [a]

WAI: Water absorption index; WSI water solubility index; SP swelling power. [a,b]Indicated a significant difference ($p<0.05$).

increases.

WSI of rice flour (26±2.82 g/100 g) is higher than that of the corn flour, while the WAI indicates that the corn flour absorbs more water (12.48±0.28 g/g). So, the corn flour is more viscous than the rice flour because it has a high WAI and low WSI. These results are supported by Bryant

Table 5. Responses of gluten free corn/field bean semolina bread and rice/field bean semolina bread.

Run	Responses			
	Code values		V_{sp} CFBS	V_{sp} RFBS
	X_1, or X'_1	X_2 or X'_2	Y	Y′
1	+1.41421	0	2.39±0.02	2.24±0.01
2	-1.41421	0	1.87±0.07	1.74±0.03
3	0	+1.41421	2.12±0.02	1.85±0.02
4	-1	1	1.64±0.03	1.55±0.04
5	+1	-1	2.07±0.04	2.15±0.01
6	+1	1	2.12±0.06	1.78±0.02
7	-1	-1	1.67±0.01	1.61±0.07
8	0	-1.41421	1.79±0.03	1.60±0.05
9	0	0	2.16±0.03	1.96±0.02
10	0	0	2.13±0.01	1.99±0.02
11	0	0	2.05±0.02	2.02±0.03
12	0	0	2.12±0.02	2.04±0.02
13	0	0	2.10±0.01	1.93±0.01

CFBS: Corn/Field bean semolina bread; RFBS: rice/field bean semolina bread; Vsp: specific volume.

et al. (2000) and Yağci and Göğüş (2008).

Effects of pregelatinized flours on specific volume of breads (CFBS and RFBS) and optimization

The effect of a range of water and pregelatinized flours on specific volume of CFBS *Khobz Eddar* bread and RFBS *Khobz Eddar* bread is shown in Table 5.

CFBS bread had specific volume ranged from 1.64±0.03 to 2.39±0.02 cm^3/g. The highest specific volume (2.39±0.02 cm^3/g) was obtained at a level of 115 g of water and 7.05 g of pregelatinized corn. This specific volume was lower than that of durum wheat semolina (control) *Khobz Eddar* (3.64 cm^3/g) and higher than CFBS *Khobz Eddar* with no pregelatinized corn improver (1.79±0.03 cm^3/g) (Figure 3A, B, and C).

The plots in Figure 4 showed that the specific volume of samples has increased with an increase in the amount of water, as its linear effect was positive ($p<0.05$). However, the effect of the amount of pregelatinized corn showed a negative quadratic effect on the V*sp* of *Khobz Eddar*.

The specific volume of RFBS *Khobz Eddar* increases from 1.55±0.04 to 2.24±0.01 cm^3/g which is considerably lower than the value 3.64±0.03 cm^3/g reported in wheat durum semolina *Khobz Eddar.* A higher specific volume (2.24 ± 0.01 cm^3/g) was obtained at the level of 105 g of water and 6.3 g of pregelatinized rice. This specific volume was higher than RFBS *Khobz Eddar* with no pregelatinized rice improver (1.60±0.05 cm^3/g) (Figure 3A, D, and E). It can be observed (Figure 5) that the V*sp* depended on the amount of water added. The effect of water showed positive linear ($p<0.05$) effect and the effect of amount of pregelatinized rice showed a negative quadratic effect ($p<0.05$).

All gluten free *Khobz Eddar* containing pregelatinized corn had higher specific volume than that containing pregelatinized rice because the corn flour is more viscous than the rice flour.

Similar effects on specific volume of CFBS and RFBS *Khobz Eddar* have been reported with additions of pregelatinized flour. The specific volume for each gluten free bread formula gave a quadratic curve with a downward opening parabola, mainly due to the pregelatinize flour incorporation and not to the hydration which appears to increase linearly the V*sp*. Maxima of both surfaces, indicative of optimal gluten free bread, is near the axial point (+1.41421, 0) correspond to X_1=115 g and X_2=7.05 g of CFBS formula and to X'_1=105 g and X'_2=6.3 g. No great further improvement of a specific volume of CFBS or RFBS *Khobz Eddar* was observed at the highest pregelatinized flour addition.

The specific volume of the samples had increased as water addition increased; this may be related to the starchy nature of gluten-free bread (Schoenlechner et al., 2010). The viscosity of the starch-water mixture also changes during gelatinisation due to swelling of the granules. If the amount of water is insufficient to provide complete swelling and disruption of the starch granules, only part of the crystallinity of the starch granules is lost (Baks et al., 2007). The reason why the gluten free *Khobz Eddar* containing pregelatinized corn or rice had Vsp higher than that with no pregelatinized flour is that the high viscosity induced by pregelatinized rice and corn favor the entrapment of air bubbles in the dough structure, and it is even enough to hold the gas pressure during expansion at the early stage of baking (Shibata et

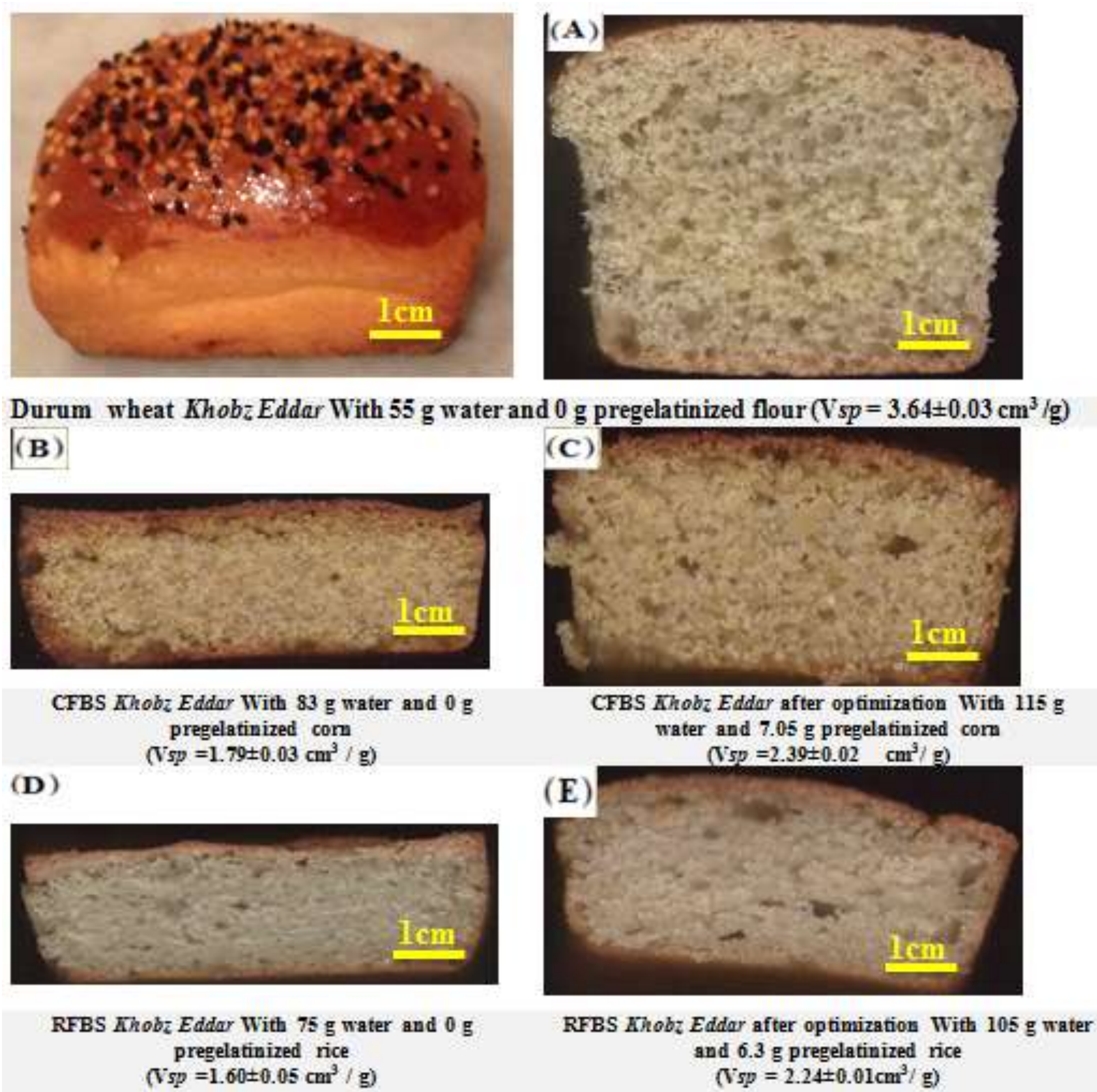

Figure 3. Crumb structure of gluten-free *Khobz Eddar* breads (with corn and with rice) as compared to wheat bread.

al., 2011).

During the bread baking, the starch granules absorb water, swell, and set to form the rigid bulk of the walls that surround the bubbles of carbon dioxide. At the same time, their swollen rigidity stops the expansion of the bubbles (Mcgee, 2007). So in the pregelatinized flour, the starches are already swollen before they were mixed with other ingredients. This means that they do not need to compete with the starch of semolina (corn or rice) to absorb water in the oven.

For samples containing pregelatinized corn or pregelatinized rice, the contour plots of response surfaces are shown in Figures 4 and 5, respectively. By analyzing the contour plots and evaluation of the

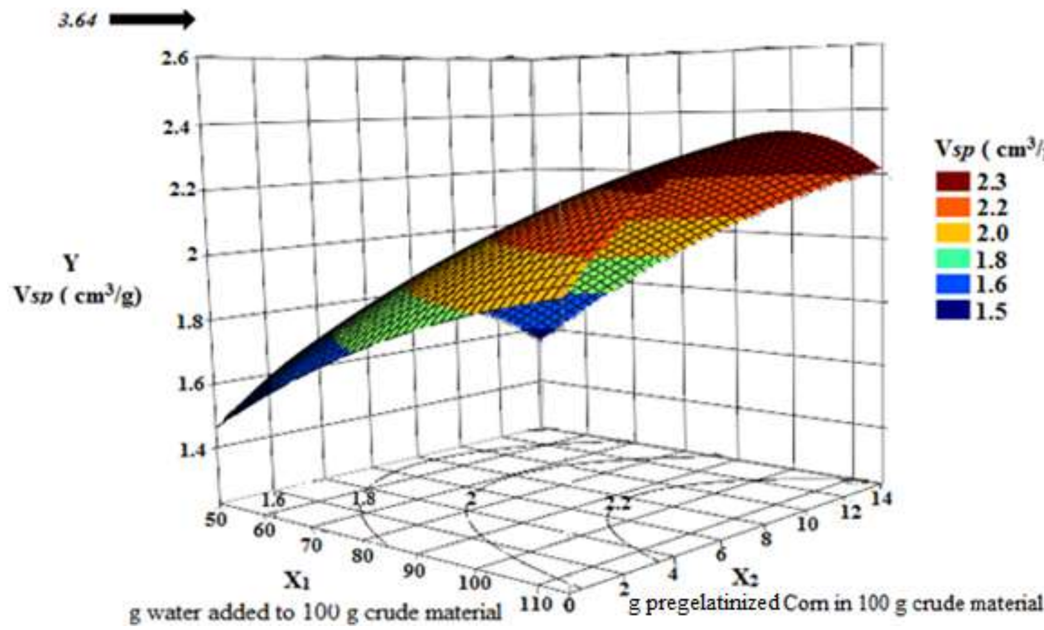

Figure 4. Effect of hydration and pregelatinized corn on V*sp* of CFBS gluten free *Khobz Eddar*. 3.64 cm^3/g: Specific volume (V*sp)* obtained from durum wheat semolina bread.

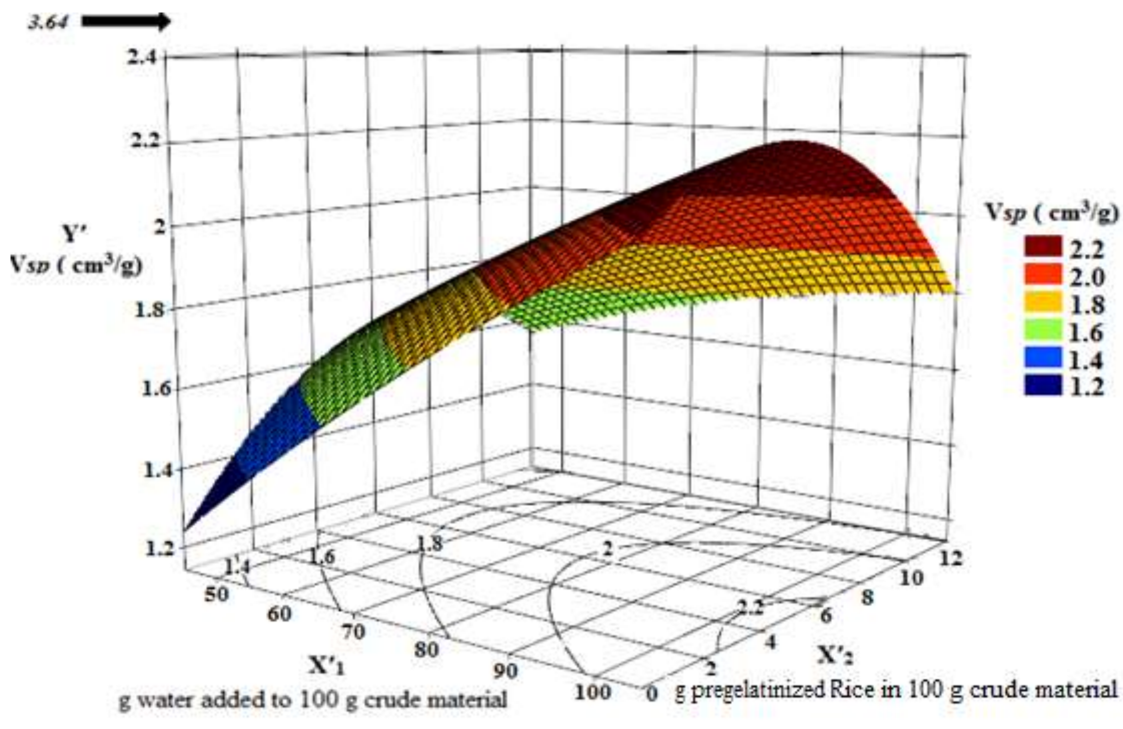

Figure 5. Effect of hydration and pregelatinized rice on specific volume (V*sp)* of RFBS gluten free *Khobz Eddar.*

relationships between response and variable, an optimum formulation of gluten-free traditional *Khobz Eddar* is presented as a bread having an acceptable specific volume. In the current study, it is suggested that the optimum formulation of CFBS bread was $X_{1=}$115 g of water and X_2=7.05 g of pregelatinized flours corn and the optimum formulation of RFBB was $X`_{1=}$105 g of water and $X`_2$=6.3 g of pregelatinized flours rice.

Table 6. Results of breads crumb images analysis (Control, CFBS, and RFBS).

Parameter	Number of cells	Average size	Area fraction (%)	Circularity
Control	112	0.92±2.71	25.95	0.72±0.25
CFBS optimal	278	0.13±0.31	11.30	0.83±0.21
RFBS optimal	241	0.18±0.45	9.63	0.81±0.24

CFBS: Corn/Field Bean Semolina Bread; RFBS: Rice/Field Bean Semolina Bread.

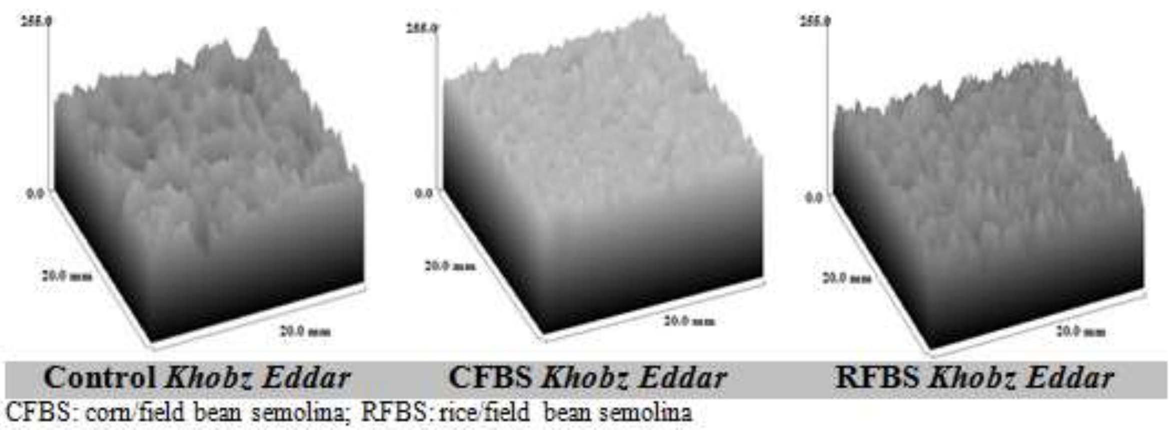

Figure 6. The surface plots of *Khobz Eddar* breads crumb (20 × 20 mm^2). CFBS: Corn/Field bean semolina bread; RFBS: rice/field bean semolina bread.

Image analysis

Specific volume as an important quality parameter was found to have good correlations with longitudinal average size and cross circularity (Pourfarzadv et al., 2012). The number and size of the cells have a remarkable effect on the rheological properties of the dough. The characteristics of air bubbles of *Khobz Eddar* crumbs (control, CFBS optimal and RFBS optimal) obtained from the analysis of scanned images are shown in Table 6 and the surface plots are as shown in Figure 6.

The total number of cells of control *Khobz Eddar* (112) was lower than that of gluten free *Khobz Eddar* CFBS optimal (278) and RFBS optimal (241), whereas the average size and the area fraction of cells were lower than the control bread (Figure 6). So the pregelatinized flours (corn or rice) have a similar effect on the gluten free bread *Khobz Eddar* (CFBS and RFBS).

The addition of pregelatinized flours (corn or rice) facilitated the formation of air bubbles during mixture, but inhibited the growth of these bubbles during fermentation. This might be due to the addition of pregelatinized flour which increased the viscosity of the dough and slow gas diffusion hence the growth of the smaller bubbes were difficult.

The roundness value of CFBS optimal and RFBS of optimal (0.83±0.21 and 0.81±0.24) *KhobzEddar* bread was considerably more than control *Khobz Eddar* (0.72±0.25).

Conclusion

This study confirmed that the pregelatinized flours can be used as natural improver to optimize the specific volume of gluten free *Khobz Eddar* bread, but this specific volume stay lower than *Khobz Eddar* durumone. The air bubbles of both formulas were more in number (278 for corn and 241 for rice) with smaller sizes and more roundness than the control *Khobz Eddar* bread with a number of cells of 112.

The recipe optimized may be given a higher specific volume by replacing the water mixed with pregelatinized flour by milk at the same weight or used the pregelatinized flour in powder form.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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