Physicochemical and Technological Studies on Improving the Nutritional Value of Egyptian Balady Bread Using Barley, Sorghum and Quinoa Flours

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ABSTRACT:

This investigation was carried out to study the Physicochemical constituents of Egyption wheat, barley, sorghum and quinoa flours. Also, studying the effect of adding these flours at different levels (10, 20, 30, and 40%) to wheat flour 87.5% extraction on chemical, technological and rheological properties of making Egyption balady bread. Results indicated that barley and quinoa flours (W) contain 0.44 and 0.45 of lysine, but wheat and sorghum flours contain 0.28 and 0.31%, respectively. Huless barley and sorghum flours contain a relatively high amount of β-glucan, 4.20 and 3.00 mg\g, respectively. But wheat and quinoa flours contain a low amount 0.20 and 0.10 mg\g. Results reported that wheat flour is the only cereal crop containing 27.00% wet gluten and the other flours under investigation were gluten-free (0.00 %). The results of rheological properties cleared that huless barley flour was a higher value of water absorption, dough development, dough stability and dough weakening. The results concluded that the addition of barley, sorghum and quinoa flours to wheat flour affected the rheological properties of making Egyptian balady bread.

Keywords: wheat flour; Hulless barley flour; Stability; Wet gluten; Water absorption; B-glucan.

INTRODUCTION

Cereals are considered one of the most important economic and food commodities in the world. It is well known that bread constitutes the main diet for the Egyptian people and for the most developed countries. Wheat flour is the ingredient that, more than any other, influences the processing response of most dough and determines the finished quality of most bakery products. Hulless barley *(Hordeum vulgare* L.) could be used as flour when mixed with wheat flour 87.5 % extraction. In Egypt, the total area cultivated with barley grains is 87752 hectare which produced annually 117113 tones (FAO, 2010).

Baum *et al*., (1990) mentioned that oat and barley high extraction flour has become popular in recent years as a food ingredient, because its effectiveness in lowering elevated cholesterol levels. Oat and barley effectiveness has been attributed to its soluble fiber content. Marta *et al*., (2001) study the effects of addition of whole barley on rheological properties of dough prepared from wheat flours with variable gluten quality. Upon addition of β-glucan or arabinoxylans, significant increases in peak dough resistance, mixing stability, and work input were recorded in all flours.

Abd El Motaleb (2001) reported that the chemical composition of flour was 12.63 % moisture, 0.67 % ash, 11.82 % protein and 85.63 % total carbohydrates. Ismail *et al*., (2001) found that the water absorption, mixing time, stability time, tolerance index and weakening of the dough of wheat flour were 62%, 1.5 min, 9.0 min, 30 B.U and 60 B.U, respectively. *Abd El-Khalek (2002)* found that the resistance to extension B.U, extensibility (mm) and energy were 365, 167 and 73 of extensograph. Barley (*Hordeum vulgare* L.) is the world's most nutritional crop. This is because it contains many elements that rich sources of health and energy. Barley flour contained 11.65%, 2.31%, 6.75% and 2.22% for crude protein, fat, fibers, and ash, respectively (Phyllis, 2003).

Gill *et al*., (2002) reported that Phoenix barley flour at 15% substitution produced breads with higher loaf volume and softer crumb than Candle barley flour. Shfali and Sudesh (2002) supplemented of soybean (full fat and defatted) and barley flours to wheat flour at 5, 10, 15 and 20% levels. All blends at 20% levels were found

nutritionally superior, but breads prepared from them were organoleptically unacceptable. However, addition of 15% barley flour not only increased the total protein, total lysine, dietary fiber and beta -glucan contents of bread making, but also produces a product of acceptable quality. Basman *et al*., (2003) reported that with increasing levels of barley/soya bean flour, farinograph water absorption in the soft and hard wheat cultivars also increased. They also found that, dough resistance increased and extensibility decreased. Kaneko *et al*., (2003) indicated that, the barley intake significantly lowered plasma total and low-density lipoprotein cholesterol concentrations and reduced plasma triacylglycerol concentration. Behall *et al*., (2004) found that barley has high amounts of soluble fiber and the consumption of barley would reduce cardiovascular disease risk factors comparably with that of other sources of soluble fiber. Christine (2004) showed that barley flour offers unique flavor and texture. Protein in barley was about 12 to 15%. He also reported that, lysine is an amino acid needed to produce complete proteins in the body. Barley contains the unique water-soluble fiber form, beta-glucan, which is reported to have serum cholesterol lowering properties.

Abo-Shama (2006) found that the water absorption %, dough stability (min), mixing time (min) and dough weakening B.U were 55.3%, 5.0 min, 2.0 min and 90 B.U while the extensograph test recorded 135 (mm) , extensibility , 350 B.U of resistance to extension 2.6 R/E and 46 cm^2 of energy. Barley contains (4-5%) B- Glucan as a source of soluble dietary fiber. B-glucan extracted from barley flour contained 75.5%soluble dietary fiber and 10.25% insoluble dietary fiber (Din and Kaur, 2009). In this respect, the needed intake level of dietary fiber was estimated by many organizations around the world to be 30-50gm\day (Lyly, 2006). Koppel and Ingver (2010) study the baking quality of wheat varieties for Protein content, farinograph absorption, and dough stability time and loaf volume. They found that wheat variety affect with protein content, and correlation existed between protein content and farinograph absorption, correlated also was found with dough stability and Loaf volume.

Mahesh *et al*., (2011) found that addition of 20% of barley flour to wheat flour produced acceptable rusks shown by sensory scores. Alu'datt *et al*., (2014) indicated that bread made from fortification of wheat flour with barley flour at 15% showed superior chemical, physico-chemical, nutritional and biological properties. Hamed *et al*., (2014) found that the addition of barley flour at 10% in frozen dough reduced deterioration effects caused by frozen storage via minimizing water redistribution and maintaining rheological properties of frozen dough. El-Fadaly (2015) illustrated that the addition of barley or oat flour to wheat flour led to increase the content of protein, fiber, ash and fat in produced bread. He also should that there are an improvement of rheological and sensory properties of bread. The nutritional value of balady bread can be improved by addition of other cereal flours such as barley, sorghum, and Quinoa (Aattabi *et al*., 2017, Aly 2018, Mansoor *et al*., 2022).

Therefore, this investigation was carried out to study the chemical composition of wheat (87.5 % extraction), hulless barely, sorghum and quinoa flours. Also studying the fortification of wheat flour by using different levels of hulless barely, sorghum and quinoa flours on rheological and physicochemical characteristics of making Egyptian balady bread

Wheat (W) flour 87.5 % extraction rate was mixed with huless barley (B), sorghum (S) andquinoa (Q) flour at levels of 10, 20, 30 and 40 %.(Table 1).

MATERIALS AND METHODS

Commercial wheat (W) flour 87.5% extraction rate provided by Egyptian mille (6th of October City, Giza, Egypt). Huless barley (B), sorghum (S) and quinoa (Q) flours were obtained from Food Sci., Res. and Technology Institute, Agricultural Research Center (ARC), Giza, Egypt. Instant active dry yeast and salt were obtained from local market.

Blends Preparation:

Chemical analysis of raw materials:

Moisture content, ash content, protein, lysine, fat fiber and total carbohydrates were determined according to A.A.C.C. (2002). Color grade measurement was determined on the flour paste using Kent Jones and Martin flour color

grader (Henry Simon Limited, stock port, Cheshire, England). Wet Gluten and Gluten index were determined according to A.A.C.C. (2002) methods No. 54-21.01. B-glucan was determined according to the method described by Carr *et al.,* (1990).

Rheological properties of flour:

The rheological properties of flour blends were determined using the Brabender farinograph according to the methods described method No. 54-21, extensograph according to the method No. 54-10.01 and amylograph according to the described method No. 22-10.01 A.A.C.C. (2002).

Balady bread preparation:

Balady bread was prepared according to (Hussein, 1999).

Sensory evaluation of balady bread:

The produced bread was organoleptically evaluated for their sensory characteristics using 10 experienced panelists from Egyptian Baking Technology Center Giza, Egypt.

RESULTS AND DISCUSSIONS

Chemical composition and physical properties of raw materials:

The chemical composition of wheat flour (W) 87.5% extraction rates, hulless barley (B), sorghum(S) and quinoa (Q) flours are given in table (3) and Fig. (1). Results indicated that moisture content was similar in all sample flours, values were 12.60, 11.80, 12.50 and 12.70 % for wheat flour (W) 87.5% extraction rates , huless barley (B), sorghum(S) and quinoa (Q) flours , respectively.

Analytical data indicated that quinoa flour was the highest value of protein percent (19.70%) followed by sorghum flour (14.50 %). Wheat and barley flours were similar in protein content (10.60 and 10.80%), respectively. Results stated that quinoa flour was the highest value of fats (4.60 %) followed by wheat (2.70), sorghum (1.90%) and barley (1.52%). Values of ash content were 1.57, 2.16, 1.48 and 1.11% for wheat flour (W) 87.5% extraction rates, hulless barley (B), sorghum(S) and quinoa (Q) flours, respectively.

The highest value of total carbohydrates was recorded for wheat flour 87.5% extraction rate followed by huless barley (68.26%), sorghum (67.22%) and quinoa flour (58.20%).

Concerning to lysine content, it clear that barley flour were higher than wheat flour, values were 0.28, 0.44, 0.31 and 0.45 % for wheat flour 87.5% extraction rates, hulless barley (B), Sorghum (S) and Quinoa (Q) , respectively.

Data in table (3) and fig. (1) Showed that barley flour contains the highest amount of β-glucan (4.20 mg/g) follpwed by sorghum flour (3.00 mg/g). But, wheat flour 87.5% extraction and quinoa flour contain the lowest amount of β-glucan (0.20 and 0.10 mg/g), respectively.

Results confirmed that wheat flour was the only flour contains a high value of wet gluten (27.00%), while the three other flours were gluten-free. these results are in line with those obtained by Din and Kaur (2009), Hamed *et al.*, (2014), Aattabi *et al*., (2017), Aly, (2018) and Mansoor *et al*., (2022).

Rheological Properties of dough prepared from wheat flour 87.5% extraction rates mixed with huless barley, sorghum and quinoa flour at different levels.

Farinograph parameters:

Data in table (4) and fig. (2; a, b, c and d) showed the water absorption percentage (a), dough development (b), dough stability min (c) and weakening (d) of 87.5% extraction rates , huless barley, sorghum and quinoa flour at different levels 10, 20, 30 and 40%. Results were 71 %, 4, 5 and 80 of control sample (100% wheat flour 87.5% extraction rates). For water absorption percentage, dough development, dough stability (min) and weakening. Results indicated that Farinograph parameters; water absorption percentage, dough development, dough stability (min) and weakening were increased with increasing the addition of huless barley up to 40%.

Results indicated that the addition of quinoa flour at different levels 10, 20 , 30 and 40 % were increased Farinograph parameters with increasing the addition of quinoa flour up to 40%.

On the hand, it could be noticed that the replacement of wheat flour 87.5 % extraction rate by different levels of 10, 20, 30 and 40% sorghum flour was decreased water absorption

percentage from 71 to 68 %, dough development from 4 to 2.5 min and dough stability from 5.5 to 3.5 min. Results also indicated that, weakening dough was increased from 80 to 110 with increasing the levels of sorghum flour up to 40%.

Also, from the results presented in table (4) and fig. (2), it could be noticed that the replacement of wheat flour by 10 % of huless barley, 10% sorghum and 10 quinoa flours was increased slightly water absorption percentage from 71.5 to 72%, dough development from 4.5 to 3.5 min and dough stability from 5 to 4 min . Weakening dough was still stable at 80 for the 10 % addition of huless barley, sorghum and quinoa flours these results are in line with those obtained by Alu'Datt *et al.,* (2014), El-Fadaly (2015), Aattabi *et al*., (2017), Aly, (2018) and Mansoor *et al*., (2022).

Sensory evaluation of Egyptian balady bread prepared from wheat 87.5% extraction rate and its blends with huless barley, sorghum and quinoa flours:

Data in tables (5) and fig. (3) Showed the external and internal properties of Egyptian balady bread prepared from wheat 87.5% extraction rate and its blends with different levels (10, 20, 30 and 40%) of huless barley, sorghum and quinoa flours.

Results of external properties of Egyptian balady bread such as loaf rising crust quality and Crust colors were slightly decreased with increasing the levels of huless barley, sorghum and quinoa flours from 10 to 40 %. The internal properties of Egyptian balady bread such as crumb uniformity, crumb color, odor, and taste were mentioned in table 5 and fig. 3. The results of these parameters were slightly also decreased with increasing the levels of huless barley, sorghum and quinoa flours from 10 to 40 %. Total score was gradually decreased from 94-84% for Egyptian balady bread prepared from 87.5% extraction rate and 10, 20, 30, and 40% huless barley.

Data in the same table (5) and fig.3 showed the same trend for the replacement of 10-40% of sorghum and quinoa flowers. These results are in harmony with those obtained by Aattabi *et al*., (2017), Aly, (2018) and Mansoor *et al*., (2022).

CONCLUSION

It could be concluded that the addition of huless barley, sorghum and quinoa flours to wheat flour 87.5% extraction rate with percentage up to 40% led to increasing the chemical constituents of blends and improving the nutritional values of making Egyptian balady bread. The important use of hulless barley, sorghum and quinoa flours flour in Egypt for bread making or health food and mixing with wheat flour by using different levels will be reduced the import of wheat flour or grains.

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Table 1: The different blends of wheat (W) with huless barely, Sorghum and quinoa flours**:**

Flours Blends	Wheat	Barley	Sorghum	Quinoa	Yeast	Salt
Control (W 100 %)	100				0.5	1.0
W 90 / B 10	90	10			0.5	1.0
W 80 / B 20	80	20			0.5	1.0
W 70 / B 30	70	30			0.5	1.0
W 60 / B 40	60	40			0.5	1.0
W 90 / Q 10	90			10	0.5	1.0
W 80 / Q 20	80			20	0.5	1.0
W 70 /Q 30	70			30	0.5	1.0
W 60 / Q 40	60			40	0.5	1.0
W 90 / S 10	90		10		0.5	1.0
W 80 /S 20	80		20		0.5	1.0
W 70 /S 30	70		30		0.5	1.0
W 60 / S 40	60		40		0.5	1.0
W 80 / B 10 / Q 10	80	10		10	0.5	1.0
W 80 / B 10 /S 10	80		10		0.5	1.0
W 80 / Q 10 / S 10	80		10		0.5	1.0
W 70 / B 10 / Q 10 / S 10	70	10	10	10	0.5	1.0

Table 2: Balady bread preparation

Balady bread formulation	%
Flour	100.00
Yeast	0.50
Salt	1.00
Water	60.00

Table 3: Chemical composition of wheat flour 87.5 % extraction rate, huless barley, sorghum and quinoa flours *

Constituents	Wheat – 87.5%	Barley(B)	Sorghum(S)	Quinoa(Q)
Moisture	12.60	11.80	12.50	12.70
Protein	10.60	10.80	14.50	19.70
Fat	2.70	1.52	1.90	4.60
Fiber	2.20	4.46	2.40	3.60
Ash	1.57	2.16	1.48	1.11
T. Carbohydates	70.15	69.26	67.22	58.29
Lysine	0.28	0.44	0.31	0.45
β-glucan (mg/g)	0.20	4.20	3.00	0.10
Wet gluten	27.6	0.00	0.00	0.00

* Average of duplicate determination.

Table 4: Farinograph parameters of wheat, and its blends with different levels of huless barley, sorghum and quinoa flours.

Parameters Blends	Water absorption (%)	Dough development time (min)	Stability (min)	Weakening (nm)
CONTROL (W / 100%)	71	4	5	80
W 90 / B 10	71.5	4	5.5	80
W 80 / B 20	72	4.5	6	80
W 70 / B 30	72.5	5	6.5	90
W 60 / B 40	73	5.5	7.5	100
W 90 / Q 10	72	4.5	5	80
W 80 / Q 20	73	5	4	90
W 70 /Q 30	74	5.5	3.5	110
W 60 / Q 40	75	6	2.5	120
W 90 / S 10	71	4	5.5	80
W 80 /S 20	70	3.5	5	90
W 70 /S 30	69	3	4	100
W 60 / S 40	68	2.5	3.5	110
W 80 / B 10 / Q 10	71.5	4.5	5	80
W 80 / B 10 /S 10	71.5	4.5	5	80
W 80 / Q 10 / S 10	71.5	4	4.5	80
W 70 / B 10 / Q 10 / S 10	72	3.5	4	80

Table 5: Sensory evaluation of Egyptian balady bread prepared from wheat 87.5% extraction rate and its blends with huless barley, sorghum and quinoa flours.

Blends	External properties			Internal properties				Overall acceptability
	Loaf rising	Crust Quality	Crust color	Crumb uniformity	Crumb color	Odor	Taste	
Score	10	10	10	10	25	10	25	100
Control (W / 100%)	9.5	9.5	8.5	9	23.5	9.5	24.5	94
W 90 / B 10	9.5	9	8.5	9	23.5	9.5	24.5	93.5
W 80 / B 20	9	8.5	8.5	9	23.5	9.5	24.5	92.5
W 70 / B 30	8	8	8	8	23	9	23.5	87.5
W 60 / B 40	7.5	7	7.5	8	22	8.5	23.5	84
W 90 / Q 10	8.5	8	8	8.5	23	9.5	24	89.5
W 80 / Q 20	7.5	7.5	7.5	8.5	22	9	23	85
W 70 /Q 30	6.5	7	7	8	21	8	21.5	79
W 60 / Q 40	5	5	4	4	18	5.5	19.5	61
W 90 / S 10	8	7.5	8	8	22.5	8.5	23	85.5
W 80 /S 20	7	6.5	7	7.5	21	7.5	22	78.5
W 70 /S 30	6	5.5	6.5	6	20	6	20	70
W 60 / S 40	4.5	4	4	4	18	5	18.5	58
W 80 / B 10 / Q 10	9	9	8.5	8.5	23	9.5	24	91.5
W 80 / B 10 /S 10	8.5	9	8	8	22.5	9.5	23.5	89
W 80 / Q 10 / S 10	8	8	7	7.5	21.5	8.5	22.5	83
W 70 / B 10 / Q 10 / S 10	8.5	8.5	7.5	7.5	21	8	21	82

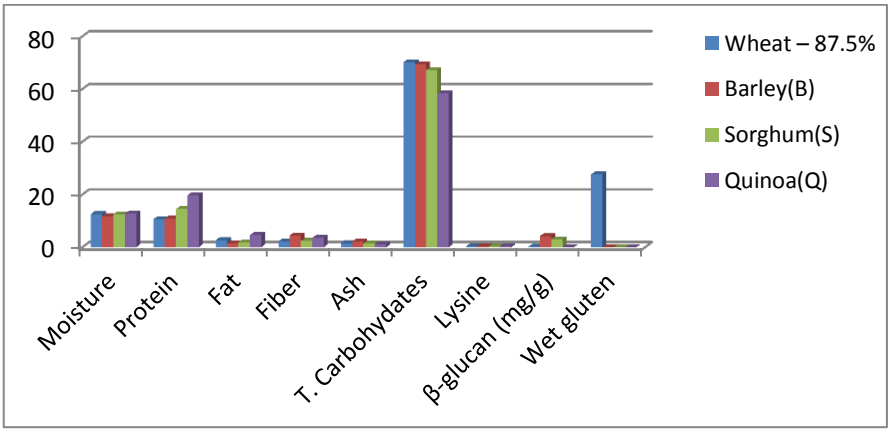

Figure 1: Chemical composition of wheat flour 87.5 % extraction rate, huless barley, sorghum and quinoa flours:

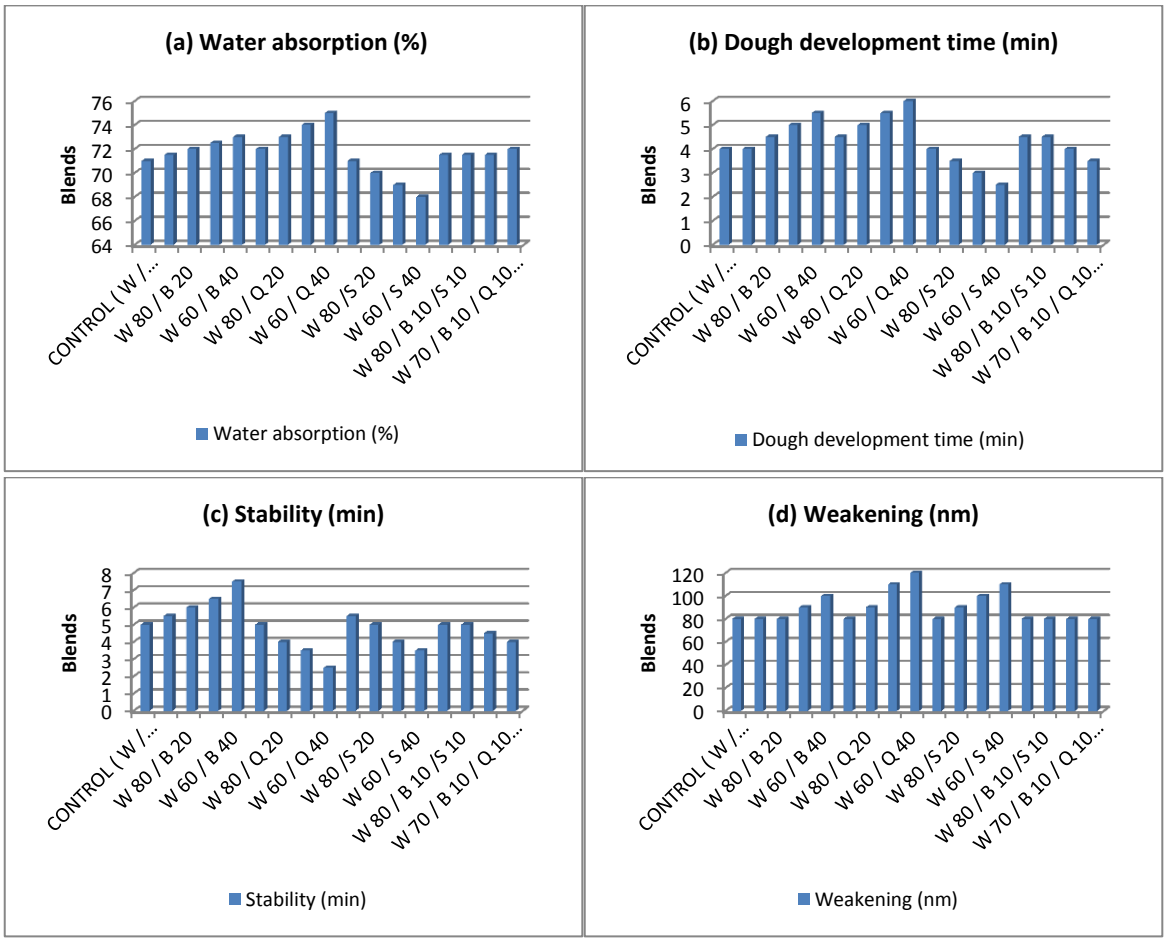

Figure 2: Farinograph parameters of wheat and its blends with different levels of huless barley, sorghum and quinoa flours: Water absorption (%) (b) Dough development time (min) (c) Stability (min) (d) Weakening**:**

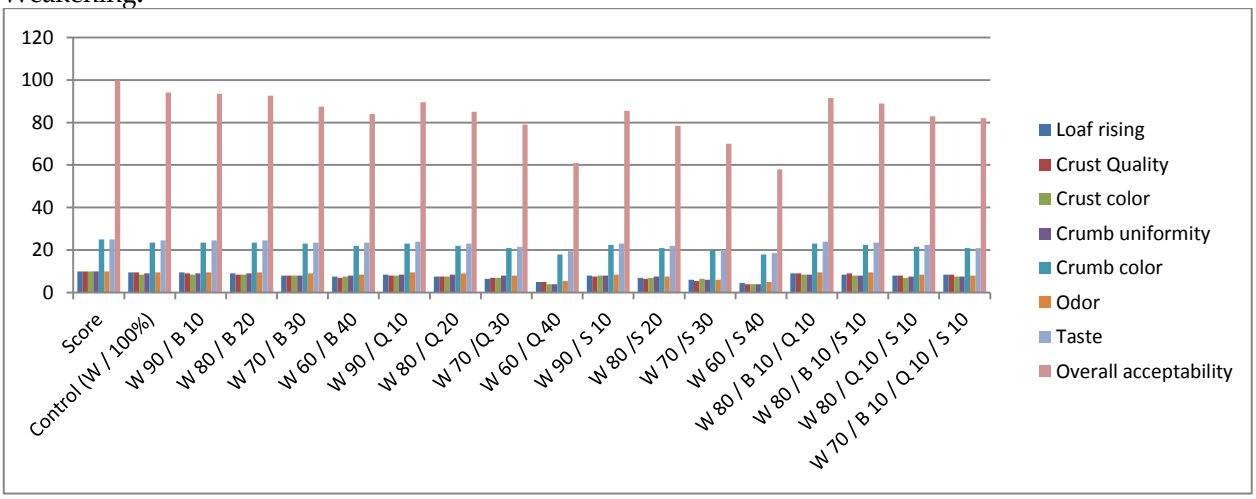

Figure 3: Sensory evaluation of Egyptian balady bread prepared from wheat 87.5% extraction rate and its blends with huless barley, sorghum and quinoa flours:

دراسات فيزيائية كيميائية وتكنولوجية على تحسين القيمة الغذائية للخبز البلدى المصرى باستخدام دقيق الشعير العارى والذرةالرفيعة والكينوا

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الملخص العربي

يهدف هذا البحث إلى دراسة المكونات الكيميائية لدقيق القمح و الشعير العاري و الذرة الرفيعة والكينوا, كذلك دراسة تأثير إضافة دقيق هذه الانواع بنسب 10 و20 و30 و40 % إلى دقيق القمح استخلاص 87,5% على الصفات الحسية والتكنولوجية للخبز البلدي المصري.أوضحت النتائج أن دقيق الشعير والكينوا غني بمحتواه من الحمض الاميني اللايسين (حمض اميني اساسي) 0,44% و0,45% على الترتيب بينما يحتوي دقيق القمح والذرة على أقل كمية من حمض اللايسين 0,28 و0,31% .كذلك أظهرت التحاليل الكيميائية أن دقيق الشعير العاري يحتوي على نسبة عالية من مركب بيتا-جلوكان β-glucan (4.20 mg\g) يلية دقيق الذرة الرفيعة 3.00 mg\g , بينما يحتوي دقيق القمح على 0.20mg\g ودقيق الكينوا على 0.10 mg\g , كذلك أكدت النتائج ايضاً أن دقيق القمح يحتوي على 27.00% جلوتين و أن باقي الانواع تعتبر خالية من الجلوتين (gluten-free).أوضحت النتائج أن إستخدام دقيق الشعير و الذرة الرفيعة والكينوا يمكن إحلالها بنسب 10 إلى 40% والتي يمكن خلطها مع دقيق القمح و الذي أدى إلى تحسين الصفات الحسية والتكنولوجية للخبز البلدي المصري الناتج.

wheat flour; Hulless barley flour; Stability; Wet gluten; Water absorption; B-glucan

الكلمات الاسترشادية: دقيق القمح, الثبات ,الجلوتين الرطب, امتصاص الماء