IMPROVING THE RHEOLOGICAL AND QUALITATIVE PROPERTIES OF BREAD WHEAT BY BARLEY-EXTRACTED PENTOSANES

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ABSTRACT

This study was aimed to improve the rheological and qualitative properties of the most common bread, wheat bread, by barley pentosanes, which is not optimally utilized although it's many benefits and its huge production. Therefore, water-soluble pentosanes (WSP) and water-insoluble pentosanes (WIP) were extracted from barley (*Hordeum vulgare*) and added to wheat flour at different percentages. Five treatments were prepared: (T1) from flour only, (T2 and T3) adding WSP at levels(1 and 2%), (T4 and T5) adding WIP at the same levels respectively. The results showed significant improvement in rheological and qualitative properties of the dough and bread made from this dough with increasing the level of addition. The water absorption, the mixing time and the stability time of the dough for T3 and T5, increased from (61.9%) to (64.8 and 65.3%) and from (2min) to (2.4 and 3 min) and from (11 min) to (17 and 18 min)respectively, as compared with T1 . Additionally, total scores of sensory evaluation increased from (89.1) to (95.7 and 89.3), the specific volume increased from (4.37 cm3/gm) to (4.79 and 4.54 cm3/gm). The chemical composition analysis showed an increase in the percentages of protein and fat for the same treatments (T3 & T5) as the values increased from (9.34%) to (10.55 and 9.98%) and from (0.85%) to (1.03 and 0.94%) respectively. The percentages of fibre and ash were also increased from (1.71%) to (1.89 and 2.10%) and from (0.74%) to (1.68 and 1.65%) respectively. While the total calorie decreased from (2.73.63 cal) to (261.98 and 253.18 cal).

Key words: wheat bread, pentosanes from barely, fortification, improving.
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مجلة العلوم الزراعية العراقية -2022 :53(5):1212-1222 نشمي و ناصر

تحسين الخصائص الريولوجية والنوعية لخبز القمح بواسطة البنتوسانات المستخلصة من الشعير

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المستخلص

هدفت هذه الدراسة إلى تحسين الخصائص الريولوجية والنوعية للخبز الأكثر شيوعًا، خبز القمح، بواسطة البنتوسانات المستخلصة من الشعير، والتي لا يتم استخدامها بالشكل الأمثل على الرغم من فوائدها العديدة وإنتاجها الضخم. لذلك، تم استخلاص البنتوسانات القابلة للذوبان في الماء (WSP) والبنتوسانات غير القابلة للذوبان في الماء (WIP) من الشعير (*Hordeum vulgare*) وإضافتها إلى دقيق القمح بنسب مختلفة. تم تحضير خمسة معاملات: (T1) من الدقيق فقط، (T2 و T3) إضافة WSP عند مستويات (1 و 2٪)، (T4 و T5) بإضافة WIP بنفس المستويات على التوالي. أظهرت النتائج تحسناً معنوياً في الخصائص الريولوجية والنوعية للعجين والخبز المصنوع من هذه العجين مع زيادة مستوى الإضافة. زاد امتصاص الماء ووقت الخلط ووقت ثبات العجين للمعاملات (T3 و T5) من (61.9٪) إلى (64.8 و 65.3٪) ومن (2 دقيقة) إلى (2.4 و 3 دقائق) ومن (11 دقيقة) إلى (17 و 18 دقيقة) على التوالي ، مقارنة مع T1. كما ارتفع إجمالي درجات التقييم الحسي لذات المعاملتين من (89.1) إلى (95.7 و 89.3)، وارتفع الحجم النوعي من (4.37 سم 3 / جم) إلى (4.79 و 4.54 سم 3 / جم). كما أظهرتحليل التركيب الكيميائي زيادة في نسب العناصر الغذائية ، حيث زاد البروتين والدهون من (9.34٪) إلى (10.55 و 9.98٪) ومن (0.85٪) إلى (1.03 و 0.94٪) على التوالي. وزادت قيم كل من الألياف والرماد من (1.71٪) إلى (1.89 و 2.10٪) ومن (0.74٪) إلى (1.68 و 1.65٪) على التوالي. بينما انخفضت الطاقة من (2.73.63 كالوري) إلى (261.98 و 253.18 كالوري).

الكلمات المفتاحية: خبز القمح، بنتوسانات الشعير، تدعيم، التحسين
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INTRODUCTION

Bread is one of the oldest foods, it is considered the principal food in countries around the world especially developing countries, and its types differ according to the common culture in each country. Wheat flour (Triticum aestivum) is the most commonly used around the world, it gives a product with excellent sensory properties and is acceptable to the consumer (27).But, in some countries, importing wheat from several sources may cause to be several varieties of wheat which differ in quality and technological properties ,and thus cause unstable properties of flour, and the quality of the bread made from it cannot be predicted (2 , 4). Technologically, there are varieties of wheat that produce dough has low rheological and technological properties that finally, cause to poor-quality products (15). Moreover, good wheat grains contain high nutritional elements, but as a result of the milling process and removal of the bran and some other parts of the grain in order to get agood sensory qualities, the flour which has a high percentage of carbohydrates but it lacks important elements such as minerals, vitamins, dietary fibers and active compounds which play an important role in improving the rheological properties of the dough (34). Also, bread made from fine wheat flour, with storage becomes unacceptable to the consumer, which cause to large quantities of wasted food and grain products (constitute 19% of the volume of wasted food). Attempts to reduce food waste are one of the most challenges for responsible for food, starting from good farming, to reach monitoring consumption in homes. Globally, the most effective of these attempts was food improving, the world food and agriculture organization Indicated that the cost of food improving constituted only about 13% from the cost of grain products losses (14). Whole grain flour using may be a solve, but despite its nutritional benefits, it usually negatively affects the technological and sensory characteristics such as appearance, texture and taste, and it is unacceptable for the consumer (34).On the other hand, barley (*Hordeumvulgare*) can be used to improve food, it is the fourth most important cereal crop in the world after wheat, maize and rice, and it is mainly produced in large quantities every year **(**44). And with regard to its consumption, barley had history as a source of human nutrition, but due to the dependence on wheat, rice and corn for human nutrition, approximately 65% of barley is used as animal feed, 33% for wine and only 2% as human's food around the world. And with interest in human health, there is a general orientation to benefit from barley to improving the consumer's health and to improving the food quality (51). Using of whole barley grain flour for improving the bread is limited because barley flour doesn't contain gluten thus reduces the elasticity and cohesion of the dough and negatively affects the sensorial properties of bread(8). Barley has been recognized around the world because of its many health benefits which are due to its high content of fiber, especially the pentosanes, which works to regulate blood sugar, reduce cholesterol and blood pressure, and consequently reduce the risk of heart disease (3 , 10). Not only that, but also, the pentosanes can be affect the rheological properties of dough this is du to its ability to bind water. Also it is associated with ferulic acid, which works to strengthen the gluten network and thus increase the retention efficiency of fermentation gas. In addition, pentosanespositively affects the moisture distribution inside the dough, which has a great impact on generally the quality characteristics and especially the sensory characteristics **(**37). Therefore, the aim of this study was to improve the rheological and qualitative properties of wheat bread by adding both types of pentosanes, water-soluble and water-insoluble pentosanes which was extracted from barley grain.

MATERIALS AND METHODS

Preparation of barley flour: Barley grains (Ebaa99, Harvested in 2019 AD) were obtained from the Agricultural Research Center of the Iraqi Ministry of Agriculture. After cleaning, the grains was emoistured and conditioned to bring up the moisture to 14% according to (16). Then, it was milled and the flour was passed through a sieve with holes diameter 150 microns. The extraction ratio of obtained flour was 78 and 100%.

Extraction of pentosanes: The extraction process of (WSP and WIP) from barley flour was carried out following the method mentioned by (11).

Chemical composition analysis of flour and bread: Moisture, ash, fat and carbohydrates content of flour and bread were determined according to (21), fibers and protein (by Micro-Kjeldahal method) were determined depending on (33) and (48) respectively. While, pentosanes in barley was defined and determined by HPLC, according to (18).

Determination of chemical composition of pentosanes: Moisture, ash, fat, protein and carbohydrates of pentosaneswere determined according to (1), (48), (33), (21) respectively While, Ferulic and diferulic acids were defined and determined using HPLC according to (22).

Determination of functional properties ofpentosanes: Functional properties of pentosanes (solubility, water holding capacity,swelling capacity and foaming capacity and stability) were determined according to (45), whil eviscosity and fat holding capacity were determined depending on the methods followed by (39) and (36) respectively.

Determination of rheological properties of dough: Rheological properties ofdough (water absorption, mixing time and stability time) were determined by farinoghraphdevice, according to (1).

Preparation of bread (loaf): Bread (loaf) was prepared according to (1) and a proportions amendment of some ingredients, 100 grams of wheat flour were taken and the other ingredients (salt, fat, sugar and yeast) were added at proportions (1.5, 3, 4 and 2 g/100g), respectively. (WSP) was added at (1 and 2%). Also, (WIP) was added at the same percentages.

Sensory evaluation of bread (loaf): Sensory characteristicswere evaluated by 10 evaluators,the evaluation criteria and evaluated treatmentswere as shown in form Awhich used by (54). **(**Form A): Sensory evaluation of bread (loaf).

Determination of qualitative properties of bread: The qualitative properties (weight, volume and specific volume) were determined according to (1) (10-10),the weight of bread (gm) was recorded after cooling to the laboratory temperature around (20-30 $^{\circ}$C)and volume (cm³) of bread were measured by rapeseed seeds displacemen, then the specific volume was calcluted(the specific volume = volume of bread /weight of bread).

Statistical analysis: SAS program was used to analyze the effect of the different factors in the studied traits, mean differencesbetween the averages were compared with the least significant difference at significance level of $p<0.05$(21)

RESULTS AND DISCUSSION

Chemical composition of barley flour: The chemical components of barley flour were estimated and the results were tabulated in Table 1. It has been noticed that the moisture content of barley flour (78% extraction) was insignificantly higher thanthe moisture content of barley flour (100% extraction). This is due to increase in the conditioning timewhich causes the migration of moisture from the outer layers to endosperm layer, so, the moisture content of the flour obtained from the endosperm only is higher than the moisture content of the flour obtained from complete grains. In addition, the loss of moistureby the temperature of the mill and the grinding process heat from the outer layer is more than the inner layer of the grains, and thus moisture of partiallyextracted flour (78 %) is higher than whole extracted flour (100%) (25). Also,the carbohydrates content offlour (78% extraction) was higher than (100% extraction) this, this is due to the removal and getting rid of the husks and outer layers and most of the barley grain parts except for the endosperm, which consists mainly of carbohydrates (85% of the total endosperm) and this, is in order to obtain high quality flour (50). From the same table, it can be seen that protein, fat, fiber and ash content of partially extracted flour (78%) were lower than whole extracted flour (100%), this is due to the disposal of the bran, germ and most barley grain parts, which in turn contains a high levels of these elements, the bran consists of the aleuron and the Sub-aleuronlayeres which contain a high percentage of the barley grains total proteins (52),these proteins as prolamine around 52% and glutinen around 23% (17). Also, the germ contains around 80% of the total fatty acids in the barley grain (53),and the bran contains 1.5 to 3.5% of the fats present in the barley grain (52). Regarding its content of fiber, the bran mainly consist of cellulose, lignin and silica , and removal of these layers means that the fiber content is necessarily reduced (30). In this context, also the bran content many vitamins, potassium, phosphorus, magnesium,iron and zinc, which represent a high percentage of ash that allows said that the ash content in flour is very related to its content (52), also,it contains several phenolic compounds (30), this not only, but also the germ contains a high levels of vitamins, which represent a high percentage of ash, so, removing these layers during the partial extraction in order to obtain high-quality flour, it causes a decrease in the ash content(28).

Table 1. Chemical composition of barley flour

Extraction of barley flour	Chemical composition (%)						Content of pentosanes(g/100g)		
	moisture	Protein	fat	fibere	ash	Carbo.	WSP	WIP	Total pentos.
100%	11.20 a	13.80 a	1.45 a	5.73 a	1.29 a	66.93 b	1.55 a	8.70 a	10.25 a
%78	11.40 a	11.90 b	1.05 b	2.56 b	0.95 b	72.14 a	1.39 a	6.10 b	7.49 b
LSD	2.19 NS	1.61 *	0.30*	1.96 *	0.31 *	4.86 *	0.206 NS	1.277*	1.815 *

From the same table, it can be observed that the content of total pentosanes, water-soluble pentosanes and water-insoluble pentosanes of barley flour (78% extraction) were higher than that ofof barley flour (100% extraction), the values were (7.49 and 10.25 g/100g), (1.39, 1.55 g/100g), (6.1 and 8.7 g/100g) respectively. This is due to the bran mainly consists of fibers which also mainly consists of pentosanes(30). So, the removing of the bran in order to obtain high quality flour causes a decrease in total pentosanes content and therefore, decrease content of water-soluble pentosanes and water-insoluble pentosanes(10). From the same table, and on the other hand, it can be observed that the value of water-insoluble pentosanes was higher than water-soluble pentosanes of whole extracted flour (100%). Also,and likewise, it can be notedthe same not whenlook at the data of partially extracted flour (78 %) and this is agree with (10)was reported that pentosanes are two forms water-soluble pentosanes and water-insoluble pentosanes, but the water-soluble pentosanes content is less than water-insoluble pentosanes. And in a similar study Wang *et al.*(49) mentioned that pentosanes are two forms water-soluble pentosanes and it represents around 25%, while water-insoluble pentosanes represents 75% of the total pentosanes of grains approximately.

Chemical composition of pentosanes

Chemical composition of pentosanes (WSP and WIP) was determined, and the results show in Table 2. It has been noticed that the moistur content of (WIP) was lower than that of (WSP) with insignificant difference at ($p<0.05$), the values were (5.82 and 6.16%) respectively. These findings are agreed with (41), and this may be due to the extraction ratio used And the effectiveness of the lyophilization process of these compounds (11). From the same table, it is noticed that the protein content of (WSP) was significantly higher ($p>0.05$) than that of (WIP), the values were (21.8 ,13.5 %) respectively. This is due to the force of bonds between the soluble pentosanes and protein chains are stronger than that between protein and water-insoluble pentosanes because WSP contain more ferulic acid in comparison WIP this, which means stronger bonds (49), and this is supported by (34), who mentioned that ferulic acid is either free or tied because of its ability to form bonds between pentosanate and protein chains.While Ognean et al. (35) indicated that the reason may be due to the removal of most of the proteins during the extraction of the pentosanes.. but, in the case of (WSP) , it is strongly associated with Arabino-galactan-peptide (AGP), because it is similar to it in the degree of water-solubility on the one hand, and able to form strong bonds with it on the other hand, this is because this protein contains two types of amino acids in the same time, non-polar hydrophobic amino acids and involve inside on themselves and also with a part of the pentosanes, and polar hydrophilic amino acids that bind to water in an outward direction to take a spherical structure, which explains their ability to dissolve in Water and at the same time it binds to pentosanes, and thus eliminating this type of protein is more difficult than that associated with insoluble pentosanes. The fat and ash content of (WSP) were significantly ($P<0.05$) higher than that in

(WIP),the values were (1.45 and 0.77%) and (2.9 and 0.44%) respectively. These results agreed with (7) and due to the (WSP) high percentage of protein, which is related to a proportion of unpolar fats, while the polar fats are lost during extraction(49). Also, Roman *et al*. (43) reported that the high percentage of ash in (WSP) may be due to its high protein content and thus its increased content of mineral such as; potassium, phosphorous, magnesium, iron and zinc, as well as its high fat content and fat-soluble vitamins, as well as its high content of phenolic acids, all of these compounds form the backbone of the ash . In contrast, the carbohydrates content of (WSP) was lower than that in (WIP) with a significant difference at (p>0.05), the values were (67.69, 79.45%) respectively.These results are similar that in(24) and this may be due to an increase in other ingredients, while in case of (WIP), the opposite, it is true. The results also showed that xylose content of (WSP) were significantly (P<0.05)higher than its that in (WIP). On the contrary, arabinose content of (WSP) were significantly (P<0.05) lower than that of (WIP) at (P<0.05) the values were (1.45 and 0.77%) and (2.9 and 0.44%) respectively, These ratios have great importance because many of the properties of pentosanes depend on them. Perhaps the most important of these properties is the water-solubility or insolubility by several different mechanisms (23,45).

Table 2. Chemical composition of water-soluble pentosanes (WSP) and water-insoluble pentosanes (WIP).

Pentosanes	Chemical composition ofpentosanes (%)							
	Moisture	ash	protein	fat	carbohydrates	Pentosaccharidrs		
						Total	Xylose	Arabinose
WSP	6.16 a	2.90 a	21.80a	1.45a	67.69b	84.82a	64.57a	20.25b
WIP	5.82 a	0.44b	13.50b	0.77b	79.45a	79.39b	44.45b	34.94a
LSD	1.008 NS	0.67 *	2.70 *	0.86 *	6.31 *	3.28 *	5.49 *	4.31 *

Pentosanes content of ferulic and diferulic acids: The results in Table 3 indicate that there is a significant difference (P <0.05) between the total ferulic acids content for (WSP) and (WIP), the values were (409.55 and 311.7µg/100g) respectively. These results are in agreement with (42 , 49) who indicated that (WSP) represents 25% of the total pentosanes, but it is containing the highest percentage of Phenolic acids and the most common of these acids are ferulic and diferulic acids. Also, the results indicate that there is a significant difference (P<0.05) between ferulic and diferulic content for (WSP) and (WIP),(WSP) contained the highest ferulic acid content when compared to (WIP), the values were (286.35 and 171.75 µg/100g) respectively. On the contrary, (WSP) recorded the lowest diferulic acid content been (123.2 µg/100g) when compared to (WIP) which recorded (139.95 µg/100g), These results are in agreement with (36) , they stated that ferulic and diferulic acid are the two acids most closely related to pentoses, with different concentrations of each in soluble and insoluble pentosans, where the former contains almost twice the content of the latter, but it binds to a lower percentage with diferulic acid, this may be due to the nature and strength of the bond that each of them is linked to, but it is known that soluble pentosans are covalently linked with ferulic acid by an ester bond with the feruloyl groups present in this acid.

Table 3. Content of ferulic and diferulic acids in water-soluble pentosanes (WSP) and water-insoluble pentosanes (WIP).

Pentosanes	Content of Phenolic acids (µg/100g)		
	Ferulic acids	Diferulic acid	Total
WSP	286.35 a	123.2 b	409.55 a
WIP	171.75 b	139.95 a	311.7 b
LSD	31.763 *	11.594 *	52.439 *

Functional properties ofpentosanes

The results in Table 4 indicate the functional properties of pentosanes. It has been noticed that the water holding capacity of WIP (6.08 g/g) was significantly higher than that for WSP(4.05 g/g) . These finding were in agreement with (38), this due to the large size of pentosanes particles, as it has been proven that the small size of pentosanes particles reduces their water-holding ability and vice versa, it also depends on the organization and arrangement of polysaccharide chains. Ognean et al. (35) stated that pentosanes differs in its water holding ability, one part of (WSP) can hold on approximately 4 parts of water, while one part of the (WIP) was able to hold on 10 parts of water. It is notworthy that, this functional characteristic is deu to many important technological properties which works to change and modify the rheological properties of the dough (10). Also, the pentosanes showed a significant difference (p<0.05) in water solubility, the values were (52.2%) for (WSP) and (7.25%) for (WIP) and these results are in agreement with (45), who mentioned that the water solubility mainly depends on the degree of substitution for xylose, which contributes to the solubility of the xylan chain of pentosanes, while Koehler *et al.* (23) indicated that the solubility of pentosanes not only depend on its xylose content, but also on the most important parameter, xylose/ arabinose ratio. This characteristic depends on this parameter mainly.On the contrary, the swelling capacity of (WIP) was higher than (WSP), they showed a significant difference (p<0.05), the values were (2.1 ,1.48 g/g), and these results are agreed with (45),Who mentioned that the swelling ability depends on the physical properties such as the molecular size, porosity and degree of crystallinity of these compounds.The foaming capacity for (WSP) were higher than (WIP) the values were (3.03 and 1 ml/100ml) respectively. But the foaming stability at (30 and 60 min), were differed insignificantly . These results are in agreement with (45), who confirmed that the foaming capacity and foaming stability is due to the fact that (WSP) has the ability to increase the water viscosity and creates a sticky and flexible layer around the formed bubble, which works to stabilize it by protecting the bubble coating membrane, on the other hand preventing the bubbles adhesion. In a related context, the results indicated that there is a significant difference (p <0.05) between viscosity values of (WSP) and (WIP), where the values were (2.2 cp) and (1.3 cp) respectively. These results are consistent with those reported by (35) where they indicated that this was due to the high solubility of (WSP) in water and formation of highly viscous colloidal solutions, in contrast to WIP. Likewise, the fat holding capacity for (WSP) was higher than of (WIP) the values were (4.52 and 2.81 gm/gm) respectively, and these results are in agreement with (9).This is because of the water soluble pentosanes contains some active substances that act as emulsifiers that have the ability to attract and bind the fat, so, this function also depends on the extraction and purification degree. Figuerola *et al.* (12), Liu *et al.* (26) reported that this was due to a decrease in the crystallization degree of WSP sugars which means increase in porosity of their surface, and ultimatly increasing a binding sites between (WSP) and fat.

Table 4. Functional properties of water-soluble pentosanes (WSP) and water-insoluble pentosanes (WIP).

Functional properties	WSP	WIP	LSD
Water holding (g/g)	4.05 b	6.08 a	1.267 *
(%)Water solubility	52.2 a	7.25 b	6.501 *
Swelling capacity (g/g)	1.48 b	2.10 a	0.492 *
Foaming capacity (%)	3.03 a	1.00 b	1.028 *
Foamingstability (30 min)	0.52 a	0.41 a	0.178 NS
Foaming stability (60 min)	0.50 a	0.41 a	0.166 NS
fat holding (g/g)	4.52 a	2.81 b	1.173 *
Viscosity (cp)	2.20 a	1.30 b	0.671 *

Rheological properties ofdough

Table 5, represents the rheological properties of the experimental dough samples . The water absorption values showed dgraduall increase with increasing of added (WSP) and (WIP) level. The values were (61.9, 63.6, 64.8, 63.9, 65.3) for (T1, T2, T3, T4 and T5) respectively . These results are in agreement with (32), and this may be due to the fact that the pentosanate has a high water absorption capacity, which leads to an increase in the water holding capacity of the flour to produce a cohesive dough (38). It was obvious that the increase in rate of water holding capacity for the treatmenteswhich were prepared by adding (WIP) was higher than that for the treatmentes prepared by adding (WSP). This is because the water holding capacity for (WIP) was higher than that for (WSP) (35). From the results of the same table, all treatments showed a gradual increase in peak time values as a result of adding (WSP) and (WIP) at levels (1 and 2%), those values were (2.4 and 2.7 min) and (2.5 and 3 min) respectively as compared to control treatment (2 min. These results were inaccordance with (32). Arif *et al*. (6) suggested that the increase of peak time may be related to the increase of the water holding capacity which makes the dough in this case requires a longer mixing time to absorbs more water inoder to get the desired dough texture. On the other hand, the stability time showed a gradual increase by the gradual increase in the added level of (WSP) and (WIP) , the values were (16 and 17 min) and(17.5 and 18 min) for (T2 and T3) and (T4 and T5) while for the control treatment (T1) was (11min) . These results are in agreement with Arif *et al*. (6) who mentioned that the pentosanes increases the dough stability about (28-71%) as compared to the dough stability time in the apsences pentosanes and this could be attributed to the ability of pentosanes to strengthen the gluten network in the obtained dough.

Table 5. Rheological properties of expermintal dough samples.

Treatments	water absorption (ml)	peak time (min)	Stability (min)
T1	61.9	2.0	.011
T2	63.6	2.4	.016
T3	64.8	2.7	.017
T4	63.9	2.5	17.5
T5	65.3	.03	.018
LSD	3.276 *	0.502 *	4.598 *

(T1) prepared from the basic ingredient, (T2 and T3) adding WSP at levels(1 and 2%), (T4 and T5) adding WIP at levels (1 and 2%) respectively.

Sensory evaluation of bread (loaf)

The results in Table (6) illustrate the sensory characteristics of the experimental bread. There were insignificant difference (P <0.05) among the treatments except for (T3) as it showed the highest total scores, being (95.7). While for (T1, T2 , T4 and T5), the total scores values were (89.1, 89.9, 89.4, and 89.3) respectively, these results are in accordance with Altınel and Unal findings (5), they reported that addition of pentosanes resulted in the bread quality improvement It has been seen that (T3) were gained the highest scores for most of the evaluated sensory characteristics, these characteristics such as the taste and flavor which comes in the second place of importance after the specific volume. Those scores was (19.1/20) for aroma and (30/30) for the specific volume . This may be due to the functional properties of pentosanes that increase the size of bread by several different mechanisms, Moreover ,it works to enhance the gluten network to preserve the fermentation gas (34).

Table 6. Sensory evaluation of bread (loaf).

Characteristic	Degree	T1	T2	T3	T4	T5	LSD
Specific volume	30	27.4 ac	26.7 bc	30 a	27.1 bc	28.8 ab	2.89 *
- (cm^3/g)		4.37	4.27	4.79	4.32	4.54	0.378*
Color of crust	10	8.5 a	9a	9.5 a	8.7 a	8.5 a	1.18 NS
Symmetry of form	5	4.4 a	4.4 a	3.8 a	4.1 a	4.4 a	0.755 NS
Evenness of bake	5	4.3 a	4.6 a	4.6 a	4.5 a	4.3 a	0.603 NS
Grain of crumb	10	8.7 a	8.8 a	9.5 a	8.8 a	8.5 a	1.06 NS
Color of crumb	10	9.3 a	9.3 a	9.5 a	9.3 a	9.4 a	1.44 NS
Aroma and taste	20	17.7ab	17.8ab	19.1a	18.4ab	17.1 b	1.84 *
Texture of crumb	10	8.8ab	9.3ab	9.7a	8.5ab	8.3 a	1.25 *
Total score	100	89.1 b	89.9 b	95.7 a	89.4 b	89.3 b	5.019 *

Chemical composition of bread (loaf)

As shown in Table 7, the percentages of moisture, protein and fat were gradually increased by increasing the addition level of (WSP) and (WIP) to wheat flour, the values of moisture were (31.66, 32.23, 33.27 and 34.13%) while for control treatment was (30.20%) . This may be due to the highwater holding ability of pentosans which improved the rheological properties of the dough and increased the moisture content of the bread made from this dough (6). The protein and fat percentages were gradually increased, from (9.34 and 0.85%) for the control treatment to reached a maximum values of (10.55 and 9.98%) and (1.03 and 0.94%) for T3 and T5 respectively, this is due to the protein and fat content of pentosanes which were higher than that for wheat flour (46). The increment in proten and fat percentages deu to the addition of (WSP) was higher than (WIP) the values were (21.8 and 1.45%) and (13.5 and 0.77%) respectively, and these results are in agreement with (49). Similarly the fibers and ash content were increased when (WSP) and (WIP) were added to the wheat flour. The percentages of fibers and ash for the control treatment were(1.71%&(0.74%) respectively. whereas for the treatments with 2% (WSP) and (WIP) were (1.89 and 2.10%) and (1.68 and 1.65%) respectively. These results are in agreement with Salmenkallio *et al*. (43),The reason for the increase in fiber is that pentosanes are the main, most important and largest component of fiber (10), while the increase in ash content is due to the higher ash content for pentosanesas compare to wheat flour, and this is because pentosanes contains many vitamins, mineral and some phenolic acids, which represent high percentage of ash (7). Adding (WSP) and (WIP) to wheat flour showed a gradual decrease incarbohydrates and total solids percentage, the values were (57.16%) and (69.8%) for the control treatment, then decreased until reached to (52.62 and 67.77%) as (2%) of (WSP) was add to the wheat flour, and (51.2 and 65.87%) with same level of (WIP). The gradual decrease in the percentage of carbohydrates is explained by the corresponding gradual rise in the rest of the components, in other words, the increase in one of the components calculated as a percentage comes at the expense of the decrease in the other component. The decrease in total solids is also explained by the corresponding gradual increas in the moisture content, where they have an integral relationship, and these results are consistent with Salmenkallio *et al*. (43) results. Similarly, the energy showed a gradual decrease by increasing of added pentosanes, although the increase of pentosanes was accompanied with an increase in protein and fat content, as energy sources, at the same time the flour carbohydrates, which are the main and more important source of energy was decreased . These findings were agreed with (32). Generally, can be said that, In spite of the relatively low energy of fortificated bread with both types of pentosanes (WSP and WIP), it still has a high nutritional value, the statistical analysis showed insignificant difference among the energy values for the five treatments (p <0.05).

Table 7. Chemical composition of bread (loaf).

Treatments	Chemical composition of bread (%)							
	moisture	protein	fat	fiberes	ash	carbohydrates	total solids	energy
T1	30.20 b	9.34 b	0.85 a	1.71 b	0.74 b	57.16 a	69.8 a	273.63 a
T2	31.66 ab	9.42 b	0.88 a	1.87 ab	1.06 b	55.17 ab	68.34 ab	266. 2 a
T3	32.23 ab	10.55 a	1.03 a	1.89 ab	1.68 a	52.62 ab	67.77 ab	261.98 a
T4	33.27 a	9.40 b	0.83 a	2.01 a	1.02 b	53.42 ab	66.73 ab	258.74 a
T5	34.13 a	9.98 ab	0.94 a	2.10 a	1.65 a	51.2 b	65.87 b	253.18 a
LSD	2.68 *	1.051 *	0.217 NS	0.274 *	0.405 *	5.12 *	3.885 *	27.17 NS

(T1) prepared from the basic ingredient, (T2 and T3) adding WSP at levels(1 and 2%), (T4 and T5) adding WIP at levels (1 and 2%) respectively.

4.Conclusion

This study succeeded in achieving its goal of improving the rheological and qualitative properties of wheat bread using water-soluble and water-insoluble pentosanes from barley grains . The addition of water-soluble and water-insoluble pentosanes to wheat flour improved the rheological properties of the dough and also improved the sensory and qualitative characteristics of wheat bread made from this dough. Not only that, also it raised many nutrients level which are necessary for human health, such as protein, fats, dietary fibers and minerals. Therefore, using pentosanes to improve bread qualities is an effective and established method and may become a fertile ground and starting seed for development of bakery products .

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