Improving the sensory and qualitative properties of barley bread using broken wheat wet gluten

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Abstract. Vital wheat gluten was extracted from broken wheat flour (Triticum aestivum), which is an accidental product during the technical milling process and used to improve the sensory and qualitative properties of bread made using flour from two varieties of Iraqi barley (IPA 99, IPA265) which were obtained from the Ministry of Agriculture / Agricultural Research Center. The chemical composition analysis revealed that the percentage of β-glucan in barley flour (72% extraction) (BFE) of IPA 99 and IPA 265 were (3.9, 4.5%), respectively, while for whole barley flour (100% extraction) (WBF) those values were  (3, 3.9%), respectively. The percentage of pentosanes in (WBF) of the experimental of varieties were (7.8, 12.6%). However, in the (BFE) these values drooped to (6.0 - 8.7%). This study, two experiments with seven treatments were carried out. The first experiment include using broken wheat wet gluten (BWWG) at different percentage in bread mix as follows, barley flour (type A) with 14% (BWWG) (T1), 16% (BWWG) (T2), 18% (BWWG) (T3), 20% (BWWG) (T4), and 22% (BWWG) (T5) of the experimental gluten, T6 was barley flour and 20% commercial gluten (CG) (for comprised) while T7 was barley flour with no added gluten. The second experiment was with barley flour from type (B) with a similar ratio of add gluten. The results have shown that the specific volume of the bread for IPA 99 & IPA 265 was significantly higher (P<0.05) than that of control. The highest value of specific volume were in the treatments AT5 &BT5 (3.3 & 3.34 cm3/gm) compared with the control where it was (1.43 & 1.5 cm3/gm). Sensory evaluation test showed an improvement in the sensory and qualitative characteristics of gluten contenting bread. Chemical analysis of the loaf prepared from superior treatments showed that percentage of protein increased from 10.7-113% to 25-26.6%, fiber to 1.3 - 1.8%, and carbohydrates to 57.5- 60.4% as compared with control treatment which was 74.5%.

1. Introduction

Bread is consumed as the important food all over in the world, which is accepted as a perishable commodity, due to its fast decline of freshness and fast staling [39]. Wheat is the most important cereal for making bread
because it has a high percentage of gluten compared to other cereals [40]. Increased consumer demand for healthy food has led to considerable efforts to develop bread that join a health benefits with good sensory properties. The use of whole grain wheat flour is the first strategy for the development of healthy bread as the consumption of the whole grain has been shown to lessen the risk of colorectal cancer, cardiovascular diseases, diabetes and obesity [48]. The high content of dietary fiber in whole grain plays a significant role in preventing many diseases and gives health benefits [45]. Increasing the content of cereal β-glucan in the bread is another strategy to raise their nutritional quality. Cereal β-glucans are known for their ability to decrease postprandial serum glucose levels and insulin response and to decrease serum cholesterol levels [13]. The high content of β-glucan in barley (3-11.3%) and oat (2.5-7.8%) compared with wheat (0.4-1.4%) which made these two kinds of cereal increasingly attractive for bread production [33].

Barley grains have a chemical composition are almost identical to those of wheat, while barley has a wide range of health benefits. Barley (Hordeum Vulgare L.) is cultivated as a commercial crop in about a hundred countries all over the world [36]. Barley is among the most ancient cereal crops grown around the world today. Archeological evidence mentioned the existence of barley in Egypt along the River Nile around 17,000 years ago [10]. It is one of the top most cultivated crops globally (12% of total cereal cultivated), which is the fourth cereal grains after wheat, maize, and rice [44]. Barley outperforms other cereals under various environmental stresses due to its winter-hardy, early maturing nature and drought-resistant, accordingly it is generally more economical to cultivate [16]. Approximately only 2% is used directly for human consumption, 33% for malting whereas 65% of cultivated barley is used for animal feed [46]. Moreover, it can be argued that barley is a great source of different carbohydrates, different minerals and vitamin group B and E. Vitamin E is natural antioxidants which can reduction heart diseases and the risk of cancer [11].

Many health professionals have given guidance to people to eat more barley products, which can confirm its health benefits by consuming the grain [5]. In 2014, more than 48 million hectares of barley were cultivated globally, lead to a harvest of 144 million metric tons [47]. Only a small sum of barley is used for human consumption. Appearance and taste factors along with its poor baking quality have restricted the use of barley in human foods [23]. According to [22] some studies have added the barley flour up to 15 % can improve the physicochemical properties of mixed bread by replacing wheat flour with barley flour. In some other reported, combine more than 25% barley flour leads to darkening, hardness, lack of uniformity and less overall acceptability.

However, the incorporation of oat and barley flour or the use of whole grain flour (commonly from wheat) or bran all minimize bread quality, specially loaf volume, of wheat composite bread [26]. [9] Reported that 5-10% addition of barley flour to bread products was accepted by the consumers. Moreover, parameters like texture and color were like to those of the bread made of only wheat flour. The aim of this study is to improve the sensory and qualitative characteristics of barley bread using broken wheat gluten.

2. Materials and Methods

2.1. Barley flour preparation

Two varieties of barley (IPA 99, IPA 265) were obtained from the Ministry of Agriculture/Agricultural Research Center. Both varieties were grown in north of Baghdad, Iraq in 2017. Barley samples were grinding with Brabender Laboratory mill after conditioning to 14 % moisture for 30 hours [29], and the flour was passing through (150 Micron). The extraction rate of barley flour was 72%.
2.2. Gluten preparation
The wet gluten was extracted from broken wheat (*Triticum aestivum*) with 14% moisture for 30 hours before milling. Flour was passing through (150 Micron), and the extraction rate of wheat flour was 60%. The extraction and estimation of the gluten were followed by the interesting mentioned in [1].

2.3. Chemical analysis
Proximate compositions of all flour and bread samples were studied using [6] methods.

2.4. Extraction and determination of β-glucan
β-glucan was extracted from barley flour and determinate, according to [25].

2.4.1. Determination of protein content in the β-glucan extract
Total nitrogen ratio was determinate using the Micro-Kaldal method using the American Association of Chemical Chemistry [2].

2.4.2. Determination of Moisture of β-glucan
Moisture was determinate using the standard method of [3].

2.4.3. Determination of Water holding capacity of β–glucan
The water holding capacity of β-glucan was determinate, according to [8]. According to the following equation:

\[
\text{Water holding capacity (WHC)} = \frac{\text{Weight of the binding water (g)}}{\text{Weight of the sample}} \times 100
\]

2.5. Determination of Pentosanes in barley flour
Pentosanes in barley flour were determinate according to the method followed by [21].

2.6. Bread (loaf) preparation
The breadmaking performances of the flour (control and blends) were determined using the straight dough [4] with a slight modification. Bread mix consists of barley flour (BFE), wet gluten (BWWG), yeast, salt, sugar, fat and an adequate amount of water to obtain dough of optimum consistency. The breadmaking procedure was included mixing the dry materials, at low speed for 2 min for dry materials followed by a 9 min rapid mixing with small piece of wet gluten using spiral arm mixer, and then hold for a proving time (50 min) at 36°C and 70-80% relative humidity (r.h.) and baking for 23 min at 180°C in a conventional oven.

Baking bread loaves were cooled down to room temperature for 60 min, wrapped in a plastic film and then stored at room temperature (20-22°C). Standard bread was weighed and its volume was measured by displacement of sage seeds. The specific volume was calculated.

Sensory characteristic of the bread was evaluated by 9 evaluators The ingredients of experiments as treatments were as listed in following Table 1. The sensory evaluation form used was followed by [51].

2.7. Statistical analysis
SAS program was used to analyze the effect of the different factors in the studied traits, mean differences between the averages were compared with the least significant difference at significance level of \( p<0.05 \) [14].
## The sensory evaluation Table [51].

| treatments | Bread volume | Color of crust | Symmetry of form | Evenness of bake | Grain of crumb | Color of crumb | Texture of crumb | Aroma and taste | Total score |
|------------|--------------|----------------|------------------|------------------|----------------|----------------|-----------------|----------------|-------------|
| Degree     | 30           | 10             | 5                | 5                | 10             | 10             | 10              | 20             | 100         |
| T1         |              |                |                  |                  |                |                |                 |                |             |
| T2         |              |                |                  |                  |                |                |                 |                |             |
| T3         |              |                |                  |                  |                |                |                 |                |             |
| T4         |              |                |                  |                  |                |                |                 |                |             |
| T5         |              |                |                  |                  |                |                |                 |                |             |
| LSD value  |              |                |                  |                  |                |                |                 |                |             |

T= mean of the treatments
Table 1. The Ingredients of experiment treatments (g).

| Treatments | Barley flour (BFE) (g) | Wheat flour (g) | wet gluten Based on dry matter (g) | Yeast (g) | Salt (g) | Sugar (g) | Fat (g) |
|------------|------------------------|-----------------|-----------------------------------|-----------|----------|-----------|---------|
| AT1        | 86 IPA 99              | -               | 14 from broken wheat              | 2         | 1.5      | 4         | 3       |
| AT2        | 84 IPA99               | -               | 16 from broken wheat              | 2         | 1.5      | 4         | 3       |
| AT3        | 82 IPA 99              | -               | 18 from broken wheat              | 2         | 1.5      | 4         | 3       |
| AT4        | 80 IPA99               | -               | 20 from broken wheat              | 2         | 1.5      | 4         | 3       |
| AT5        | 78 IPA 99              | -               | 22 from broken wheat              | 2         | 1.5      | 4         | 3       |
| AT6        | 80 IPA99               | -               | 20 from Commercial                | 2         | 1.5      | 4         | 3       |
| AT7        | 100 IPA99              | -               | -                                 | 2         | 1.5      | 4         | 3       |
| BT1        | 86 IPA 265             | -               | 14 from broken wheat              | 2         | 1.5      | 4         | 3       |
| BT2        | 84 IPA265              | -               | 16 from broken wheat              | 2         | 1.5      | 4         | 3       |
| BT3        | 82 IPA 265             | -               | 18 from broken wheat              | 2         | 1.5      | 4         | 3       |
| BT4        | 80 IPA265              | -               | 20 from broken wheat              | 2         | 1.5      | 4         | 3       |
| BT5        | 78 IPA 265             | -               | 22 from broken wheat              | 2         | 1.5      | 4         | 3       |
| BT6        | 80 IPA265              | -               | 20 from Commercial                | 2         | 1.5      | 4         | 3       |
| BT7        | 100 IPA265             | -               | -                                 | 2         | 1.5      | 4         | 3       |

A= mean the first experiment  B= mean second experiment  T= mean the treatment
3. Result and discussions

3.1. Chemical composition of barley and broken wheat flour

Table 2 shows the chemical composition of (BFE), (WBF) of IPA 99 and IPA 265. The percentage of moisture, protein and fat in class IPA 265 (for both extraction rates) were (12.60, 13.0, 2.8%) and (13.1, 13.4, 1.0%), respectively, which were higher than that for class IPA 99 (12.05, 11.70, 1.50%) and (13, 12, 0.8%), respectively. The percentages of fiber, carbohydrate and ash were lower in the flour of class IPA 265 (for both extraction rates), being (5.9, 60.8, 4.9%) (2.0, 69.3, 1.2%), respectively, as compared to that of class IPA 99 flour, being (6.15, 63.45, 5.14%) (2.0, 70.9, 1.3%), respectively. The results obtained in this study are agreed with the findings of other authors [49] [46] [12]. Differences in the proportions of components between different varieties are due to genetic and environmental differences [12].

The same table shows the chemical composition of the broken wheat flour. The percentages of moisture, protein, fat, fiber, ash and carbohydrates for broken wheat flour were (8.4, 10.78, 1.2, 70.82, 4, and 4.8%), respectively. Results were different than that reported by [7] which were (11.3, 3.2, 11, 2.2, and 72 %) respectively, and these differences may be due to the variation in the experimental grain mix and the storage conditions. It has been noticed that the protein in broken wheat was high being (13.0%) and this will provide good gluten for the production of barley bread.

**Table 2. Chemical composition of the experimental barley and broken wheat flour**

| Cereal varieties          | Ash% | Carbohydrate% | Fiber% | Protein% | Fat% | Moisture% |
|---------------------------|------|---------------|--------|----------|------|-----------|
| (WBF)(IPA 99)             | 5.14 | 63.45         | 6.15   | 11.70    | 1.50 | 12.05     |
| (BFE)(IPA99)              | 1.3  | 70.9          | 2.0    | 12.0     | 0.8  | 13.0      |
| (WPF)(IPA 265)            | 4.9  | 60.8          | 5.9    | 13.0     | 2.8  | 12.6      |
| (BEF)(IPA 265)            | 1.2  | 69.3          | 2.0    | 13.4     | 1.0  | 13.1      |
| Broken wheat              | 4.0  | 70.82         | 4.8    | 10.78    | 1.2  | 8.4       |

3.2. Chemical composition of commercial gluten and broken wheat gluten

Table 3 shows the chemical composition of commercial gluten (CG) and broken wheat gluten. The percentage of moisture, protein, fat, fiber and carbohydrate for (CG) were (5, 65.4, 0.2, 27.6, 1.7%), respectively and for broken wheat gluten (4.4, 74.36, 0.1, 19.5, 1.5%), respectively. The results were consistent with [50] and [18]. The chemical composition of (CG) in their studies where (7.5, 71-80, -50, 0.5, 15-20%), respectively. The difference in the moisture content of gluten is due to the different methods of drying, while the difference in the ratio of lipid to gluten depends on the ratio of the presence of polar and non-polar fat, where most polar fats are removed during the washing of the gluten in sufficient amounts of water. While non-polar fat is associated with proteins and this is confirmed by [20].

The difference in the percentage of protein in gluten is due to the difference in the source of gluten and the different method of extraction [50]. The remaining percentage of carbohydrate in the extracted gluten is due to the overlap and encapsulation of the protein matrix of a part of the carbohydrate (starch and / or fibers) that are difficult to separate from the protein during the process of washing [41]. The difference in the percentage of ash may be due to the difference in the percentage of minerals and extraction methods.
Table 3. The chemical composition of commercial gluten (CG) and broken wheat gluten on the basis of dry matter

| Chemical content% | Commercial gluten (CG) | Broken wheat gluten |
|-------------------|------------------------|---------------------|
| Moisture          | 5                      | 4.4                 |
| Protein           | 65.4                   | 74.36               |
| Fat               | 0.2                    | 0.1                 |
| Carbohydrate      | 27.66                  | 19.57               |
| Ash               | 1.74                   | 1.57                |

3.3. Determination of β-glucan extracted from barley varieties

The percentages of β-glucan in the barley varieties IPA 99 and IPA 265 with different extraction rates, moisture content and protein and its water holding capacity. The results indicate that the percentage of β-glucan in the WBF was (3.0, 3.3%), respectively, this is in line with [37] when the studied studying 27 barley varieties, where the presence of β-glucan by 2.4 - 7.4% in full barley, and the difference in the ratio of β-glucan is due to different genetic traits. The results also indicate a high percentage of β-glucan in flour with (BFE) to reach (3.9, 4.54%) in the two varieties respectively. This corresponds to the findings of [33] who indicated that β-glucan was higher in endosperm than other parts of the grain. The moisture content was 9% and 7.8% in the β-glucan extracted from WBF, and 8.7% and 7.8% for BFE. This is in line with the findings of [42], who indicated that the moisture content of the β-glucan extract was 3.6 to 10.8% when studying the β-glucan extract from different sources (Table 4). β-glucan has a high moisture content due to its high water-binding ability because it is a colloidal compound, which is important in food processing because it increases the product's improvement as it also increases the volume of bread [34]. The same table shows that the percentage of proteins in β-glucan extracted from WBF was (4.4, 5.6%) respectively, and extracted from BFE was (5.7, 5.3%), respectively. The proportion of proteins in BFE from WBF increased, this was confirmed by [43], when they studied the effect of milling operations on the chemical content of whole barley flour and extracted it by 65%. [42] Reported that β-glucan extracted from barley flour contains (5.3%) proteins.

The high-water holding capacity (WHC) of the β-glucan extracted from the WBF was 630% and 752% for the cultivars IPA 99 and 265 respectively, compared to β-glucan extracted from BFE, which was 527% and 604% for the two varieties mentioned above. This is in line with the findings of [42], where WHC was 500-600% for β-glucan derived from yeast. The difference in WHC between the two varieties may be due to the different effect of the extraction and drying methods on the rheological properties of β-glucan. [30] Reported that the polyglucan polysaccharides network can be formed when β-glucan units are associated with water, this association is affected by the extraction method of β-glucan and drying.
Table 4. Percentages of $\beta$-glucan in the barley varieties IPA.99 and IPA.265 with different extraction rates, moisture and protein content in $\beta$-glucan and its ability to water holding capacity

| Cereals varieties | $\beta$-glucan % | Moisture % | Protein % | Water Holding Capacity(WHC) |
|-------------------|------------------|------------|-----------|----------------------------|
| WBF (IPA 99)      | 3                | 9          | 4.4       | 630                        |
| BFE (IPA 99)      | 3.9              | 8.7        | 5.7       | 527                        |
| WBF (IPA 265)     | 3.3              | 7.8        | 5.6       | 752                        |
| BFE (IPA 265)     | 4.54             | 7.86       | 7.3       | 604                        |

3.4. Determination of pentosanes in barley varieties

The percentage of pentosanes in the barley flour of IPA 99 and IPA 265 prepared with different extraction ratios. The results indicated that the percentage of pentosanes in WBF was (12.6, 7.8) % for the class of IPA 99 and IPA 265 respectively, while the percentage pentosanes in flour with a (BFE) were (6.0 - 8.77%) in the two varieties under study. The increase in the ratio of pentosanes in class 265 was due to genetic and environmental differences. This is in line with the findings of [35] when they studied 50 varieties of six-row barley seedlings grown in three regions of Finland, the percentage of pentosanes in their results were (7.3 -11%).

The increase in the percentage of pentosanes in WBF compared to a flour with BFE is due to the increase of this component in the whole barley grain compared with endosperm barley grain. This was confirmed by [28] when comparing the presence of pentosanes and $\beta$-glucan between whole grains content and their content in endosperm for barley, oats, and wheat. This explains the importance of eating whole grains to get the highest proportion of dietary fiber. Pentosanes play an important role in increasing water uptake and increasing the volume of bread produced, as well as having a positive effect on the properties of Staling because they reduce the amount of starch available for crystallization [32] (Table 5).

Table 5. The percentage of pentosanes in the barley flour varieties IPA 99 and IPA 265 with on (WBF) and (BFE)

| Barley varieties | (WBF) IPA 99 | (BFE)IPA 99 | (WBF) IPA 265 | (BFE)IPA 265 |
|------------------|--------------|-------------|---------------|--------------|
| Pentosanes %     | 7.8          | 6           | 12.6          | 8.77         |

3.5. Effect of added gluten on the weight, size and specific volume of the barley bread

3.5.1. The effect of added wet gluten (WG) on the weight, size and specific volume of the bread produced from the barley flour Class IPA 99

Table 6 shows the effect of the addition of protein wheat (gluten) (WG) to bread mix on the weight, size and specific volume of bread manufactured from (BFE) IPA99, (treatment A). The results indicate an increase in the weight of the prepared bread with an increase in the amount of added gluten. The statistical analysis reveals that the differences insignificant among the treatment except for AT7.
There was also an increase in volume and specific volume with each increase in the quantity of added (WG) and significantly (P <0.05) to reach the highest value in size and specific volume at the treatment AT5 where it was (635 cm³ and 3.3 g / cm³) respectively, compared with the control treatment of AT 7, which size and specific volume were 240 cm³ and 1.43 g / cm³ respectively. This is consistent with [17], which found a positive relationship between the amount of gluten added to the flour and the volume of the resulting bread and also that the (WG) gave better results than the dry gluten in the bake test when it was fortified with wheat flour. The results of the same table show that gluten of broken wheat has a higher effect on the specific volume of bread, the specific volume was 2.5, 2.6, 2.7, 2.8, and 3.3 for treatments (AT1, AT2, AT3, AT4, AT5) respectively, compared with AT6 and AT7. The specific volume of the AT5 was higher than that of [24] when they estimating the specific volume of the Yemeni wheat varieties Al-Boni and the Samarra and varieties of American and Australian wheat where the specific volume were 2.02, 2, 2.49, 2.91 g / cm³ respectively.

Table 6. Effect of added wet gluten extracted from broken wheat on the weight, size and specific volume of bread produced from (BFE) class IPA.99 (experiment A)

| Treatments | Weight (g) | Size (cm³) | Specific volume (cm³/g) |
|------------|------------|------------|------------------------|
| AT1        | 175 bc     | 440 c      | 2.50 ab                |
| AT 2       | 180 abc    | 480bc      | 2.60 ab                |
| AT 3       | 184 ab     | 510 b      | 2.77 a                 |
| AT 4       | 182 ab     | 510 b      | 2.80 a                 |
| AT 5       | 190 a      | 635 a      | 3.30 a                 |
| AT 6       | 183 ab     | 310 d      | 1.70 bc                |
| AT 7       | 167.3 c    | 240 f      | 1.43 c                 |
| LSD value  | 13.08 *    | 41.57 *    | 1.066 *                |

* (P<0.05).

3.5.2. Effect of added wet gluten (WG) on the weight, size and specific volume of the bread produced from the barley flour class IPA.265

The effect of the addition of (WG) extracted from broken wheat on the weight, size and specific volume of bread produced from barley flour class IPA265 (experiment B). The results indicate an increase in the weight of the prepared bread with an increase in the amount of added gluten. This increase was insignificant except for the treatments BT5 compared to control treatments BT7.

There was also an increase in volume and specific volume with each increase in the quantity of added (WG) and significantly (P <0.05) to reach the highest value in size and specific volume at the treatment BT 5 where it was (635 cm³ and 3.34 g / cm³) respectively, compared with the control treatment of BT7, which size and specific volume were 240 cm³ and 1.5 g / cm³ respectively. This corresponds to [17] that there is a direct correlation between the amounts of added gluten and the volume of bread produced (Table 7).
Table 7. Effect of added (WG) extracted from broken wheat on the weight, size and specific volume of bread produced from (BFE) class IPA.265 (experiment B)

| Treatments | Weight(g) | Size(cm³) | Specific volume(cm³/g) |
|------------|-----------|-----------|-----------------------|
| BT. 1      | 178.1 a   | 405 c     | 2.27 bc               |
| BT. 2      | 180.0 a   | 500 b     | 2.70 ab               |
| BT. 3      | 179.1 a   | 525 b     | 2.90 a                |
| BT. 4      | 190.0 a   | 620 a     | 3.26 ab               |
| BT. 5      | 190.1 a   | 635 a     | 3.34 ab               |
| BT. 6      | 184.0 a   | 300 d     | 1.63 c                |
| BT. 7      | 160.0 b   | 240 d     | 1.50 c                |
| LSD value  | 12.94 *   | 73.04 *   | 0.825 *               |

* (P<0.05).

3.6. Sensory characteristics of Barley Bread

3.6.1. The sensory characteristics of the laboratory bread manufactured from the barley flour (BFE) class IPA.99

Results of the sensory evaluation of the laboratory bread manufactured from the (BFE) class IPA 99 and supported by (WG) extracted from broken wheat (Tables 8). Statistical analysis showed that there were significant differences (P <0.05) in the specific volume of the loaf bread for all treatments with gluten-supported and significantly higher (P <0.05) for the sensory characteristics of the treatments with higher (WG) ratios compared with control-treatment bread and bread barley subsidized by 20% (CG).

The results showed that the two treatments with support ratios of 20-22% of (WG) (AT4, AT5) obtained a higher specific volume for the bread compared with the control treatment (unrefined barley flour), as well as with barley flour supplemented with 20% (CG). Both treatments received the best sensory scores compared with all other treatments. The higher specific volume of the gluten-supported bread than the unsupported flour is due to the ability of the gluten to form a network that has the ability to capture the CO2 gas produced by the biological activity of the yeast.

The highest percentage of added gluten, the greatest the ability of the network to hold the gas and increased the specific volume of the bread [17] [27] , demonstrated that there is a positive relationship between the amount of added gluten and the resulting bread volume. The addition of (WG) gave better results than the addition of dry gluten. Sensory evaluation of the processed bread was consistent with that of [15] which confirmed the improvement of the flavor of the bread produced from the medium flour quality, symmetry of form and crust and texture of crumb after 2% support of vital gluten. This was in line with the results reported in Tables (8), which showed improved sensory scores with increased levels of added gluten. Table (8) showed significant differences (P <0.05) in the total sensory evaluation for AT4
and AT5, which achieved the highest degree of sensory evaluation (90.1, 95.8%) respectively, compared with AT1, AT2, AT3, AT6, was (78.4, 84.2, 84.8, 54.3 and 49.3%) respectively.
This is due to the effect of (WG) used (20-22% on a dry weight basis), which improved the sensory characteristics of the produced bread as well as increased nutritional value. This is confirmed by [15] and [19], which indicated that the addition of gluten positively affects the improvement of the rheological characteristics of the dough and production with good specifications.

![Figure 1. Superior treatment in the experiment A. AT5(22% gluten), (BFE)+ (WG)](image)

Table 8. The results of the sensory evaluation of the bread produced from the (BFE) class IPA.99 and supported by wet gluten extracted from the broken wheat

| treatments | Bread volume | Color of crust | Symmetry of form | Evenness of bake | Grain of crumb | Color of crumb | Texture of crumb | Aroma and taste | Total score |
|------------|--------------|----------------|------------------|-----------------|----------------|----------------|-----------------|----------------|-------------|
| Degree     | 30           | 10             | 5                | 5               | 10             | 10             | 20              | 100            |
| AT1        | 22.8 b       | 8.1 A          | 3.8 a            | 4.2 a           | 8.1 ab         | 8.6 ab         | 8.3 A           | 14.5 B         | 78.4b       |
| AT2        | 26.1 ab      | 9.0 A          | 4.2 a            | 4.4 a           | 8.6 a          | 8.6 ab         | 8.8 a           | 14.5 b         | 84.2b       |
| AT3        | 25.18ab      | 9.3 A          | 4.3 a            | 4.5 a           | 8.5 a          | 8.7 ab         | 8.7 a           | 16.4 b         | 84.8b       |
| AT4        | 25.45a       | 9.4 A          | 4.7 a            | 4.7 a           | 9.3 a          | 9.4 a          | 9.2 a           | 18.0 A         | 90.1a       |
| AT5        | 30.0 a       | 9.6 A          | 4.5 a            | 4.5 a           | 9.1 a          | 9.5 a          | 9.5 a           | 19.1 a         | 95.8a       |
| AT6        | 15.3 c       | 4.6 B          | 2.3 B            | 2.5 b           | 5.5 bc         | 6.8 bc         | 5.3 b           | 12.0 c         | 54.3c       |
| ACT 7      | 13.0 c       | 4.0 B          | 2.1 B            | 2.5 b           | 5.1 c          | 6.4 c          | 4.7 b           | 11.5 c         | 49.3c       |
| LSD value  | 5.266 *      | 2.533 *        | 1.006 *          | 1.622 *         | 2.746 *        | 2.056 *        | 2.832 *         | 2.24 *         | 6.82 *      |

NS . * (P<0.05).
3.6.2. The sensory characteristics of the laboratory bread manufactured from the (BFE) class IPA265 Tables (9) show the results of the sensory evaluation of the laboratory bread manufactured from the (BFE), IPA265 and supported by (WG) extracted from broken wheat.

The results of the statistical analysis showed that there were significant differences ($P <0.05$) in the specific volume of the loaf bread for all treatments with gluten-supported and significantly higher ($P <0.05$) for the sensory characteristics of the treatments with higher (WG) ratios compared with control-treatment bread and bread barley subsidized by 20% commercial gluten.
Table 9. The results of the sensory evaluation of the bread produced from the (BFE) class IPA 265 and supported by (WG) extracted from the broken wheat treatments

| treatments | Bread volume | Color of crust | Symmetry of form | Evenness of bake | Grain of crumb | Color of crumb | Texture of crumb | Aroma and taste | Total score |
|------------|--------------|----------------|------------------|------------------|---------------|----------------|------------------|----------------|-------------|
| Degree     | 30           | 10             | 5                | 5                | 10            | 10             | 10               | 10             | 100         |
| BT. 1      | 20.6b        | 7.1a           | 3.3 bc           | 3.5 ab           | 7.3 a         | 8.1 a          | 7.7 a            | 15.8 a         | 73.5b       |
| BT. 2      | 27.69b       | 8.8a           | 4.1ab            | 4.2a             | 8.2a          | 8.7a           | 8.5a             | 17.6a          | 86.5a       |
| BT. 3      | 27.7b        | 9.3a           | 4.8a             | 4.4a             | 8.6a          | 9.0a           | 9.0a             | 18.0a          | 89.7a       |
| BT. 4      | 29.5a        | 9.4a           | 4.3ab            | 4.3a             | 8.6a          | 9.3a           | 8.5a             | 18.3a          | 92.3a       |
| BT. 5      | 30.0a        | 9.2a           | 4.2ab            | 4.4a             | 8.4a          | 8.8a           | 8.8a             | 18.5a          | 92.3a       |
| BT. 6      | 20.7d        | 3.6b           | 2.2c             | 2.4b             | 3.6b          | 4.0b           | 3.5b             | 8.4b           | 42.5c       |
| BT. 7      | 20.5d        | 3.3b           | 2.3c             | 2.3c             | 3.6b          | 4.0b           | 3.3b             | 8.5b           | 40.9c       |
| LSD value  | 3.266 *      | 3.094 *        | 1.255 *          | 1.075 *          | 2.662 *       | 2.317 *        | 2.657 *          | 4.39 *         | 7.13 *      |

* (P<0.05).

Table (9) showed significant differences (P<0.05) in the total sensory evaluation between (BT2, BT3, BT4, BT5) which achieved the highest degree of sensory evaluation (85.5, 89.7, 92.3, 92.3%) respectively, compared with (BT6, BT7) were (40.9, 42.5%) respectively. This is due to the effect of (WG) used (16, 18, 20, 22% on a dry weight basis), which improved the sensory characteristics of the produced bread.

Figure 4. Superior treatment in the experiment B. BT5 (22% gluten), (BFE) + (WG)
3.7. Chemical composition of laboratory bread product

Table (10) shows the chemical composition of the laboratory bread manufactured from (BFE) class IPA99 and class IPA265, supported by (WG) extracted from broken wheat, for superior treatments in the statistical analysis of sensory evaluation AT5, BT5 (figure 1 and figure 4). The results showed that the percentage of protein in the fourth and fifth treatments was 25.8 and 26.6% respectively, compared with the first, second and third treatments which were (14.1, 10.7 and 11.3% respectively), the high protein content was due to the addition of (WG) to (BFE).

This is in line with [15], who indicated that the addition of gluten to flour improves the quality of the bread and increases its nutritional value. The percentage of carbohydrates in the fourth, fifth treatments were 60.4 and 57.5%, respectively, compared with the first, second and third treatment which were 74.5, 74.1 and 74.6%. While it is noted that the proportion of fat in all treatments were close and did not differ significantly from some. The results showed that the percentage of fiber in the fourth and fifth treatments were (1.3 and 1.8%) respectively and less than the fiber ratio in the second and third treatments where it was 3.8 and 3.6% respectively, the first treatment was where (1%).

Ratio ash of the fourth and fifth treatments was 2 and 1.8, which is an approach to control treatment which was 1.8%. The ratio of protein, fiber, and ash in the treatments with the addition of gluten was higher than that in wheat bread for the study of [31], which were 10.24, 0.08, 0.9%, respectively.

It is noticed from Table (10) that the bread produced from (BFE) and supported by the (WG) extracted from the broken wheat, obtained in this study, are a rich source of protein (25-26.6%), double the proportion of protein in wheat bread. This product is also rich in fiber (1.3 - 1.8%), which is equivalent to one and a half times what is found in wheat bread, and the proportion of carbohydrates in this product decreased by more than 15% compared to normal wheat bread. This bread is more nutritious and healthier than bakery products produced from wheat.

Table 10. Chemical composition of the laboratory bread manufactured from (BFE) supported by (WG) extracted from broken wheat

| Chemical content% | 1st treatment | 2nd treatment | 3rd treatment | 4th treatment | 5th treatment |
|-------------------|--------------|--------------|--------------|--------------|--------------|
| Moisture          | 6.0          | 6.0          | 6.0          | 7.8          | 9.4          |
| Fat               | 2.6          | 2.7          | 2.7          | 2.7          | 2.8          |
| Protein           | 14.1         | 11.3         | 10.7         | 25.8         | 26.6         |
| Fiber             | 1.0          | 3.6          | 3.8          | 1.3          | 1.8          |
| Ash               | 1.8          | 2.3          | 2.2          | 2.0          | 1.8          |
| Carbohydrate      | 74.5         | 74.1         | 74.6         | 60.4         | 57.5         |

1st treatment mean bread prepared from Turkish wheat flour + the basic ingredients of the dough.
2nd treatment mean bread made from (BFE) IPA.99+ the basic ingredients of the dough.
3rd treatment mean bread made from (BFE) IPA265+ the basic ingredients of the dough.
4th treatment mean bread prepared from the (BFE) IPA.99 + (WG) of broken wheat + the basic ingredients of the dough.
5th treatment mean bread prepared from the (BFE) IPA.265 + (WG) of broken wheat + the basic ingredients of the dough.
4. Conclusions
Experience and sensory experience indicated that broken wheat gluten can be used in its wet state to improve the qualitative and sensory characteristics of barley bread and make it similar to wheat bread with an increase in protein and fiber content and reduced carbohydrate content in prepared bread.

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