Fortification Of Laboratory Bread with Oat Flour and Study of Effect on Sensory and Nutritional Characteristics

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Abstract

The study was conducted in the laboratories of the Faculty of Agriculture, Tikrit University, where bread was made fortified with oat flour in different proportions (5-25)%, as differences were observed between the proportions of the ingredients, the humidity in the treatment to which oat flour was added increased 5% to record 33.15%, as well as the percentage of fat, protein, ash, and fiber increased to (1.2 ,13.87 3.06 ،,3.41)% respectively, but the percentage of carbohydrates in the standard treatment increased to be 73.36%. Through the analysis of mineral elements, it was noted that sodium increased to 0.535 ppm for the added treatment of 25% oat flour, while other mineral elements such as potassium, calcium, iron, and zinc recorded an increase for the added treatment of 20% oat flour to be (28.43, 2.16, 0.24, 0.19) ppm. Also, the estimation of amino acids for oat flour-fortified bread gave different ratios of amino acids compared to the standard treatment, as most of the amino acids increased due to the difference in the percentage of addition. Strengthening bread with oatmeal helps to raise the nutritional value of bread in addition to reducing the risk of kidneys on the body, and it also contributes to filling the Daily need of micro and macro nutrients needed by the body.

Keywords :

Introduction

Bread is the main food of most of the peoples of the East due to its nutritional importance, it provides a person with his nutritional needs, which have often been addressed in previous studies. Bread is a bakery product that is priced according to its taste, aroma, taste, and texture and is a staple food that is prepared by baking a dough of flour and water. Salt, fat, and yeast are present as common ingredients [1]. Oatmeal is characterized by its high protein content and provides essential amino acids well, and it also contains fats in a good proportion, including unsaturated fatty acids. Adding different proportions of oat flour to wheat bread to produce healthy bread can increase its nutritional value but at the same time degrade its physical properties [2]. The increase is obvious in the content of proteins, crude fiber, ash, and fats, but a significant decrease in the carbohydrate content and calorific value of processed products was recorded with an increase in the addition of oatmeal up to 30% [3]. The production of bread with a 30% oat flour substitute improves the diet and organoleptic properties of bread, as it gives a high amount of fiber and beta-glucan to lower cholesterol in the blood, which reduces the risk of heart disease, and

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reduces the absorption of glucose in the blood, which increases the satiety period [4]. The replacement of oatmeal leads to an increase in nutritional value, but in turn, it deteriorates the consistency of wheat bread. The results indicated that the ratio of oat beta-glucan (OBG) in bread decreased from 7.86 to 1.88 g/100 g, while the total phenols and aminobutyric increased almost threefold for sprouted barley flour [5]. The nutritional composition of oats distinguishes it from other cereals, as it provides a rich source of proteins, fats, dietary fiber, vitamins, minerals, and unique polyphenol compounds. Oats are famous for their high content of beta-glucan, which has various functional applications in the food industry. The chapter provides a detailed examination of the nutrients contained in oats, including protein, oil, carbohydrates, dietary fiber, minerals, and vitamins. It emphasizes the importance of beta-glucans, tocopherols, and antioxidants in the nutritional profile of oats and their potential health benefits [6]. This study aims to replace part of wheat flour with oat flour to reduce the effect of kidneys on people with kidney sensitivity, and other cereals can be an alternative to wheat in the production of various types of bread .

Material and Methods

Wheat flour, oat flour, almond flour, fat, sugar, salt, and yeast were obtained from local markets ،the method used by AL-Nasiry (2009) [7] and the ingredients used were based on the weight of the flour, the flour was (100) g, yeast (1) g, sugar (0.5) g, salt (1) g, water according to the absorbency of the flour, oat flour, and almond flour was also used in the proportions of (5 10 15 ،20 ،25.% (

Method: the ingredients are weighed in advance, part of the water is added to make a sugar-salt solution and the other part to dissolve the yeast, noting the use of warm water (up to 32 m) the ingredients are added to the flour, including the raw materials that are under study (oatmeal, almond flour) and all mixed manually until the dough is fully cooked, the dough is balled by hand and placed in a container intended for fermentation, this process is carried out at a temperature of 30-32 M and relative humidity of at least 85% the duration of primary fermentation lasts for 45 a minute .

This is followed by the process of gas ejection punching for seven seconds, after which the dough piece is returned to the fermenter as it enters the secondary fermentation stage (rest period of 10 minutes), followed by the forming stage, and here the same method is used as mentioned in AACC 10-10 (1976) [8] after forming the final fermentation process is carried out for 60 Minutes under the same conditions, then the baking process is carried out at a temperature of 225 M and for 25 minutes after the end of baking the laboratory bread is left to cool in the room atmosphere.

Measuring the Volume of Laboratory Bread:

The volume of laboratory bread was measured manually using the seed displacement method for millet.

Estimation of mineral elements

The mineral elements in the Oatmeal bread samples were estimated, which included (sodium, potassium, iron, calcium, zinc) according to the method adopted by A.O.A.C (2019) by incinerating 3 g of samples at a temperature of (350 0C) until white ash is obtained, then dissolve the resulting ash in (5 ml) of 5% nitric acid and mix it well, then filter the mixture and take (1 ml) of the filter and complete the volume with distilled water

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to (10 ml) using an atomic absorption spectrometer.

Chemical Tests Performed on Laboratory Bread :

Humidity Estimation

The percentage of humidity was estimated according to the mentioned method A.O.A.C (2019) [9] by a Rapid moisture test device at a temperature of 105 m until the weight was fixed.

Fat Estimation

The percentage of fat was estimated according to the method mentioned in A.O.A.C (2019) [9] using the Soxhlet extraction device using petroleum ether.

Protein Estimation

The percentage of protein was estimated by the microkeldahl method according to A.O.A.C (2019) [9] then multiply the resulting amount of nitrogen by the coefficient 6.38 to extract the protein ratio.

Ashes Estimation

I followed the standard method mentioned in A.O.A.C (2019) [9] at a temperature of 550 m and the samples were left until obtaining a whitish-gray color.

Carbohydrate Estimation

Calculated by the method of calculating the difference between the components (moisture, fat, protein, ash) subtracted from the 100 mentioned in AOAC (2019) [9] and as follows :

Total carbohydrates % = 100 – (moisture % + ash % + fat % + protein.(

Estimation Of Amino Acids by HPLC Apparatus for Laboratory Baking:

Estimation and diagnosis of amino acids in cake mugs diagnosis and estimation of amino acids in bread products containing pieces and by a device using high-efficiency liquid chromatography (HPLC) located in the al-Yaqeen laboratory for chemical, clinical, and biological analyses in Nineveh Governorate, adopting standard separation conditions and using a separation column (3.5 mm-3-150 mm) C-18 and at a temperature of 80 m, the mobile phase consisted of acetone and water and was read at 250 NM. mineral estimation the elements were measured in the laboratories of the Department of Chemical Engineering-automatic analysis laboratory using the atomic absorption spectrometer type-6200SHIMADZU AA .-

Results and Discussion

The chemical composition of the bread to which oat flour is added. The results in Table (1) showed the chemical composition of bread with added oatmeal significant differences at the level of $0.05 < p$. The results of humidity showed that the highest percentage was 33.15% when adding 5% oats, while the lowest percentage was 13.09% in the standard treatment. This change is because oats contain a high content of fiber that absorbs water, such as beta-glucan, which increases the moisture content of the dough. Fiber contributes to the absorption of water and the formation of jelly, which increases the moisture of the dough and makes the dough softer and easier to knead, improving the final baking properties. These results do not agree with (Litwinek et al., 2013) [10], which showed that the moisture content may reach 41.5% in bread with added oat flour and in approximately the same proportions. As for what he found Carocho et al., 2020) [11], his results for humidity were similar to what was obtained in the study, as he stated that the percentage of moisture in bread with added oatmeal reaches 33%.

When the fat results of the same table were observed, they differed significantly to give the highest fat percentage of 1.21% for the treatment to which 25% oats were added, but the percentage decreased to 0.79% in the

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standard treatment. Oats contain natural fats such as unsaturated fatty acids, which contribute to improving the texture and flavor of bread by interacting with gluten and other proteins in the dough. These healthy fats help improve flavor and texture, but you should be careful not to increase the percentage of fat to avoid unwanted fatty taste and reduce the shelf life of bread due to the increased likelihood of oxidation. It was found (Rashed et al., 2024) [12] that the percentage of fat in the sample produced from wheat flour recorded a fat percentage of 0.61%, that is, it is similar to what was found in the studied standard transaction, while the percentage of fat in the transactions with added oat flour in different proportions ranged from (3.5-5.5) %, and this percentage is higher than recorded by the studied transactions.

The percentage of protein in the transactions showed significant differences, as the protein percentage increased to 13.87% for the added 25% of oats, but decreased to 9.69% in the standard treatment. The high protein content is due to the fact that oats contain a high content of vegetable proteins such as avenins, which enhance the nutritional value of bread and support the structure of the dough by interacting with gluten. These results correspond to what was stated (Litwinek et al., 2013) [10] that the percentage of protein in bread with added oatmeal may reach 13.36%, and (Carocho et al., 2020) [11] that the percentage of protein in bread produced from wheat flour is 9.5%, and these results are consistent with what was found in the study.

As for the ash percentage, the highest percentage was recorded at 3.06% for the treatment with 25% added oats, and the lowest percentage was 2.03% in the standard treatment. The high ash content is because oats contain a variety of minerals such as potassium, calcium, iron, and zinc, which increase the nutritional value of bread. (Temnikova, 2021) [13] showed that oatmeal contains a high content of mineral elements, as the percentage of ash increases with the high percentage of addition.

When observing the percentage of fiber in the transactions for the same table, it was found that the percentage of fiber in the added transaction of 25% oats increased to a record 3.41%, while it decreased in the standard transaction to 1.04%. The dietary fiber contained in oats, such as beta-glucan, contributes to better digestion and increases the nutritional value of bread. It has been shown (Grgić et al., 2024) [14] that oat flour has a fiber content ranging from (9.29 - 20.51) % and that the addition of oat flour increases the fiber content of the bread produced.

With regard to the percentage of carbohydrates, it increased to 73.36% in the standard treatment, while it decreased to 48.65% in the treatment containing 25% oat flour. The low carbohydrate content is due to the fact that oats contain less carbohydrates than buckwheat, which makes bread suitable for those who follow a low-carb diet. (Miśkiewicz et al., 2024) [15] found that oatmeal contains carbohydrates, but most of them are maltose, sucrose, and glucose, these are consumed by yeast during the fermentation period, which reduces their percentage in baking products

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Table 1. Chemical composition of bread with added oat flour

Transactions	Carbohydrates (%)	Fiber (%)	Ash (%)	Protein (%)	Fat (%)	Moisture (%)
Control	73.36 ± 0.001	1.04 ± 0.001	2.03 ± 0.001	9.69 ± 0.001	0.79 ± 0.001	13.09 ± 0.001
5% Oats	49.30 ± 0.001	2.09 ± 0.001	2.17 ± 0.001	12.23 ± 0.001	1.06 ± 0.001	33.15 ± 0.001
10% Oats	51.33 ± 0.001	2.40 ± 0.001	2.37 ± 0.001	12.56 ± 0.001	1.12 ± 0.001	30.22 ± 0.001
15% Oats	54.09 ± 0.001	2.76 ± 0.001	2.58 ± 0.001	12.63 ± 0.001	1.14 ± 0.001	26.80 ± 0.001
20% Oats	52.02 ± 0.001	3.11 ± 0.001	2.79 ± 0.001	13.62 ± 0.001	1.18 ± 0.001	27.28 ± 0.001
25% Oats	48.65 ± 0.001	3.41 ± 0.001	3.06 ± 0.001	13.87 ± 0.001	1.21 ± 0.001	29.80 ± 0.001

Mineral Elements for Baking the Product Added to Oat Flour

Minerals are necessary for the proper formation of body fluids including blood, and are also important for the proper formation of tissues, bones, teeth, muscles, and nerves. Minerals also play an important role in maintaining nerve health and functioning, regulating muscle movement, and promoting the health of the cardiovascular system.

The results are shown in Table (2) when analyzing the effect of the addition of oats on the properties of bread, we find noticeable changes in the mineral elements of the bread produced, as the results showed that the sodium content in the added treatment is 25% oatmeal, while its content decreased to 0.46615 ppm when adding 20% oats. The decrease in sodium content is attributed to the fact that oats contain less sodium than buckwheat, which reduces the total sodium content in the dough when replacing part of the buckwheat with oats. The increase in sodium content when adding 25% oats can be explained by a change in the balance of mineral ions in the dough, as the fiber contained in oats can contribute to a reaction with mineral salts, which leads to a redistribution of sodium in the dough.

As for the potassium content, the highest percentage was 28.4315 ppm when adding 20% oats, and the lowest percentage was 17.20405 ppm when adding 25% oats. Oats have a high potassium content, which increases the total potassium content in the dough. The decrease at 25% oats can be the result of the interaction of dietary fiber with potassium since fiber can absorb some mineral ions and reduce their bioavailability .

The calcium content was recorded at 2.16595 ppm when adding 20% oats, while it decreased to 1.2842 ppm at 25% oats. Oats have a high calcium content, which increases the total calcium content in the dough. The decrease of 25% can be the result of chemical reactions between calcium and other components in oats, such as phytates, which can form insoluble complexes with calcium, reducing its bioavailability.

The results showed that the highest iron content was 0.24451 ppm at 20% oats, and the lowest content was 0.18225 ppm at 25% oats. Oats have a high iron content, which increases the total iron content in the dough. The decrease of 25% can be due to interactions between iron and other active substances in

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oats, such as tannins, which can form complexes that reduce iron absorption.

As for zinc, the highest content was 0.194625 ppm at 20% oats, and the lowest content was 0.1424 ppm at 25% oats. Oats have a high zinc content, which increases the total zinc content in the dough. The decrease of 25% can be attributed to the interactions of zinc with phytates in oats, which form complexes that reduce the bioavailability of zinc .

It has been shown (Alemayehu et al., 2021) [16] that oatmeal has a good content of mineral elements such as calcium, potassium, iron, zinc, and magnesium, which can provide part of the daily requirement of mineral elements needed by the body .

These results are consistent with those (Rybicka & Świgło, 2017) [17], as sodium, potassium, and copper were similar to what they found in the proportions of these mineral elements in oatmeal, and the percentage of addition increases the content of these elements in the product.

Table 2. The content of minerals in samples with oats.

Samples	The ratio of oats	Zn (ppm)	Fe (ppm)	Ca (ppm)	K (ppm)	Na (ppm)
2	5%	0.1569	0.19834	1.49886	20.0294	0.5215
3	10%	0.170825	0.211983	1.727648	22.78185	0.50034
4	15%	0.18292	0.22772	1.92792	25.6072	0.4822
5	20%	0.194625	0.24451	2.16595	28.4315	0.46615
6	25%	0.1424	0.18225	1.2842	17.20405	0.53552

Amino Acids for Bread Added to Oatmeal

The results for the bread produced through the HPLC machine are shown in Table (3) for the standard treatment and Table (3) for the added oatmeal, the percentage of Lysine was 23.1%. When 5% oats were added, the percentage decreased to 5.8% and then increased significantly to 40.5% when 25% oats were added. Oats contain a high concentration of Lysine, which increases its percentage when added. The initial decrease may be caused by interaction with the components of the groats, since Lysine can bind to other proteins in the dough, reducing its availability. As the percentage of oats increases, a greater amount of Lysine is available to compensate for the initial decrease and increase the overall percentage .

As for Serine, in pure buckwheat, the percentage of Serine was 15.5%. In the samples mixed with oats, the highest percentage of Serine was 10.7% in the proportions of 10% and 15% oats, and the lowest percentage was 1.8% when adding 25% oats. Oats contain less Serine, as a result of which its percentage decreases when mixed in large quantities. Changes may be the result of the interaction of amino acids with other proteins in the dough since Serine can bind to proteins differently at different concentrations of oats, which affects its availability .

As for Glutamic Acid, in pure buckwheat, its percentage was 10.1%. In the samples mixed with oats, a significant increase was observed at 10% and 15% oats, reaching 22.6%. Oats enhance the glutamic Acid ratio when mixed in small to medium amounts. Irregular changes may be the result of

chemical reactions that lead to the redistribution of this amino acid. Glutamic Acid can bind to other proteins in the dough, increasing its availability at certain concentrations of oats.

As for Cystine, in pure buckwheat, its percentage was 8.1%. In samples mixed with oats by 20%, it increased to 24.6%. Oats have a high content of Cystine, which increases its percentage when added. Irregular changes may be the result of complex interactions between amino acids and other proteins in the dough. At different concentrations of oats, the ability of Cystine to form disulfide bonds can change, which affects its availability.

As for Valine, in pure buckwheat, its percentage was 4.5%. In samples mixed with oats by 25%, it increased to 10.9%. Oats enhance the percentage of Valine when added. The changes may be the result of chemical reactions leading to a redistribution of this amino acid. Valine can bind to other proteins in the dough, which affects its availability at different concentrations of oats. And finally, for Methionine, in pure buckwheat, its percentage was 6.5%. In samples mixed with oats by 25%, it increased to 10.9%. Oats have a high content of Methionine, which increases its percentage when added. Irregular changes may be the result of complex interactions between amino acids and other proteins in the dough. At different concentrations of oats, the ability of Methionine to form bonds with proteins can change, which affects its availability. Shabolkina et al., (2023) [18], have shown that oats contain a high content of amino acids, which can meet the individual's needs, and they also meet the specifications and standards mentioned by both the Food Organization and the World Health Organization.

Table 3. Amino acids for bread added to oatmeal.

The ratio of oats	**Control**	**5%**	**10%**	**15%**	**20%**	**%25**
Aspartic Acid	23.1%	0.4%	0.5%	0.5%	0.5%	**0.2%**
Glutamic Acid	15.5%	5.8%	22.6%	22.6%	6.7%	**2.2%**
Histidine	10.1%	5.7%	13.4%	13.4%	8.1%	**0.7%**
Serine	8.2%	10.3%	10.7%	10.7%	7.5%	**1.8%**
Glycine	8.1%	6.9%	4.8%	4.8%	1.7%	**1.5%**
Threonine	6.5%	7.9%	5.9%	5.9%	3.8%	**0.3%**
Arginine	5.2%	6.4%	4.8%	4.8%	2.8%	**0.1%**
Alanine	4.5%	8.3%	8.3%	8.3%	4.8%	**0.3%**
Cystine	4.4%	9.9%	9.0%	9.0%	24.6%	**3.1%**
Valine	2.9%	8.7%	3.9%	3.9%	14.5%	**10.9%**
Tyrosine	1.8%	4.4%	9.3%	9.3%	5.8%	**6.5%**
Methionine	2.0%	3.3%	1.9%	1.9%	7.1%	**10.9%**
Isoleucine	3.8%	6.5%	2.2%	2.2%	9.8%	**6.2%**
Leucine	0.4%	6.2%	2.7%	2.7%	8.6%	**1.9%**
Phenylalanine	3.4%	9.4%	9.3%	9.3%	9.3%	**40.5%**
Lysine	23.1%	5.8%	5.3%	4.7%	6.4%	**9.4%**

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