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Research Article

Effect of Adding Local Rice Malt on the Qualitative and Rheological Properties of Low-Gluten Wheat Flour

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Author Details

Ahmed A. Abdullah* and Dhia F. Al-Fekaiki

Authors Affiliations

Food Sciences Department - College of Agriculture - University of Basrah, Iraq

Corresponding Author*

Ahmed A. Abdullah

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Abstract: This study was conducted to improve the qualitative and rheological properties of the local wheat flour, Ibaa/99 cultivar (80% extraction), which suffers from low gluten, by adding local rice malt (Jasmine cultivar) as an improver to the flour. The chemical composition showed that the percentages of moisture, protein, ash, fat, and carbohydrates in the flour were 12.8%, 8.2%, 0.9%, 1.8%, and 69.3%, respectively, while the percentages after germination were 13.8%, 8.6%, 1.5%, 1.4%, and 66.5% respectively. The flour was treated by adding rice malt to show its effect as an improvement in the rheological properties of the dough. The results were that the malt showed a "positive" effect on the rheological properties of the dough after adding it to the flour in proportions of 1, 2, and 3 g\100 g flour, as the addition ratio of 2 g\100 g was the best. Between the ratios used according to the Farinograph and Extensograph readings. It was observed when conducting the baking test that there was a significant decrease in the weight of the loaf with a significant increase in both the volume and the specific size in all the used ratios. Still, the addition ratio of 2 g\100g was the best among the used ratios. Sensory evaluation results showed a "significant" improvement in loaf samples' external and internal characteristics.

Keywords: Rice malt, Rheological properties, Baking making.

INTRODUCTION

Rice is the staple food for most of the world's population. Because of the quantity and quality of the nutrients, it contains and the different methods of consumption (Li and Yang, 2020). Rice in its complete form contains more fiber, starch, and a variety of proteins and fats compared to its polished form, which contains mainly starch with some protein fractions. Some cultivars of colored rice also contain antioxidant compounds that are beneficial for health (Krishnan et al., 2021).

Because rice is consumed in different forms, many rice products have been developed in light of different methods, such as dry parboiled rice, softening, and quick cooking, including some processes that stimulate germination (Zhong *et al*., 2020). These parameters not only affect the amount of nutrients (free amino acids, vitamins, etc.). One such method is germination; germination increases the bioavailability of nutrients such as carbohydrates and proteins; an increase in some active compounds such as gamma-aminobutyric acid (GABA) and antioxidants was also found. Germination also increases fiber levels, stimulates bioactive compounds' production, and sometimes reduces compounds that are expendable or harmful to human nutrition, such as phytates (Xia *et al*., 2017).

Germination modifies the dough's rheological properties and gas retention (Chaijan and Panpipat, 2020). The enzymatic activity is increased in the germinated grain, which may have advantages or disadvantages depending on the conditions under which germination occurs. The enzymatic activity can improve the functional properties of the dough. It makes greater enzymatic activity hydrolyze larger molecules that can be easier to digest and generate bioactive compounds.

Due to the lack of local studies on sprouted Iraqi rice, this study was conducted on some rice cultivars.

The study aimed to:

- Conducting chemical tests for local rice grains, Jasmine cultivar, before and after germination.
- Studying the effect of adding rice malt on the rheological properties of flour.
- The use of rice malt as an improved material in the loaf industry and as a flavoring agent in the cake industry.

MATERIALS AND METHODS

Iraqi rice grains of Jasmine cultivar (Oryza sativa L.) for the agricultural season 2020-2021 were obtained from Al-Mishkhab Research Station in Al-Mishkhab District, Najaf Governorate. The study was conducted in the laboratories of the Food Research and Consumer Protection Unit, College of Agriculture, University of Basra. The rice grains were well-cleaned from foreign substances, harvesting materials residues, impurities, and damaged grains. It was packaged in polyethylene bags, information was recorded on it, and kept refrigerated.

Malt Production

The malt was produced according to the method of Biruma *et al*. (2012). The grains germinated at a temperature of 18-20 ◦ C; during the germination period, the grains were moistened with water. Soaking stages include soaking the grains in water for 48 hours at a temperature of 18-20 ◦C, with washing and changing the soaking water every 12 hours. The grains were dried for 12 hours in a convection oven.

Chemical Tests

The percentage of moisture and fat of the local rice grains, the Jasmine cultivar, was estimated according to the method mentioned in A.O.A.C. (2000). As for the ash, it was estimated using the Muffle furnace incineration device at 500 ºC according to the method mentioned in A.O.A.C. (2000). While the percentage of protein was estimated according to the Kjeldahl method mentioned by Pearson (1970). The percentage of total nitrogen was extracted and multiplied by the general protein coefficient (5.7). The percentage of carbohydrates was calculated by the difference from the aforementioned components, as indicated by Pearson (1970).

Rheological Properties Determination

1- The Farinograph Test

Perform this test according to the method described in A.A.C.C. (2012) using a Farinograph device with a basin of 300 g flour based on a moisture content of 14% equipped by the German company Brabender. In the quality control laboratory of the grain processing company in Baghdad.

2- Extensograph Test

Perform this test according to the method described in A.A.C.C. (2012) using the Extensograph equipped by the German Brabender company, which contains two units (Balling unit, Rolling unit) in addition to three rooms called rest cabints equipped by the German Brabender company.

Table (1) Percentages of Malt Added to Flour

No.	Treatments	Amount of malt added (g)
1	standard sample	0
2	A	1
3	B	2
4	C	3

Baking Tests

The method mentioned in AACC (1976) was used to prepare laboratory bread and followed the straight dough method. Adding rice malt improved the loaf industry in varying proportions ranging between (0, 1, 2, 3)/ g100 of used flour. With an adjustment to the proportions of some of the basic components of the mixture, where 100 g of flour was mixed with 3 g of yeast, 6 g of sugar, and 1.5 g of salt, and the amount of water was added according to the readings of the Farinograph for absorbency.

Sensory Evaluation of Loaves

The sensory evaluation of laboratory bread was carried out according to the evaluation system used by the American Institute of Baking (Dalby and Hill, 1960). According to the grades specified in the aforementioned institute form.

Statistical Analysis

The results were analyzed statistically using a completely randomized design (CRD). The differences between the means were tested using the least significant difference test according to the R.L.S.D test, and all analyses were conducted using the statistical program Spss (2012).

RESULTS AND DISCUSSION

Physical Tests of Rice Grain and Malt Product

The Speed of Grain Absorption of Water

During the germination process, the first stage is the grain's absorption of water, which is mainly affected by the permeability of the grain, which is important during germination and bud production. How quickly the grain takes in water depends on the water-holding capacity of the grain and the amount of water available to soak the grain. The rate of water absorption due to osmotic effects decreases with increasing concentration of dissolved substances in water. Starch synthesis contributes significantly to water absorption (Ikram *et al*., 2020). It is noted from Figure (1) that the time required to raise the moisture content of rice grains to 44-45% is 48 hours to start the germination process. This may be attributed to obtaining Iraqi rice cultivars in the same harvest season. Al-Fekaiki (2013) showed significant differences between the periods required to raise the moisture content to 44-45% ranging from 20-60 hours depending on the type of grain. This discrepancy is due to the differences in the composition of the grains of protein and cellulose and their initial moisture content before starting the soaking process.

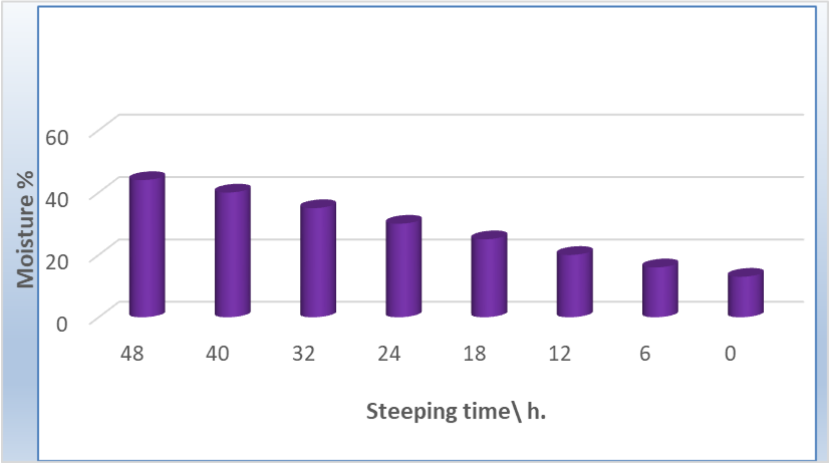


Figure 1: Estimation of the Water Absorption Rate of Rice Grains

Germination Strength

The germination strength of rice grains was estimated at 96% for the cultivar Yasmine, as shown in Table (2). These results agreed with Osuji *et al*. (2019). It recorded germination rates that ranged between 97-98%, and it is noted that the higher the germination rate, the higher the seed size accompanied by an increase (Osuji *et al*., 2019). A germination test can be defined as a measure of the ability of seeds to germinate. The seed germination test is used to assess the suitability of seeds for planting, categorize the quality of the problem and the solution, and control specific drying and curing requirements and related procedures for future use. Ensure that the seeds meet the specified quality standards. It is also an important test for price determination (Gill and Singh, 2020).

Table (2): Percentage of Live Embryos and Strength of Germination in Rice Grains

Percentage of live embryos and strength of germination in rice grains, Jasmine cultivar					
No.	**Cultivar**	**live embryos**			**Strength of germination%**
		Normal	**Un normal**	**Dead**	
1	Jasmine	94	4	2	96

Chemical Tests of Rice Grain and Malt Product

The moisture content of the rice grains of the cultivar Jasmine before and after germination was estimated to be 12.8% and 13.8%, respectively. The differences were significant between the two percentages at a significant level ($P < 0.05$). As shown in Table (3). The results agreed with what was reached by Osuji *et al*. (2019), as moisture levels ranged between 5-11% in sprouted and non-germinated rice for different cultivars of rice. These results also agreed with Wireko and Amamoo (2017), whose moisture content ranged from 11.46-15.17% in some rice cultivars. It also agreed with the findings of Priya *et al*. (2019). The moisture content ranged between 9.3-12.94% among rice cultivars.

The differences in the moisture content of the un-sprouted rice can be attributed to environmental conditions such as climate, soil, processing conditions, and storage period of rice grains after harvest. That increase in the amount of moisture in the sprouted rice results from the soaking process to raise the moisture content to 45-50% during the germination process, increasing the moisture content in the sprouted grains, which makes the moisture content higher even after the drying process. Moisture content is an indicator of the quality of the grain and also gives information about the consistency of the ground grain. (Osuji *et al*., 2019). As for the average percentage of fat in rice grains, it was 1.8 and 1.4% before and after germination, respectively, for the same cultivar, and the differences were non-significant between them at ($P < 0.05$), as shown in Table (3). The results are consistent with the findings of Osuji *et al*. (2019). The fat percentage in non-germinated rice ranged between 2.90-5.42% for different rice cultivars, while the germinated rice samples ranged from 0.97-1.94%. The results also agree with the findings of Wireko and Amamoo (2017), which showed that the fat percentages ranged between 0.49-2.57 %, according to the rice cultivars. The lower lipid content in sprouted rice may be due to the increased activity of lipolytic enzymes during germination, which breaks down fats into fatty acids and glycerin. That germination is due to the activity of embryos that contain higher fat percentages than in the outer layers of bran (Osuji *et al*., 2019).

As for the average percentage of protein in rice, it was estimated at 8.2 and 8.6% before and after germination, with significant differences between them at ($P < 0.05$), as shown in Table (3). These results largely agreed with the findings of Osuji *et al*. (2019), which showed that the protein percentages were 7.7-8.9% in sprouted rice cultivars and 6.7-8.9% in non-germinated rice cultivars. The results also agreed with Wireko and Amamoo's (2017) findings, which showed that the protein content ranged from 5.6-8.4% among some rice cultivars. The increase in protein content in sprouted rice compared to un-sprouted rice can be attributed to the early developmental response of the grain during steeping as the embryo begins to secrete gibberellic acid to complete the production of amino acids and provide what the embryo needs for growth. During germination, some higher molecular weight enzymes are produced as a percentage of the whole grain of rice, the protein and other compounds that result from proteolysis increase due to germination. This observation is consistent with other scientific research indicating that germination increases the nutritional quality of food products, especially in terms of their protein content. The increase in protein content was due to the increase in nitrogenous compounds (Laxmi *et al.*, 2015).

Table (3): Chemical Content of Jasmine Rice Grains

Cultivar	Moisture %		**Ash %**		**Protein %**		**Fat %**		**Carbohydrates%**	
	Before g.	**after g.**	**Before g.**	**after g.**	**Before g.**	**after g.**	**Before g.**	**after g.**	**Before g.**	**after g.**
Jasmine	12.8	13.8	0.9	1.5	8.4	9.3	1.8	1.4	69.3	66

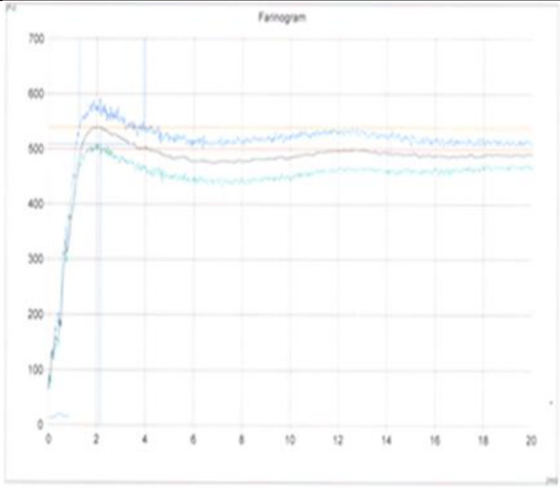
As for carbohydrates, they reached 69.3 and 66.5%, respectively, before and after germination, without any significant differences in the same cultivar. As shown in Table (3). These results agreed with the findings of Osuji *et al*. (2019). The average values of carbohydrate content for non-germinated rice ranged from 73.77-80.28%, while the values for germinated rice ranged from 79.78-84.84%. Also, the results agreed with the findings of Wireko and Amamoo (2017). The percentage of carbohydrates ranged between 47-79% as the highest and lowest value among rice cultivars. The results agreed with Priya *et al*. (2019) that the proportions of carbohydrates ranged between 64-73%. It is expected that the average values of the content of carbohydrates in sprouted rice would be lower than those found in non-germinated rice because, during the germination process, rice grains undergo various metabolic processes such as the decomposition of the endosperm, which results in increased availability of enzymes (Morris. *et al*. 2004; Osuji. *et al*., 2019).

As for the ash percentages, the results showed that the percentages were 0.9 and 1.5% before and after germination, respectively. The differences were significant at ($p > 0.05$). As shown in Table (3). These results are consistent with the findings of Osuji et al. (2019). The mean values of ash content in rice ranged between 0.49-1.95 % and agreed with what Wireko and Amamoo (2017) found. The ash percentage ranged between 0.5-1.95 % among rice cultivars. The ash content of the sample gives an idea of the available metallic elements (Wireko and Amamoo, 2017). Rice bran contains much more minerals than endosperm, and the tendency of rice bran to stick to the grain during grinding and polishing thus influences the ash content (Wireko and Amamoo, 2017). The minerals are more concentrated in the bran and then lost during milling and polishing when the bran is removed from the grain (Wireko and Amamoo, 2017).

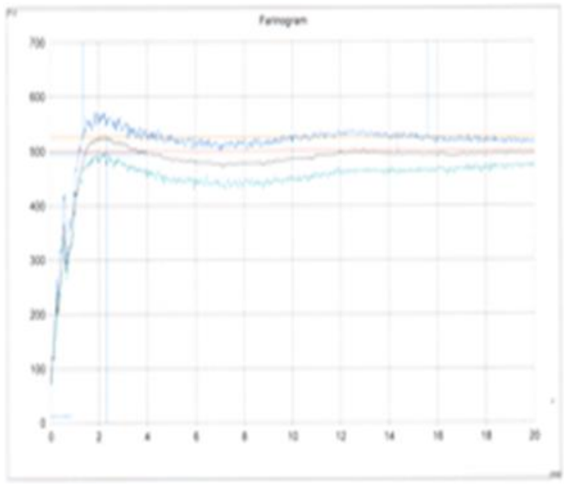
Rheological Properties

Farinograph Readings

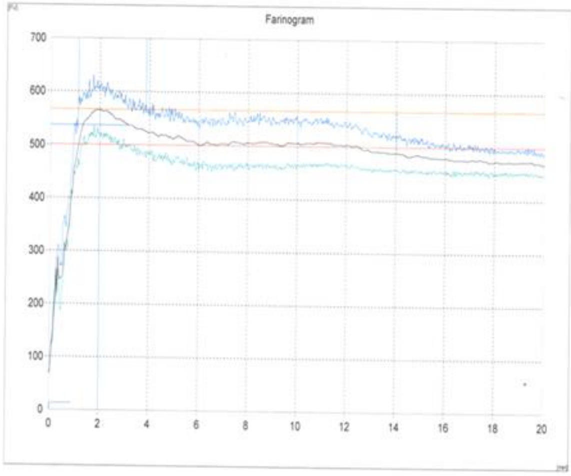
Farinograph readings of wheat flour treated with rice malt in addition to improving rheological properties, showed that the absorbance was at BU 500, which is the amount of water needed by the flour to form a dough with a resistance of 500 barbender. The results ranged between 65.10, 65.50, 65.20 and 65.20% for the samples (standard, A, B, C), respectively, as there were no significant differences between the treatments, as shown in Figure (2) modified absorbance at 14% humidity, the results ranged between 64.30, 64.10, 64.10 and 64.40% for the samples (Standard, A, B and C) respectively without any significant differences between the treatments. As for the dough development time in a minute, the highest time was in the standard sample and sample B, which amounted to 2.4 minutes, and the lowest time was for sample C, which amounted to 2 minutes. There were apparent differences between the treatments at the level ($p > 0.05$), as shown in Figure (2). While the stability time is in a minute, which is the period from the beginning of entering the curve to the line of 500 Brabender until exiting it. The highest stability time was for the standard sample, as it recorded 14.2 minutes. The rest of the treatments recorded a stability time of 2.7 minutes. The differences were significant between the standard and the rest of the samples at the level ($p > 0.05$). As shown in Figure (2). As for the degree of elasticity after 10 minutes of starting, the results showed that the degree of elasticity ranged between (38, 53, 58, 64) for the samples (Standard, A, B, C), respectively. The differences were significant between the treatments at a significant level ($p > 0.05$). While the degree of elasticity after 12 minutes of reaching the top, the values varied between (30, 47, 58, 77) for the samples (standard, A, B, C), respectively, and the differences were significant between the treatments at a significant level ($p > 0.05$). As shown in Figure (2). The decrease in the stability time of the dough due to the treatments indicates the activity of the alpha-amylase enzyme, which hydrolyzes starch and produces compounds with a low molecular weight characterized by its low ability to bind with water.



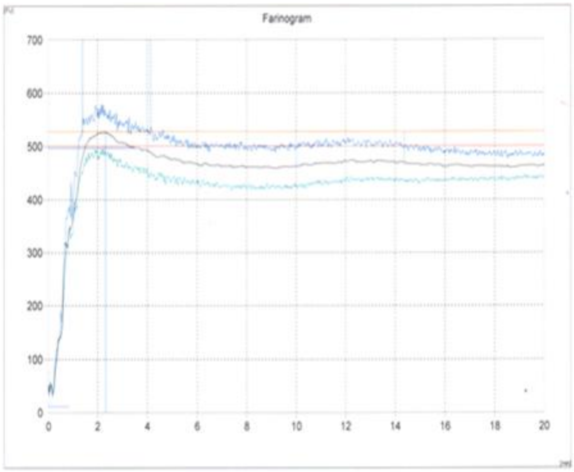
A Sample



Standard sample



C Sample



D Sample

Figure (2) Farinograph Graph for Flour Treated with Rice Malt Addition

Extensograph Readings

Rice malt was added in ratios (1, 2, 3) to wheat flour to identify its effect on the characteristics recorded by the Extensograph, Figure (3). This test indicates the fermented dough's resistance to a tensile force applied to it and gives the results as a curve. The following results recorded energy cm2; the results showed that the highest value was for sample C, which reached 129 at a time of 90 minutes and was significantly higher than the rest of the treatments at a significant level ($p > 0.05$). The increase in energy indicates the strength of flour and, thus, an increase in the volume of bread produced. Rubber resistance BU is the curve's height after 5 cm from the beginning of drawing the curve. The results showed that the highest value was for the standard sample and sample A, 983 and 985, respectively, at 135 minutes. It was significantly higher than the rest of the treatments at a significant level ($p > 0.05$) inflatables mm.

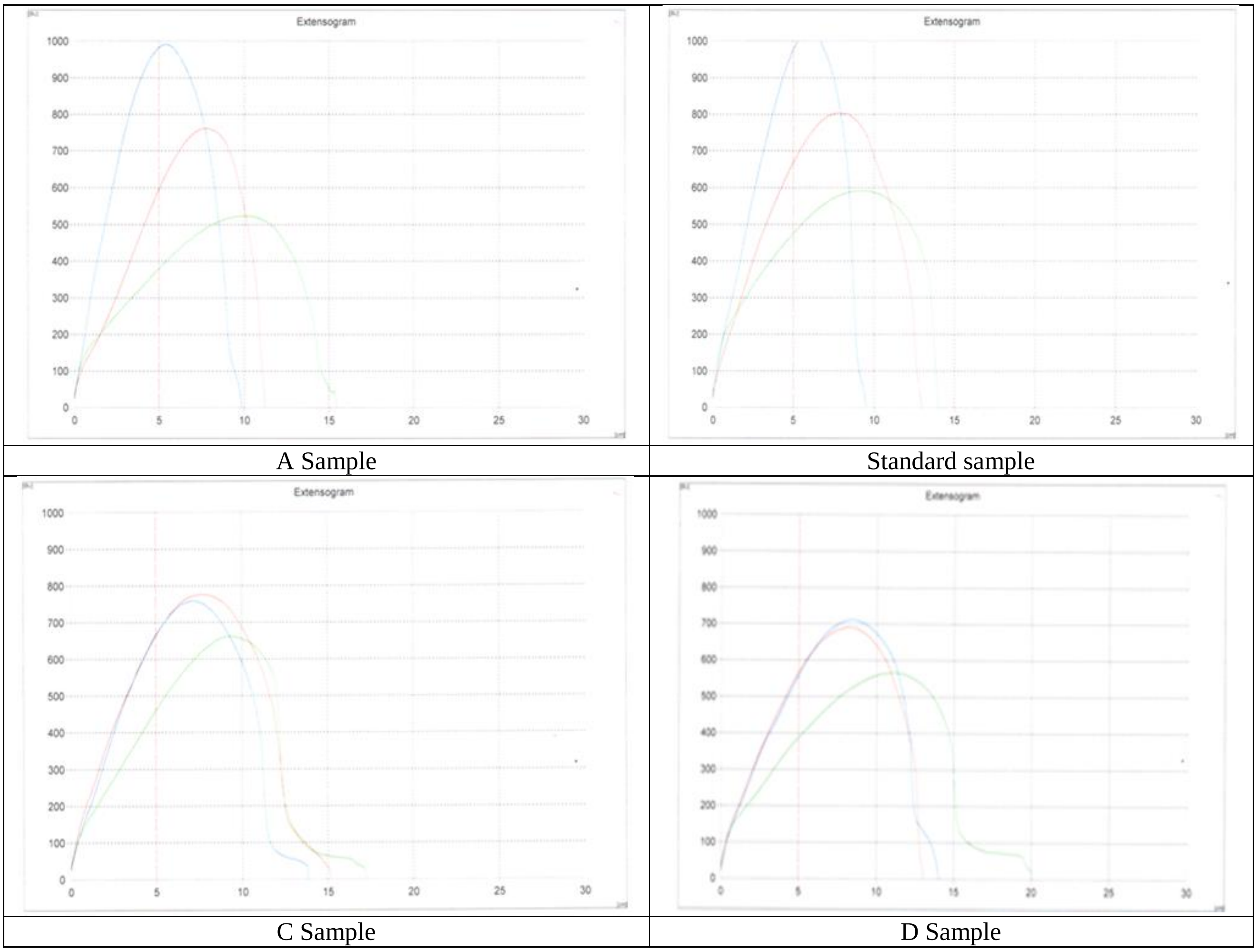


Figure (3) Farinograph Graph for Flour Treated with Rice Malt Addition

The results showed that the highest value was for sample number C, 173, at a period of 45 minutes and was significantly higher than the rest of the treatments at a significant level ($p > 0.05$). Elasticity refers to the curve's length, i.e., the dough's stretchability. The coefficient of elasticity is the ratio of the amount of resistance to the amount of elasticity. The higher percentage, more this means shrinkage of dough, and lower it means weakness and fluidity of dough. The results showed that the highest value was for the A and B samples, 10.3 and 10, respectively, at 135 minutes. It was significantly higher than the rest of the treatments at a significant level ($p > 0.05$).

Sensory Evaluation

The use of rice malt as an improvement in the loaf industry:

The results showed the addition of rice malt to the loaf industry in proportions that ranged between (0, 1, 2, 3) g /100 g flour: qualitative size characteristic, ranging from 7.6 of 10 for the standard sample and sample B, and sample A was recorded. The lowest value was 7.2 of 10, and no significant differences existed between the treatments. The characteristic of the color of the crust, the highest score recorded, was for the B sample, which reached 7.2/8, and the differences were significant at a significant level ($P < 0.05$) with the rest of the treatments. At the same time, the standard sample scored 5.4/8 degrees. The characteristic of dandruff, the highest score, was recorded for samples B and C, reaching 2.6 of 3, and the differences were significant at a significant level ($P < 0.05$) with the rest of the treatments.

Baking characteristic, the highest degree recorded was for the B sample, reaching 2.5 of 3. In comparison, the standard sample recorded 1.7 of 3 degrees. The differences were significant at a significant level ($P < 0.05$) with the rest of the treatments.

In contrast, the standard sample recorded 1.7 of 3 degrees. The characteristic of the similarity of the body, the highest score recorded, was for the B sample, as it reached 2.7 of 3, and the differences were significant at a significant level ($P < 0.05$) compared with the rest of the treatments. While the standard sample recorded 1.7 of 3 degrees. The characteristic of the spread line, the highest score recorded, was for the B sample, as it reached 2.4 of 3, and there were no significant differences between the treatments. While the standard sample recorded 2.1 of 3 degrees of granularity, the highest degree was for sample B, which reached 7.2 of

10, and there were no significant differences between the treatments. At the same time, the standard sample recorded 5.8 of 10 degrees.

Characteristic of the color of the pulp, the highest score recorded was for the B sample, which reached 8.4 of 10, and there were no significant differences between the treatments. In contrast, the standard sample recorded 7.4 of 10 degrees. Characteristic of the smell of pulp, the highest score recorded was for the C sample, which reached 8.3 of 10, and there were no significant differences between the treatments.

Table (4) Results of the Sensory Evaluation of the Laboratory Loaf

Degree	**10**	**8**	**3**	**3**	**3**	**3**	**10**	**10**	**10**	**15**	**10**	**15**	**100**
	External qualities						**Internal qualities**						
Treatment	**specific size**	**crust color**	**crust quality**	**Baking quality**	**Body symmetry**	**Spread cut line**	**granular quality**	**Pulp color**	**pulp smell**	**pulp taste**	**chewing**	**texture**	**Total**
Standard	7.6	5.4	1.7	1.7	1.7	2.1	5.8	7.4	7.1	9.5	7.3	10.8	68.1
A	7.2	5.6	2	1.8	2.2	2.3	6.4	7.5	7.1	10	8	11.5	71.6
B	7.6	7**	2.6**	2.5**	2.7**	2.4	7.2	8.4	8.1	11.3	8.3	12.17 **	80.8 **
C	7.5	7.2**	2.6**	2.3	2.2	2.3	6.8	7.7	8.3	11.4	8.2	12.1	78.6 **
LSD	0.4045	1.148	0.577	0.5544	0.4867	0.5658	2.549	1.154	1.255	2.355	1.146	1.76	8.58

The standard sample recorded 7.1of10 degrees. Characteristic of the taste of pulp, the highest score recorded was for curse C, reaching 11.4 of 15, and there were no significant differences between the treatments. The standard sample recorded 9.5 of 15 degrees. Chewing trait, the highest score recorded was for the B sample, which reached 8.3 of 10, and the differences were significant with the rest of the treatments at a significant level ($P < 0.05$). While the standard sample recorded 7.3 of 10 degrees. The stature characteristic, the highest score recorded, was for the B sample, as it reached 12.7 of 15, and there were no significant differences between the treatments. While the standard sample recorded 10.8 of 15 degrees. The highest score recorded for the total score was 80.8 and 78.6 of 100 for samples B and C, respectively. The differences were significant with the rest of the treatments at a significant level ($P < 0.05$). As for the standard sample, it recorded 68.1 of 100 degrees. As shown in Table (4).

It is possible to improve the quality of bread produced using sprouted grain (Guardado-Félix *et al*. 2020) (Debonne *et al*. 2018). This is due to the advantages of the germination process Tesli´c. *et al*. (2019), which increases the bioavailability of nutrients since some complex compounds are broken down into smaller components that are easier to digest and absorb by the human body (Bhinder *et al*. 2021). In addition, germination increases the amount of desirable compounds, such as phenolic compounds (Alkalthem *et al*., 2020), and some minerals, such as calcium, magnesium, zinc, and iron (Jan *et al*., 2018). It also improves dough properties (reducing viscosity and dough consistency) and, thus, the high quality of the bread produced (Codina *et al*. 2020).

Figure (4) The Side and Cross-Section of Laboratory Bread Treated with Rice Malt.

Adjusting the level of amylase activity in wheat flour is crucial for fermentation. Wheat flour contains small amounts of fermentable carbohydrates. Amylase acts on starch, which is present in large amounts in wheat flour, to produce maltose, which yeast uses to produce carbon dioxide, ethanol, and other fermentation products, resulting in more uniform and faster fermentation of dough (Codina *et al*., 2012).

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