Sakena Taha HASAN[1], Ali Flayeh AL-SARAJ[1], Zahraa M M AL-AMEEDEE[1], Ali M. SAADI[2*]

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Influence of Sesame Flour and Ascorbic Acid on the Nutritional and Rheological Qualitiy of Dough and Bread

Keywords: ascorbic acid, bread, sesame flour

1. Abstract

This study showed the effect of combining sesame flour, wheat flour dough, and ascorbic acid on nutritional qualities, rheology, and bread quality. The nutrient composition of sesame flour and wheat flour was analyzed: the sesame flour had lower carbohydrate content and higher levels of fat, protein, calcium, magnesium, zinc, and iron compared to the wheat flour.

The compound flour was prepared from replacement sesame flour with 10, 15, and 20% of wheat flour (72% extraction rate), ascorbic acid was added at a ratio of 0.1, 0.2, and 0.3% respectively to the best treatment of the replaced wheat flour with 10% sesame flour. Substituting wheat flour for sesame flour resulted in an increase in water absorption across all treatments when measured with the farinograph test. There was an increase in water absorption and stability time when ascorbic acid was added (0.1, 0.2, 0.3%) to the wheat flour sample replaced with 10% sesame flour compared to the control sample.

Sesame flour has higher quantities of mineral components, particularly calcium and magnesium, compared to wheat flour. Adding 10% sesame to sesame flour increased the mineral content compared to wheat flour.

The sensory qualities of the loaves made from a mixture of 10% sesame flour, 90% wheat flour, and 0.2% ascorbic acid showed improvements in volume, flavor, color, and texture when compared to the control sample.

[1] Department of Food Science and Technology, College of Food Science, Al-Qasim Green University, Babloon, Iraq
[2] Department of Anesthesia Techniques, Mosul Medical Technical Institute, Northern Technical University, Mosul, Iraq
* Corresponding author

Sakena Taha HASAN	Dr.sakina@fosci.uoqasim.edu.iq	https://orcid.org/0000-0002-6819-3430
Ali Flayeh AL-SARAJ	dr.aliflayehalsaraj@fosci.uoqasim.edu.iq	https://orcid.org/0000-0003-1119-5547
Zahraa M M AL-AMEEDEE		https://orcid.org/0009-0002-0050-6522
Ali M. SAADI	ali.mohammed@ntu.edu.iq	https://orcid.org/0000-0002-5779-1937

2. Introduction

Sesame (Sesamum indicum L.) belongs to the Pedaliaceae family and is one of the earliest oil crops consumed by humans. It is extensively cultivated because of its mild taste and significant nutritious content, which contributes to its widespread popularity in diets. Sesame seeds are high in protein and fats, offering numerous health advantages. (Wei et al.*,* 2022).

Bread is a fermented product made mostly from wheat flour, water, yeast, and salt. It is created by a sequence of steps involving dough mixing, fermentation, shaping, and baking. Other baked goods like biscuits and cakes are also made from wheat flour. (Nanyen et al.*,* 2016).

Sesame (Sesamum indicum L.) is an unconventional crop with unique bioactive components including sesamin, sesaminol, gamma-tocopherol, and various unsaturated fatty acids such as oleic acid, linoleic acid, stearidonic acid, palmitoleic acid, and small amounts of linolenic acid.

There is a growing interest in incorporating wheat flour with high-protein and high-lysine ingredients, such as legumes and oilseed flour, known as protein concentrate. The rise in protein content and enhancement of the nutritional value of the flour are attributed to the presence of key amino acids like arginine and lysine in sesame proteins. There are many efforts to combine high-protein sesame flour in a portion with wheat flour, as this aims to reduce the cost of expensive imported wheat and produce protein-rich bread. Sesame will enhance the protein, fat, and mineral levels of the biscuit, helping to reduce protein energy malnutrition (PEM) and numerous micronutrient deficiencies in those who consume it. In countries where using imported wheat for baking is prevalent, the expense of making biscuits is significant. (Ighere *et al.,* 2018). Sesame is rich in calcium, magnesium, iron, phosphorus, zinc, copper, manganese, selenium, molybdenum, vitamin B1, and dietary fiber. Sesame seeds include lignans, such as sesame and sesamolin, which help decrease cholesterol, prevent high blood pressure, and protect the liver from oxidation by providing vitamin E to the body. Sesame and sesame products include bioactive chemicals that provide unique health benefits, including protection against inflammation, cancer, hypocholesterolemia, coronary artery disease, and other chronic illnesses. (Dutta et al.*,* 2022)

Sesame contains a higher percentage of calcium than milk, but a lower percentage than eggshell powder. Ali et al. (2019) demonstrated that the calcium content in eggshells is 31040 mg/100g, whereas the sodium and potassium content is lower than that found in wheat flour.

Organoleptic features are crucial for customer approval of bakery products, with texture being especially important across all sorts of bakery items. Texture encompasses multiple sensory properties and is regarded as a crucial property for the quality of certain products. Texture plays a crucial role in shaping consumer perception and the value assigned to items. Ascorbic acid can enhance the quality of wheat flour by acting as an oxidant, which increases the total carbon dioxide production in wheat flour dough. The addition of ascorbic acid typically affects textural properties such as hardness, adhesiveness, springiness, cohesiveness, gumminess, chewiness, and resilience in the samples (Yildiz et al.*,* 2017).

The study aims to determine the impact of incorporating sesame and ascorbic acid into wheat flour to enhance the nutritional value, rheological characteristics, and sensory qualities of the bread.

3. Materials and methods

3.1 Materials

Wheat flour (whole meal flour), sesame seeds, instant yeast, salt, sugar, and sunflower oil were purchased at the local market in Babylon. Ascorbic acid was purchased from Alpha business with a concentration of 99.8%.

3.2 Preparation of sesame seed flour

The sesame seeds were purified to eliminate foreign substances, like dust and small plant remnants, and rinsed with fresh water. The ingredients were soaked in water for 24 hours, dried in an oven at 70°C for one hour, pounded into fine flour, sifted through a 338.6 micron sieve, and stored for 48 hours before use.

4. Methods

4.1 Rheological tests: Farinograph

The Farinograph test was conducted following the procedure outlined in AACC (2000) No. (54-21) with 300 grams of flour based on a moisture content of 14% (using three Repetitions).

4.2 Determination of Proximate Composition

The moisture using AOAC method 934.01 is for moisture determination, crude protein using AOAC 990.03, fiber using AOAC 978.10, ash using AOAC 900.02, and fat using (AOAC 984.20) contents of the wheat and sesame flour samples were analyzed (using three repetitions) using the AOAC (2010). The total carbohydrate content was calculated through subtraction. %Carbohydrate = 100% – (% moisture + % protein + % fat + % ash + % fiber)

4.3 Determination of mineral composition of flour, wheat, and sesame

The mineral composition of calcium, iron, magnesium, and zinc in the flour samples was analyzed using AOAC Official Method 984.27 (using three repetitions) via the method outlined in AOAC (2010).

4.4 Baking Tests

Preparing laboratory bread (the loaf):

The baking test is the ultimate measure of baking quality. The straight dough method was followed as outlined in AACC (2000) and numbered (10-10), with modifications made to ingredient amounts and fermentation time. The dough combination included 100g of flour, 2g of yeast, 1.5g of table salt, 4g of sugar, and 4g of sunflower oil. Water was added to each treatment based on the absorbance measured in the Farinograph at 30°C.

The first treatment: control sample without adding sesame.

The second treatment: same as control, but with the addition of 10% sesame seed to the total weight

The third treatment: same as control, but with the addition of 10% sesame seed with sesame at 10% and ascorbic acid at 0.2% to the total weight.

4.5 Sensory Evaluation

The surface and internal properties of the bread were evaluated using the American Institute of Baking (AIB) evaluation system developed by Dalby and Hill in 1960, with 20 experienced arbitrators.

4.6 Statistical analysis

The statistical analysis was performed using completely random design (CRD), and the averages were compared using the Dunkin polynomial test to determine the significance between the averages.

5. Results and discussion

5.1 Nutrient content of wheat and sesame flour

This study aimed to enhance the sensory and rheological characteristics of wheat flour dough by including sesame and ascorbic acid.

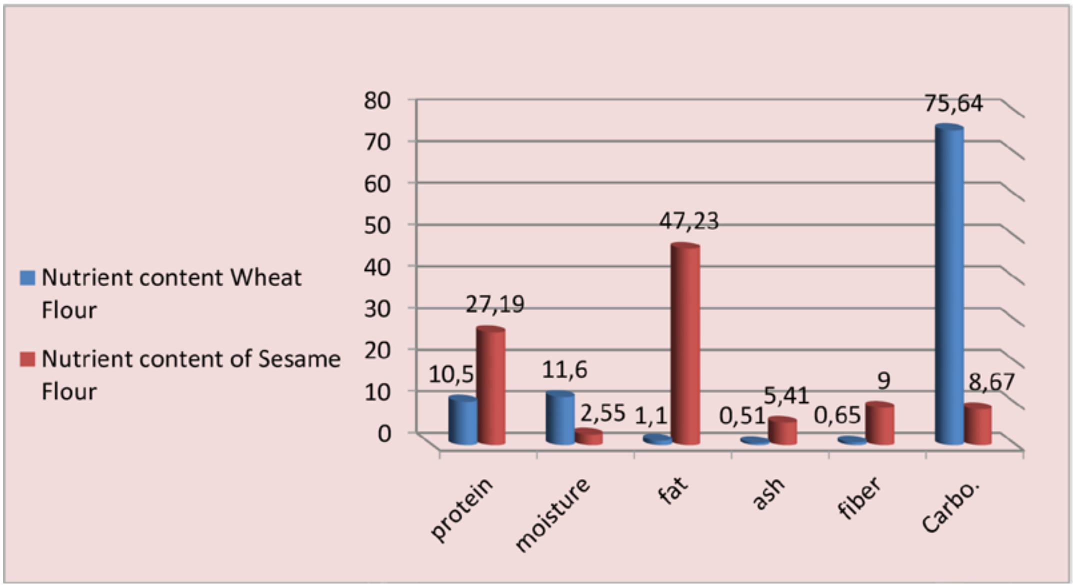

Figure 1: The nutrient contents of wheat and sesame flour

Figure 1 shows that sesame seeds have higher percentages of fat, protein, fiber, and ash, and lower percentages of moisture and carbohydrates compared to wheat flour, which is beneficial for health.

Sesame flour has a high fat content of 47.23%. It enhances the taste of the bread and extends its shelf life. Sesame oil also includes antioxidants. The findings align with Bilyk et al. (2018) on the fat content of sesame flour at 49.55%. Additionally, a larger protein percentage was observed in sesame seeds compared to wheat flour, consistent with Wei et al. (2022). Sesame seeds have a protein content of around 21.9%, which is of considerable biological significance.

The elevated fiber content in sesame seeds compared to the control sample is advantageous from a nutritional perspective. This finding aligns with the study conducted by Melo et al., 2021, which reported a fiber percentage of 6.22% in sesame seeds. Sesame has a low carbohydrate content of 8.67%, as confirmed by Aly (2020) who found it to be 11.03%.

6. Estimation of minerals

Figure 2 displays the mineral element content of wheat and sesame flour samples, with the sesame flour accounting for 10% of the mixture. The samples showed significantly higher levels of calcium, magnesium, zinc, and iron compared to the wheat flour, aligning with the results reported by Deme et al. (2017). The sesame has 5.23 mg of zinc, 342.78 mg of magnesium, 1158.83 mg of calcium, and 8.38 mg of iron per 100 g.

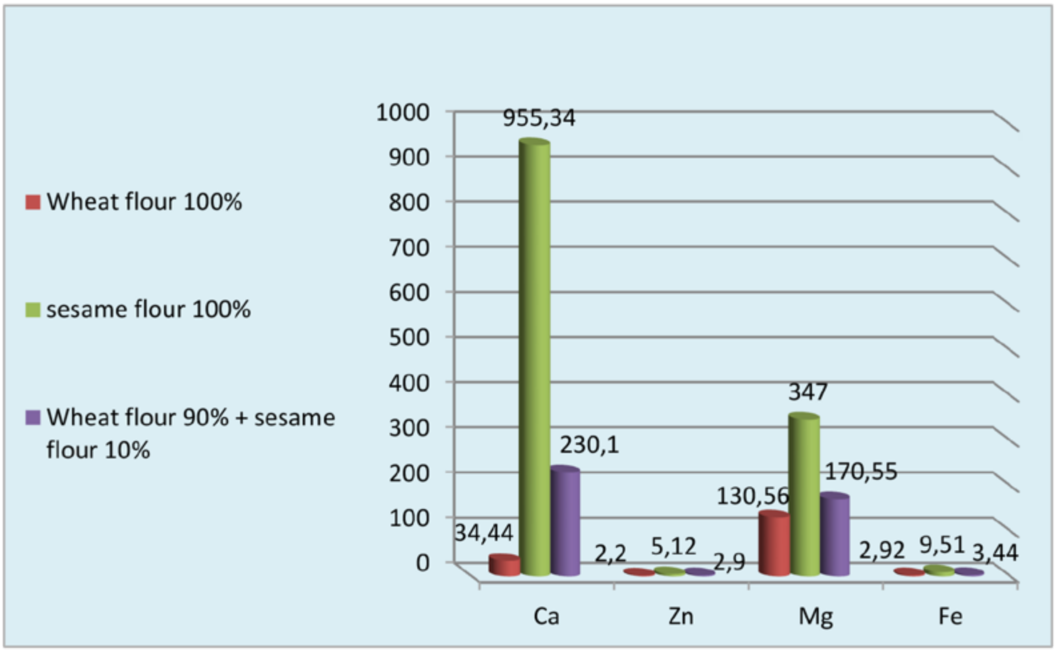

Figure 2: Content of some mineral elements in wheat and sesame flour

Iron, copper, zinc, and manganese are vital elements for plant growth at low concentrations, serving as enzyme activators. However, at greater concentrations beyond the maximum limit, they become toxic (Sajid et al., 2018).

Calcium is the third most prevalent mineral in intricate bread and is crucial for strong bones. Consuming bread made from wheat and sesame helps reduce osteomalacia and fragility. It is also utilized to decrease the likelihood of humans developing colon cancer by calcium's capacity to bind and enhance the release of bile and free fatty acids. Colon cancer was linked to diets lacking in calcium. (Heaney & Barger-Lux, 1994)

7. The effect of adding sesame and ascorbic acid on some properties of wheat dough, as measured by the Farinograph

Table 1 shows the effect of sesame mixture and ascorbic acid added to flour on the properties of the farinograph measurements.

The treatments including sesame at various percentages significantly increased water absorption compared to the control sample. The increased water absorption of flour and sesame combinations is likely attributed to the chemical composition of sesame, which contains significant levels of amino acids like lysine and polar oils. This study by El-Adawy, (1997) also reported similar findings, indicating that the inclusion of sesame in wheat flour resulted in an increase in water absorption for all additions.

Table 1: Effect of sesame flour and ascorbic acid on properties of wheat dough by Farinograph

Samples	Water absorption [%]	Dough development time [min]	Stability [min]	Mixing tolerance index [BU]
Control sample	60.0	6.3	6.5	76
90% wheat flour +10% sesame flour	61.1	6.7	5.5	24
85% wheat flour +15% sesame flour	61.8	11,7	4	4
80% wheat flour +20% sesame flour	62.5	0,4	0,2	8
90% wheat flour +10% Sesame flour +0.1% ascorbic acid	63.2	6,9	6.5	33
90% wheat flour +10% sesame flour +0.2% ascorbic acid	64.5	6.3	8.2	76
90% wheat flour +10% sesame +0.3% ascorbic acid	65.5	6.5	5.1	65.5

Dough stability measures the flour's capacity to withstand over or under mixing. Flours with strong mixing tolerance have a low mixing tolerance index, resulting in lengthy stability. The source is from Shuey, 1984. Table 1 demonstrates that the inclusion of sesame resulted in reduced dough stability and a higher mixing tolerance index in comparison to the control sample. The results obtained were compatible with El-Adawy's (1997) findings. The dough's stability decreased when sesame and isolated sesame protein were added compared to the control sample. This is attributed to the presence of sulfhydryl groups in sesame, which weaken the dough, and the addition of sesame lowers the gluten concentration (Deshpande et al., 1982).

The optimal amount of sesame added was 10%. Ascorbic acid was added in varying proportions (0.1%, 0.2%, and 0.3%) to enhance the rheological properties of a mixture of wheat flour and 10% sesame flour, improving water absorption and stability of all additives. The optimal reading indicates that adding 0.2% ascorbic acid increased dough stability by 8.2 minutes compared to the control sample's 6.5 minutes. The mixing tolerance index was higher at 76 BU for the treatment with ascorbic acid (Jafar et al., 2022).

Research has demonstrated that ascorbic acid facilitates various reactions in wheat flour, including the creation of disulfide bonds among water-soluble protein molecules and gluten, as well as the gelational oxidation of water-soluble pentosans.

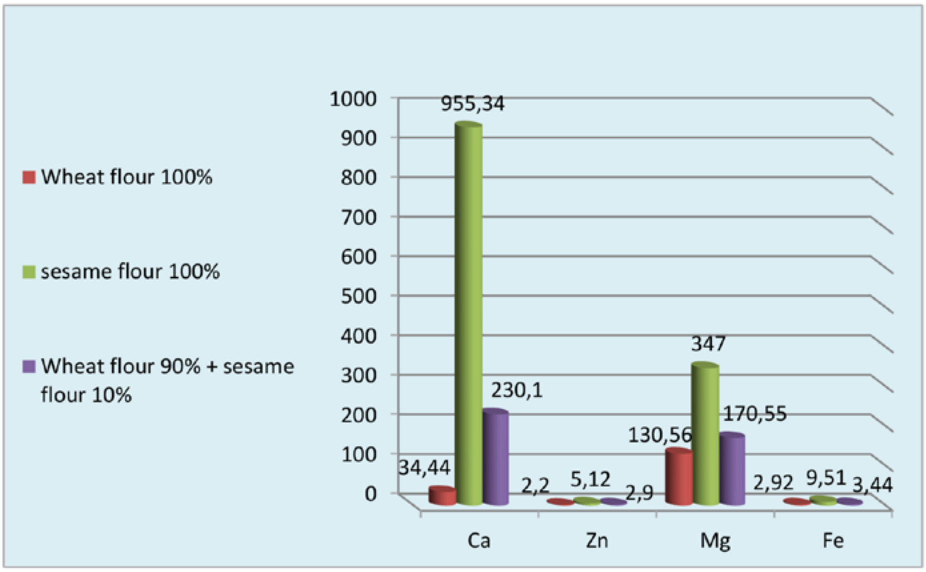

Figure 3: Effect on sample volume, sample weight, and specific volume of adding sesame flour and ascorbic acid to the wheat flour

8. Effects of adding sesame flour and ascorbic acid to wheat flour in specific bread volumes

There is a correlation between the rheological characteristics of the dough and the qualities of the bread produced. Thus, treatments such as enzymatic processes aimed at enhancing rheological qualities might enhance the quality of bread. There is a clear correlation between the value of this attribute and the quality of the bread. This characteristic's value is determined by measuring both the volume and weight of the loaf produced (Camargo and Camargo, 1987).

Figure 3 shows that adding sesame resulted in a decrease in the specific bread volume to 3.754 cm^3/g compared to the control sample. This is due to the high percentage of fiber in sesame flour, and the fact that sesame flour is gluten-free, which reduces the amount of gluten in the dough, which leads to less retention of carbon dioxide gas, and thus causes a decrease in the specific bread volume (Salama et al., 1992).

The sample containing 90% flour and 10% sesame was selected for its superior performance compared to other additives. Ascorbic acid was added at a rate of 0.2% to improve the specific bread volume. Although ascorbic acid (AH2) is a reducing agent, in bread dough it exerts an oxidizing, *i.e.* dough strengthening, effect through both an enzymatic and non-enzymatic pathway (Beghin et al. 2021).

The results showed that the use of ascorbic acid gave the best results for the specific volume, which was measured at 4.899 cm^3/g. These findings align with those of Elleuch et al. (2011) who observed similar results when adding sesame to wheat flour; the decrease in specific bread volume from 3.83 to 2.68 cm^3/g was caused by the dilution of the gluten network. This result aligns with Bilyk et al. (2018) findings, which showed a decrease in the specific bread volume when sesame flour was added to wheat flour.

9. Effect of adding sesame flour and ascorbic acid on the sensory characteristics of bread

Food product quality is typically linked to sensory assessment. Experienced individuals in the field are typically employed for this task, and their evaluation outcome generally mirrors consumer preferences for the food product. Ten academic members from the Department of Food Sciences evaluated the external and internal sensory features of bread baked with wheat flour (control), flour treated with 10% sesame, and flour treated with 10% sesame and 0.2% ascorbic acid. The recommended thresholds for sensory adjectives are as follows: excellent (90% and above), good (80-90%), fair (70-80%), and unsatisfactory (less than 70%) (Camargo and Camargo, 1987).

Table 2 demonstrates enhanced sensory attributes in terms of color, flavor, and taste. The bread sample with 10% sesame flour and 0.2% ascorbic acid showed superior sensory qualities in texture, flavor, taste, appearance, and volume compared to the control sample. This study aligns with Ighere et al. (2018) research on the acceptability and chemical makeup of bread made from sesame seed flour.

The crust of the bread sample darkened as sesame flour (SF) was added due to the high content of essential amino acids, particularly lysine, in sesame flour. The color turned browner as the level of SF increased, caused by the Maillard reaction between the proteins in sesame flour and the sugar additive. This work aligns with the research conducted by I. Mengeneh and Ariahu (2022). Acceptable biscuits with desirable sensory characteristics were made using a blend of wheat sesame seeds and millet flour.

Table 2: Effect of adding sesame flour and ascorbic acid on the sensory characteristics of bread

Sesame flour 10% +ascorbic acid 0.2%	Sesame flour 10%	Control sample	Parameters	Characteristics
External characteristics				
9^a	4^c	8^b	1-10	Volume
8^a	5^c	7^b	1-8	Crust color
2^b	1^c	3^a	1-3	Crust characteristics
3^a	1^c	2^b	1-3	Bread characteristics
3^a	1^b	3^a	1-3	Symmetry of form
3^a	1^c	2^b	1-3	Shred

Sesame flour 10% +ascorbic acid 0.2%	Sesame flour 10%	Control sample	Parameters	Characteristics
Internal characteristics				
9[a]	6[c]	8[b]	1-10	Grain
9[a]	6[b]	9[a]	1-10	Crumb color
13[a]	13[b]	10[c]	1-10	Aroma
12[a]	12[a]	10[b]	15	Taste
8[a]	7[b]	5[c]	1-10	Chew ability
13[a]	11[b]	9[c]	1-15	Crumb texture
92	**69**	**76**	**100**	**Total score**

** The different letters indicate that there are significant differences between the means.*

10. Conclusions

1. The sesame flour had lower carbohydrate content and higher levels of fat and protein as well as a higher percentage of calcium than wheat flour.
2. The incorporation of sesame flour into wheat flour with ascorbic acid resulted in higher water absorption and dough stability as determined by the Farinograph equipment.
3. The addition of sesame flour to the wheat flour decreased the specific bread volume, while the addition of ascorbic acid to the composite flour resulted in an increase in specific bread volume compared to the control.
4. Adding sesame flour to wheat flour enhanced the sensory characteristics, flavor, taste, color, softness, texture, and overall look of the loaves. Introducing ascorbic acid to the mixture enhanced the crumb texture, chew, shred, crust color, volume, and crust characteristics.

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