Journal of Nuts
Journal homepage: ijnrs.damghan.iau.ir

ORIGINAL ARTICLE

Investigating the Use of Chestnut Shells to Improve Brioche Characteristics

Khlood Waheeb*[1], Hussein S.H. Ridha[2], Mais Mazin Al-Hamdani[3], Thair L. Mizal[4], Hayder Tariq[5], Hanan Askar Hussny[6], Mustafa Abdulkareem Mustaf[7]

[1]*Al-Farahidi University, Medical Lab. Techniques Department, College of Medical Technology, Baghdad, Iraq*
[2]*Al-Nisour University College, Baghdad, Iraq*
[3]*College of Pharmacy, Al-Ayen University, Thi-Qar, Iraq*
[4]*Al-Esraa University College, College of Pharmacy, Baghdad, Iraq*
[5]*Al-Zahrawi University College, Department of Pharmacy, Karbala, Iraq*
[6]*National University of Science and Technology, Dhi Qar, Iraq*
[7]*Ashur University College, Medical Laboratory Technology, Baghdad, Iraq*

K E Y W O R D S

Ecotype;
Chestnut shell;
Dough samples;
Extensograph test;
Farinograph test

A B S T R A C T

To investigate the use of chestnut shell powder, an agricultural industry by-product, as a value-added ingredient for enhancing the nutritional profile of brioche bread, this study examined different factors such as rheological, chemical, volumetric, color properties. The study tested three levels of chestnut shell powder: 5%, 8%, and 10%. A positive correlation between the addition of chestnut shell powder and farinographic characteristics was found. Specifically, the samples containing chestnut shell powder showed higher levels of water absorption (increased by 5-10%), dough expansion time, dough resistance, and farinograph quality number (FQN) compared to the control sample without chestnut shell powder. The extensograph test showed an increase in most of the extensograph characteristics, except for the dough stretchability factor, in the samples containing chestnut shell powder compared to the control sample. In terms of colorimetric properties, the treatment with 10% chestnut shell powder had the lowest lightness score (41.8), while the control sample had the highest score (52.5). The values of redness and yellowness factors were also reported to be the lowest in the control (3.2, 13.9) and the highest in the E3 sample (5.7, 25.2). The chemical test results showed that treatment E3 had the highest values of moisture, ash, fiber, fat, and protein, while the control treatment had the lowest values. Overall, this study suggests that adding chestnut shell powder to brioche bread can enhance its quality and nutritional properties.

Introduction

Cereals have been an important part of human diet since ancient times, and they were among the first agricultural products cultivated by humans. These crops are rich in carbohydrates, fiber, vitamins, and minerals, making them a valuable source of nutrition for people all over the world (Guerrieri and Cavaletto, 2018; Román *et al*., 2019). Out of all cereals, wheat is particularly noteworthy due to its exceptional nutritional and technological properties (Simonato *et al*., 2021). It is widely consumed in many parts of the world, and bread, which is made from wheat flour, is one of the most popular and oldest foods known to

***Corresponding author**: Email address: amalhusseinabdullahamal@gmail.com
Received: 20 June 2023; Received in revised form: 25 July 2023; Accepted: 9 August 2023
DOI: 10.22034/jon.2023.1989375.1227

humanity. Bread is a staple food in many cultures and has been a symbol of sustenance and nourishment for centuries (Cappelli *et al*., 2020). In Iraq, bread holds a special place in the local cuisine and culture, and it is an essential part of daily meals. People in Iraq consume bread made from different types of grain flour, and they value bread that has high nutritional value and therapeutic properties. This is because bread is not only a source of energy but can also provide essential nutrients that promote good health and well-being (Nissan and Pasqualone, 2019; Muhialdin *et al*., 2022). In recent times, there has been increasing awareness about the importance of consuming nutrient-rich foods and sensory and nutritional attributes of nut trees (Chatrabnous *et al.*, 2018; Pakrah *et al.*, 2021), and bread makers have responded by creating new types of bread with added nutritional benefits. For example, some breads may contain whole grains, seeds, or nuts, which can provide additional fiber, healthy fats, and vitamins. These types of bread are becoming more popular among health-conscious consumers who want to incorporate more nutritious foods into their diets (Meyerding *et al*., 2018).

The high per capita consumption of bread in Iraq, which stands at about 300 kilograms, is a significant figure that highlights the importance of bread as a staple food in the country (Rasheed and Saeed, 2020; Rasheed and Salih, 2020). This consumption rate is much higher compared to the average per capita consumption of bread in the countries of the European Union, which is less than half of this amount (Brancoli *et al*., 2020; Lockyer and Spiro, 2020). This implies that bread plays a crucial role in the daily diet of the Iraqi people and is a necessary product that demands attention. Given the significance of bread in the diet of the Iraqi people, it is essential to focus on producing bread of good quality. This is crucial to ensure that the nutritional needs of the population are met, and people can consume bread without any health concerns (Kc *et al*., 2018). Hence, there is a need to pay special attention to the formulation, production, and distribution of bread in Iraq. Formulating the right type of bread that caters to the needs of the population is the first step in producing quality bread. The production process also needs to be standardized and quality-controlled to ensure that the bread produced meets the desired standards. Furthermore, efficient distribution channels need to be put in place to ensure that bread reaches all parts of the country and is readily available to the population.

Due to the low relative price of bread, there has been an increase in per capita consumption of bread in the country, which highlights the importance of examining the production situation. Additionally, there is a growing awareness of the importance of fiber in the daily diet, prompting researchers to explore ways to add this substance to widely consumed foods like bread (Saa *et al*., 2018; Ni *et al*., 2020; Ranaivo *et al*., 2022). Fiber is a crucial dietary component that confers numerous health benefits. It is a type of carbohydrate that the human body cannot digest, but rather passes through the digestive system largely unaltered. While fiber is often associated with its role in promoting digestion and relieving constipation, its effects extend beyond these processes. Fiber exhibits several benefits, including the ability to regulate blood sugar levels, reduce cholesterol levels, and improve satiety, which can facilitate weight management. Additionally, research has established that fiber promotes bowel regularity by adding bulk to stool and strengthening the intestinal muscles (Pu *et al*., 2020). For example dragon fruit with 0.7-0.9% water-soluble fiber, has several health benefits including its ability to aid in weight loss, improve digestion strengthen the immune system (Hossain *et al*., 2021).

One potential material for enriching bread is the chestnut kernel shell, which accounts for 10-12% of the chestnut's weight in the brown shell, while the remainder is the kernel (Hu *et al*., 2021; Guiné *et al*., 2022). This shell is a rich source of both soluble and insoluble fiber compounds, making its fiber content comparable to that of red beet, white cabbage, and oat bran. Furthermore, the chestnut shell contains high levels of phenolic compounds that have antioxidant properties, making it a valuable source of antioxidant dietary fiber (Aglietti *et al*., 2022). These compounds are concentrated in the outer shell of the chestnut, which is often discarded during processing. However, recent research has focused on developing methods to extract these phenolic compounds from the chestnut shell for use as a dietary supplement (Hu *et al*., 2021; Pinto *et al*., 2023).

The consumption of fiber is known to have numerous health benefits for humans. The lack of fiber in diets has been linked to several health problems, including constipation, cardiovascular diseases, and various types of cancers. Due to these potential health benefits, there has been an increasing interest in incorporating fiber compounds into foods.

Bread is one of the most widely consumed foods globally and is a staple food in many cultures. However, there is a dearth of studies exploring novel ingredients to enhance its nutritional value. This study aims to originally contribute by investigating the effects of incorporating chestnut shell powder on brioche dough and bread characteristics. Chestnut shell is an underutilized agricultural byproduct that contains beneficial fiber and antioxidants. In this context, researchers have explored the use of chestnut shell as a source of fiber in bread. The present research aims to investigate the effects of adding chestnut shell powder at varying levels of 5%, 8%, and 10% on the rheological, chemical, and physical properties of brioche dough and bread. Specifically, this study has the following research purposes:

-To examine the impact of chestnut shell powder addition on the farinograph characteristics of brioche dough, including water absorption, dough expansion time, dough resistance, dough stability, and farinograph quality number.

-To evaluate the effects of chestnut shell incorporation on the extensograph properties of brioche dough such as energy, tensile strength, elongation, and tensile strength to elongation ratio.

-To determine the influence of chestnut shell powder on the chemical composition of brioche bread in terms of moisture, ash, fiber, fat, and protein content.

-To assess changes in volume, color, and texture of the final brioche product with the addition of chestnut shell powder.

-To ultimately identify the optimal level of chestnut shell powder addition that improves the rheological, chemical, and physical attributes of brioche dough and bread.

The findings of this research could provide valuable insights into the potential use of chestnut shell as a source of fiber in bread-making and contribute to the development of healthier food products.

Material and Methods

The first treatment, known as the control treatment, was identified with code C. The other three treatments were distinguished by the amount of chestnut shell present in them, and were denoted by codes E1, E2, and E3, respectively. Treatment E1 contained 5% chestnut shell, while treatment E2 contained 8%, and treatment E3 contained 10%. Moisture, ash, fiber, fat, and protein were analyzed using chemical tests on samples of wheat flour, chestnut shell powder, and brioche bread.

Dough rheological tests are essential to understand the properties and behavior of dough during the mixing and stretching processes (Rasper and Walker, 2000). The tests provide critical insights into the quality of the dough, such as its resistance to deformation, elasticity, and stability. Two of the most commonly used dough rheological tests are the farinography and extensograph tests (Brabender, Duisburg, Germany) (Yusefkhan *et al*., 2019). The farinography test measures the resistance of dough to mixing by a series of paddles that exert a constant force on the dough. The device records the time taken for the dough to reach a specific consistency, as well as other important parameters, such as water absorption and mixing tolerance. The extensograph test, on the other hand, measures the ability of the dough to stretch without breaking. In this test, a sample of dough is stretched until it breaks, and the device records the force and extension at which the dough breaks. This test provides valuable information about the strength and elasticity of the dough and its ability to hold shape during baking.

The ingredients, including 100 grams of wheat flour, 3 grams of yeast, 2 gram of sugar, 3 grams of salt, 1.5 gram of oil, 0.5 grams of improver, and varying amounts of chestnut shell powder (5, 8, and 10 grams), were weighed and mixed together. Water was added according to the farinograph water absorption curve. After mixing the dry ingredients with water for 12-15 minutes to form a moldable mass, the dough was left to rest for 25-30 minutes. The dough was then divided into 250-gram pieces, left to rest for 10 minutes, and fermented for a second time. The dough was rolled by machine and placed in an oven tray before undergoing a final rest in a greenhouse chamber at a temperature of 37-40°C and relative humidity of 72-75% for 35-50 minutes. The bread was then baked in the oven at a temperature of 225°C for 25 minutes. Finally, the bread was cooled at 28°C for 1 hour before being tested (El-Kherbawy and Dewidar, 2019).

To prepare the chestnut kernels for use in this study, it is recommended to first roast them to loosen the hard shell. Following this, the chestnuts should be heated at 180°C for 12 to 15 minutes to remove the thin brown skin, which is the desired substance in the present research. To ensure complete separation of the skin, the chestnut kernels should be ground using a laboratory grinder. The resulting chestnut powder should then be passed through a sieve of 1.8-2.3 mm to achieve a particle size comparable to that of wheat flour used in bread production.

The Minolta CS-100A colorimeter was used to measure lightness (L^*), redness/greenness (a^*), and yellowness/blueness (b^*) in brioche bread samples. These three factors are known as color indicators. The difference in color between the samples and the control was calculated based on the value of $\Delta E = (\Delta L^2 + \Delta a^2 + \Delta b^2)^{0.5}$ (Moretton *et al*., 2023).

The experiment utilized the rapeseed displacement technique to conduct a volumetric test (Yi and Kerr, 2009). The procedure involved placing a weighed piece of bread into a container of known volume (Vt). The remaining space in the container was filled with rapeseeds, and after removing the bread, the volume of the rapeseeds was recorded as Vs. The volume of the bread was then calculated by subtracting Vs from Vt. Using the rapeseed displacement method allowed for an accurate measurement of the volume of the bread without the need for complex or expensive equipment.

The experiments were conducted using a completely random design with three replications. The resulting data was then analyzed and the average values were compared using Duncan's multi-range test at a significance level of 5%.

Results

Two types of materials were analyzed for their nutritional content: wheat flour and powdered chestnut shell. Wheat flour was found to contain 0.07% moisture, 1.20% ash, 10.87% protein, 0.64% fat, and 13.97% fiber. Powdered chestnut shell, on the other hand, had a much higher moisture content of 23.81%, ash content of 27.39%, protein content of 6.14%, fat content of 2.14%, and fiber content of 4.28%. Table 1 presents a comparison of the average results of the farinograph test, while Table 2 shows a comparison of the average outcomes of the extensograph test. Table 3 illustrates a comparison of the average chemical properties and volumetric test results in the samples of brioche bread containing chestnut shell and the control group. Fig. 1 exhibits a comparison of the average results of the colorimetric test.

Table 1. Comparison between the mean farinograph properties in the brioche dough samples with and without chestnut shell.

Treat ment	Farinograph quality number (FQN)	Degree of dough softening after 15 min (B.U) *	Degree of dough softening after 30 min (B.U) *	Dough stability time (min)	Dough expansion time (min)	Water absorption (%)
C	55.1^{b}	62.4^{a}	124.8^{a}	9.1^{ab}	3.6^{c}	60.3^{c}
E1	60.3^{a}	41.6^{b}	109.2^{b}	9.3^{a}	4.7^{b}	63.0^{b}
E2	60.3^{a}	31.2^{b}	104.0^{c}	9.6^{a}	4.9^{b}	63.4^{b}
E3	61.3^{a}	31.2^{b}	104.0^{d}	9.8^{a}	5.7^{b}	66.0^{a}

* B.U: Brabender unit
Note: If the averages in a particular column share at least one letter, according to Duncan's test they do not differ significantly at a 5% probability level.

Table 2. The mean extensograph values for the control and brioche dough samples containing chestnut shell.

Treatment	Energy (cm^2)			Tensile Strength (B.U)			Elongation (mm)			Ratio of Tensile Strength to Elongation		
Time	60	90	120	60	90	120	60	90	120	60	90	120
C	83.2^{c}	84.2^{d}	62.4^{d}	332.8^{c}	488.8^{c}	582.4^{c}	176.8^{a}	142.4^{a}	124.8^{a}	1.96^{c}	3.5^{c}	4.8^{c}
E1	94.6^{b}	93.6^{c}	70.7^{c}	384.8^{b}	696.8^{b}	665.6^{b}	166.4^{b}	119.6^{b}	109.2^{b}	2.4^{b}	6.0^{b}	6.3^{b}
E2	101.9^{a}	101.9^{b}	81.1^{b}	384.8^{b}	748.8^{a}	712.4^{a}	145.6^{c}	104^{bc}	98.8^{c}	2.7^{b}	7.4^{a}	7.5^{a}
E3	102.9^{a}	114.4^{a}	97.7^{a}	395.2^{a}	769.6^{a}	759.2^{a}	138.3^{d}	95.6^{c}	88.4^{d}	2.9^{a}	8.3^{a}	8.9^{a}

Note: If the averages in a particular column share at least one letter, according to Duncan's test they do differ significantly at a 5% probability level.

Table 3. The comparison of the volumetric and average chemical test findings in samples of control and chestnut-containing brioche bread.

Treatment	Moisture content (%)	Ash (%)	Fat (%)	Protein (%)	Volume (ml)
C	0.2^{a}	1.0^{c}	11.8^{c}	0.7^{c}	32.5^{c}
E1	0.4^{a}	1.2^{b}	12.1^{b}	1.3^{b}	33.5^{b}
E2	0.6^{a}	3.1^{a}	12.1^{b}	1.6^{b}	39.2^{a}
E3	0.8^{a}	3.3^{a}	12.7^{a}	2.1^{a}	39.2^{a}

Note: If the averages in a particular column share at least one letter, according to Duncan's test they do not differ significantly at a 5% probability level.

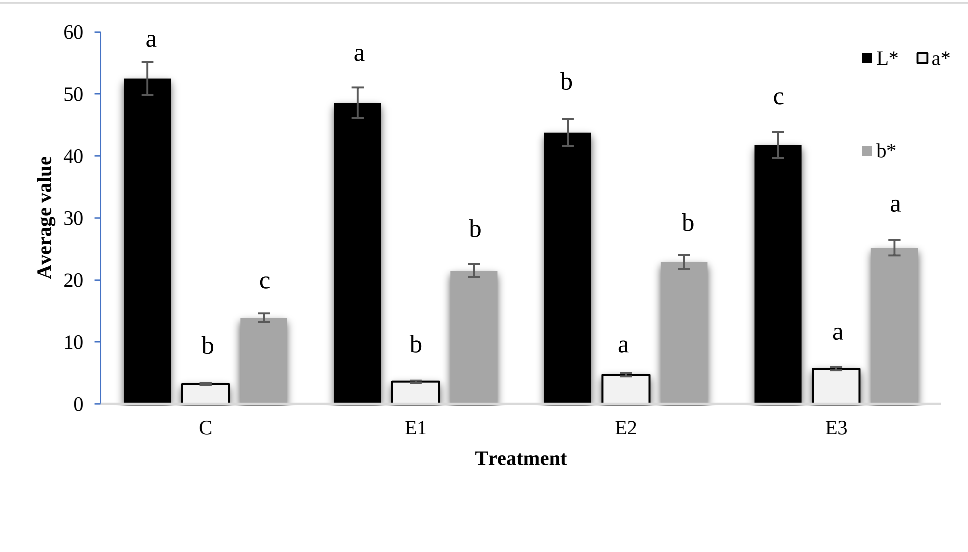

Fig. 1. The average color index test results (L*, a*, and b*) for control and chestnut-filled brioche bread samples.

Discussion

In order to compare the levels of water absorption across different treatments, this study analyzed the farinograph mean results in Table 1. Treatment E3 and E2 both showed the highest levels of water absorption, whereas treatment E1 and the control group showed the lowest levels. The study also discovered a notable difference in water absorption between the control group and all treatments containing chestnut kernel shell. The high concentration of sugar and fiber in the structure of the chestnut shell powders was attributed as the cause of the increase in water absorption. The ability of these substances to outcompete gluten for water absorption during dough formation leads to an increase in water absorption.

The experiment timed how long the dough took to expand and discovered that treatment E3 had the longest expansion time. Between E3 and the other treatments, there was a noticeable variation in the expansion time. There was no discernible difference between treatment E1 and treatment E2, despite the slightly shorter expansion time of treatment E2. The expansion time was quickest with the control treatment. The outcomes of this investigation are in agreement with those of a prior study by Hanan *et al*. (2021). Researchers found that adding fiber-rich chemicals to wheat flour used to make bread lengthened the dough's expansion time.

The highest dough stability time was observed in the E3 treatment, which means that this treatment resulted in the dough staying stable for a longer period of time compared to the other treatments. The E2 treatment was the next best treatment in terms of dough stability time, followed by E1 treatment. However, there was no significant difference observed between E1 and E2 treatments. The control treatment had the lowest dough stability time among all the treatments. In terms of the effect of chestnut shell on dough stability, no significant difference was observed between all the treatments containing chestnut shell and the control treatment. This suggests that the addition of chestnut shell did not have a significant effect on the dough stability time. Dough loosening after 15 and 30 minutes was also observed as an important factor in this study. The control treatment and the E1 treatment had the highest amount of dough loosening after 15 and 30 minutes, indicating that the dough was not as stable as in the other treatments. On the other hand, the E2 and E3 treatments had the lowest amount of dough loosening after 15 and 30 minutes, suggesting that these treatments resulted in more stable dough. A significant difference was observed between all the mentioned treatments and the control in terms of this attribute, which means that the treatments had a significant impact on the dough loosening after 15 and 30 minutes ($p<0.05$).

The baking or farinograph quality number (FQN) value of flour is one of the most crucial elements assessed in farinograph. The E3 treatment had the highest FQN value, followed by E2 and E1, which had no significant differences from one another but a significant difference from the control, and the control treatment had the lowest value ($p< 0.05$). The FQN number increased as compared to the control sample.

In accordance with the comparison of the average energy factors of the samples in Table 2, treatment E3 had the highest levels of energy in each of the three fermentation times of 60, 90, and 120, and the control treatment had the lowest levels of this attribute in each of the three time periods. Additionally, a noteworthy distinction was seen between the control and all three treatments including chestnut shell powder during the whole fermentation process ($p<0.05$). Table 2's comparison of the average tensile strength factors for the samples reveals that, throughout the course of the three time periods, there were substantial differences between all treatments using chestnut shell powder and the control treatment ($p<0.05$). Contrarily, the control treatment had the lowest level of resistance to dough stretching throughout all three fermentation times of 60, 90, and 120 minutes, while treatment E3 had the highest level. According to the comparison of the average dough stretchability factors of the samples in Table 2, it was found that the control treatment had a significant advantage over other treatments in all three fermentation time periods of 60, 90, and 120 minutes, with the maximum value of dough stretchability being related to the control treatment ($P<0.05$). The acquired results are perfectly consistent with each other since the dough's stretchability and resistance to stretching have an inverse connection. The addition of chestnut shell powder increased the ratio of tensile strength to elongation, as shown by the average comparative results in Table 2.

According to the average comparison results from Table 3, the control and E1 treatments had the maximum amount of volume, while E2 and E3 treatments had the lowest amounts of volume ($p<0.05$). The diluted gluten protein and the weakened gluten network in the produced breads may be to blame for this (Hoehnel *et al*., 2019; Barros *et al*., 2022). When the chestnut kernel's shell was added, a portion of the trace amounts of gluten in its weight dropped, which resulted in a reduction in the volume of the created breads when compared to the control.

Fig. 1 illustrates the comparative results of the colorimetric test performed on the control and chestnut shell powder-containing brioche bread samples. The colorimetric analysis aimed to evaluate the changes in the crust color of brioche bread with the addition of chestnut shell powder by measuring three color indicators - lightness (L^*), redness (a^*), and yellowness (b^*). The lightness value, which represents the brightness of the crust, showed a declining trend with increasing chestnut shell powder from 0% in the control to 10% in treatment E3. The control sample had the highest lightness score, indicating the brightest crust, while treatment E3 with 10% chestnut shell powder had the lowest lightness value of L^* signifying a darker crust. The redness value, depicted by factor a^*, increased progressively from the control sample to treatment E3. The higher positive a^* value in samples containing chestnut shell powder demonstrates enhancement in the red hue. This reddish color can be attributed to the presence of phenolic compounds and melanoidins formed during Maillard browning reactions. Similarly, the yellowness (b^*) increased with higher chestnut shell powder from control to E3. The higher b* value relates to a more yellowish color caused by carotenoids and polyphenols imparting a rich yellow tone. In summary, the colorimetry analysis clearly demonstrated that increasing chestnut shell powder quantity reduced the crust lightness while intensifying the redness and yellowness of brioche bread. This indicates that chestnut shell powder enriches the color of brioche bread crust by making it darker, redder, and more golden yellow. These findings were in line with those of a study done by Goranova *et al*. (2019), who found that increasing the amount of factor a^* and b^* while decreasing the amount of factor L^* was possible by incorporating oat beta-glucan into the recipe for sponge cake.

In conclusion, the use of chestnut shell powder, an agricultural by-product, as a novel value-added ingredient is a sustainable approach to enhance the nutritional quality of baked goods like brioche bread. The step-wise increase in chestnut shell powder incorporation from 5% to 10% enabled the systematic assessment of its impact on the rheological and physico-chemical attributes of brioche dough and bread. The advanced dough testing techniques, farinograph and extensograph, provided in-depth insights into the changes in the gluten network and dough behavior upon addition of a fiber source like chestnut shell powder. The detailed chemical analyses quantified the precise improvements in nutritional composition, especially dietary fiber, achieved by incorporating chestnut shell powder in brioche bread. The experimental approaches and methodology utilized in this study can serve as a model system to evaluate the inclusion of novel fiber sources from agricultural wastes into mainstream food products for enhancing their nutritional profile in a sustainable manner.

Conclusions

The study investigated the effect of adding chestnut kernel shell powder to wheat flour dough on its physical properties and quality. The results showed that treatments containing chestnut shell powder had higher levels of water absorption, longer dough stability times, and increased farinograph quality numbers compared to the control group. The dough resistance to stretching was also found to increase, while the dough stretchability decreased with the addition of chestnut shell powder. However, the volume of the produced bread was reduced with the addition of chestnut shell powder. The colorimetric test showed that the bread produced with chestnut shell powder had higher levels of redness and yellowness compared to the control group. Additionally, the sample containing 10% chestnut shell powder (E3) was determined to be the best treatment in terms of the aforementioned features.

Acknowledgments

We would like to express our sincere gratitude to all those who have contributed to the successful completion of this project.

Conflict of Interest

The authors declare no conflict of interest.

References

Aglietti C, Cappelli A, Andreani A (2022) From Chestnut Tree (*Castanea sativa*) to Flour and Foods: A Systematic Review of the Main Criticalities and Control Strategies towards the Relaunch of Chestnut Production Chain. Sustainability. 14, 12181.

Barros JHT, Ribeiro VA da G, Ferreira M de PK, Steel CJ (2022) Bread-making performance of wheat flours enriched with vital gluten treated with non-thermal plasma. International Journal of Food Science & Technology. 57, 3795–3803.

Brancoli P, Bolton K, Eriksson M (2020) Environmental impacts of waste management and valorisation pathways for surplus bread in Sweden. Waste Management. 117, 136–145.

Cappelli A, Oliva N, Cini E (2020) A systematic review of gluten-free dough and bread: Dough rheology, bread characteristics, and improvement strategies. Applied Sciences. 10, 6559.

Chatrabnous N, Yazdani N, Vahdati K (2018) Determination of nutritional value and oxidative stability of fresh walnut. Journal of Nuts. 9(1), 11-20.

El-Kherbawy GM, Dewidar OM (2019) Nutritional evaluation of brioche bread made from Egyptian wheat and enriched with garden cress seeds (GCS) powder as a functional food. Suez Canal University Journal of Food Sciences. 6, 27–41.

Goranova Z, Baeva M, Vrancheva R, Petrova T, Stefanov S (2019) Antioxidant properties and color characteristics of sponge cakes containing functional components. Ukrainian Food Journal. 260–270.

Guerrieri N, Cavaletto M (2018) Cereals proteins. Proteins in Food Processing. Elsevier, 223–244.

Guiné RP, Costa C, Florença SG, Correia PM (2022) A Review of the Use of Chestnut in Traditional and Innovative Food Products. Journal of Nuts. 14(1), 1-18

Hanan E, Rudra SG, Sharma V, Sagar VR, Sehgal S (2021) Pea pod powder to enhance the storage quality of buckwheat bread. Vegetos. 34, 790–799.

Hoehnel A, Axel C, Bez J, Arendt EK, Zannini E (2019) Comparative analysis of plant-based high-protein ingredients and their impact on quality of high-protein bread. Journal of Cereal Science. 89, 102816.

Hossain MF, Numan SM, Akhtar S (2021) Cultivation, nutritional value and health benefits of dragon fruit (*Hylocereus* spp.): a review. International Journal of Horticultural Science and Technology. 8(3), 259-269.

Hu M, Yang X, Chang X (2021) Bioactive phenolic components and potential health effects of chestnut shell: A review. Journal of Food Biochemistry. 45, e13696.

Kc KB, Dias GM, Veeramani A, Swanton CJ, Fraser D, Steinke D, Lee E, Wittman H, Farber JM, Dunfield K (2018) When too much isn't enough: Does current food production meet global nutritional needs? PloS One. 13, e0205683.

Lockyer S, Spiro A (2020) The role of bread in the UK diet: An update. Nutrition Bulletin. 45, 133–164.

Meyerding SG, Kürzdörfer A, Gassler B (2018) Consumer preferences for superfood ingredients—The case of bread in Germany. Sustainability. 10, 4667.

Moretton M, Cattaneo C, Mosca AC, Proserpio C, Anese M, Pagliarini E, Pellegrini N (2023) Identification of desirable mechanical and sensory properties of bread for the elderly. Food Quality and Preference. 104, 104716.

Muhialdin BJ, Filimonau V, Qasem JM, Ibrahim SA, Algboory HL (2022) Traditional fermented foods and beverages in Iraq and their potential for large-scale commercialization. Journal of Ethnic Foods. 9, 1–17.

Ni Q, Ranawana V, Hayes HE, Hayward NJ, Stead D, Raikos V (2020) Addition of broad bean hull to wheat flour for the development of high-fiber bread: Effects on physical and nutritional properties. Foods. 9, 1192.

Nissan E, Pasqualone A (2019) The Parthian "Aquatic Bread" and the Iraqi "Water-Bread"(khə́bəz ṃấy). An Instance of Material Culture Continuity? Quaderni Di Semantica. 5, 123–153.

Pakrah S, Rahemi M, Nabipour A, Zahedzadeh F, Kakavand F, Vahdati K (2021) Sensory and nutritional attributes of Persian walnut kernel influenced by maturity stage, drying method, and cultivar. Journal of Food Processing and Preservation, e15513.

Pinto D, Almeida A, López-Yerena A, Pinto S, Sarmento B, Lamuela-Raventós R, Vallverdú-Queralt A, Delerue-Matos C, Rodrigues F (2023) Appraisal of a new potential antioxidants-rich nutraceutical ingredient from chestnut shells through in-vivo assays–A targeted metabolomic approach in phenolic compounds. Food Chemistry. 404, 134546.

Pu G, Li P, Du T, Niu Q, Fan L, Wang H, Liu H, Li K, Niu P, Wu C (2020) Adding appropriate fiber in diet increases diversity and metabolic capacity of distal gut microbiota without altering fiber digestibility and growth rate of finishing pig. Frontiers in Microbiology. 11, 533.

Ranaivo H, Thirion F, Béra-Maillet C, Guilly S, Simon C, Sothier M, Van Den Berghe L, Feugier-Favier N, Lambert-Porcheron S, Dussous I (2022) Increasing the diversity of dietary fibers in a daily-consumed bread modifies gut microbiota and metabolic profile in subjects at cardiometabolic risk. Gut Microbes. 14, 2044722.

Rasheed MS, Saeed AAM (2020) Evaluation of sodium concentration in different bread types in Sulaimanyah Province, Iraqi Kurdistan. Plant Arch. 20, 836–839.

Rasheed MS, Salih K (2020) Iron Concentration in Different Bread Consumed in Sulaymanyah Province, Iraqi Kurdistan. Plant Archives. 20, 832–835.

Rasper VF, Walker CE (2000) Quality evaluation of cereals and cereal products. Handbook of Cereal Science and Technology. CRC Press. 505–537.

Román GC, Jackson RE, Gadhia R, Román AN, Reis J (2019) Mediterranean diet: The role of long-chain ømega-3 fatty acids in fish; polyphenols in fruits, vegetables, cereals, coffee, tea, cacao and wine; probiotics and vitamins in prevention of stroke, age-related cognitive decline, and Alzheimer disease. Revue Neurologique. 175, 724–741.

Saa DT, Di Silvestro R, Nissen L, Dinelli G, Gianotti

A (2018) Effect of sourdough fermentation and baking process severity on bioactive fiber compounds in immature and ripe wheat flour bread. LWT. 89, 322–328.

Simonato B, Tolve R, Rainero G, Rizzi C, Sega D, Rocchetti G, Lucini L, Giuberti G (2021) Technological, nutritional, and sensory properties of durum wheat fresh pasta fortified with *Moringa oleifera* L. leaf powder. Journal of the Science of Food and Agriculture. 101, 1920–1925.

Yi J, Kerr WL (2009) Combined effects of freezing rate, storage temperature and time on bread dough and baking properties. LWT-Food Science and Technology. 42, 1474–1483.

Yusefkhan S, Shahab Lavasani A, Eyvazzadeh O (2019) The Study of Using Mixture of Wheat flour and different levels of Quinoa flour on Farinograph and Extensograph Properties of Baguette Bread. Iranian Journal of Biological Sciences. 14, 29–43.