



STUDY OF THE EFFECTIVENESS OF RICE BRAN PROTEIN ISOLATE IN EXTENDING THE SHELF LIFE OF MANUFACTURED YOGURT

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ABSTRACT

The present study aimed to study the effect of adding Iraqi rice bran protein isolate, Amber 33 variety, at different ratios (100, 200, 300) mg to manufactured yogurt to extend its storage life, in addition to the two control treatments Yc- without any addition and Yc+ to which the industrial antioxidant BHT was added at a concentration of 200 mg. The results showed no significant differences in pH values between all treatments immediately after manufacturing, and a decrease in pH values was observed with increasing storage period. The results also showed that the PV and ADV values were close immediately after manufacturing, and these values increased with increasing storage period. The total bacterial counts varied for the control treatments and the yogurt supplemented with protein isolate, as they increased with increasing refrigerated storage period. The results showed that all treatments were free of coliform bacteria, Psychrotrophic bacteria, yeasts, and molds throughout the storage period, while yeasts and molds appeared at the end of the storage period of 21 days for all treatments.

Keywords: Functional foods, pH, peroxide, fat decomposition, milk.

دراسة فعالية معزول بروتين نخالة الرز في إطالة العمر التخزيني لليوغورت المصنع

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الخلاصة

هدفت الدراسة الحالية الى دراسة تأثير اضافة معزول بروتين نخالة الرز العراقي صنف عنبر 33 وبنسب مختلفة (100، 200، 300) ملغم الى اليوغورت المصنع لإطالة العمر التخزيني له فضلا عن معالمتي السيطرة Yc- بدون اي اضافة و Yc+ التي اضيف لها مضاد الاكسدة الصناعي BHT بتركيز 200 ملغم. بينت النتائج عدم وجود فروق معنوية في قيم pH بين جميع المعاملات بعد التصنيع مباشرة ولوحظ هناك انخفاض في قيم pH بزيادة مدة الخزن. كما بينت النتائج ان قيم PV و ADV كانت متقاربة بعد التصنيع مباشرة وازدادت هذه القيم بزيادة مدة الخزن. تباينت الاعداد الكلية للبكتريا لمعالمتي السيطرة واليوغورت المدعم بالمعزول البروتيني اذ ازدادت بزيادة مدة الخزن المبرد، وظهرت النتائج خلو جميع المعاملات من بكتريا القولون والبكتريا المحبة للبرودة والخمائر والاعفان على طول فترة الخزن، بينما ظهرت الخمائر والاعفان في نهاية مدة الخزن 21 يوم لجميع المعاملات.

الكلمات المفتاحية : الاغذية الوظيفية، الرقم الهيدروجيني، البيروكسيد، تحليل الدهن، الحليب.

*This article is taken from the doctoral dissertation of the first researcher.



INTRODUCTION

Rice (*Oryza sativa* L.) is one of the world's major cereal crops and the second most important food crop in the world after wheat among more than 30 food crops (MohammadAli *et al.*, 2024). Rice is an annual plant, native to the continent of Asia, especially India, Vietnam, Indonesia, and China. The production of these countries is estimated at 50% of the total global production of rice (Whaib & Mousa, 2022), in addition to its cultivation in many countries of the world, including countries in The Mediterranean Sea, which produces about 26% of grain production and about 20% of the total grain trade in the world (Essa *et al.*, 2015; Reddy *et al.*, 2017). As for Iraq, rice cultivation has spread in many central and southern governorates, the local production of this crop in the years 2009, 2010, 2011, and 2012 amounted to about 3,720, 3,506, 4,270, and 3,513 million tons respectively (FAO, 2014).

The composition of the whole grain of rice consists of 63-73% carbohydrates, 1-2% fat, 6-8% protein, 7-10% fiber and 3-5% ash and rice grains contain 3 main parts including the endosperm (~70%), the hull (~20%), and the bran (~10%) (Najamuddin *et al.*, 2021; Santos *et al.*, 2016).

Bran is one of the by-products that result from the rice manufacturing process, as it produces three main parts: bleached rice, bran, and hull (Xu *et al.*, 2021; Abadi & Naser, 2019). Bran is produced in large quantities during the rice milling process and constitutes about 8-10% of rice grains and, is not sufficiently exploited for many activities. It can be used as animal feed. Thus, more than 80 million tons of bran are the byproduct of rice milling worldwide (Najamuddin *et al.*, 2021; Shu *et al.*, 2021). Rice bran contains many components such as phenolics, γ -oryzanol, tocopherols, and tocotrienols, along with other nutritional components that are beneficial for health (Punia *et al.*, 2021; Abood & Mohammed, 2017). It also contains a high percentage of protein (11-15%), about 20% of fat, and an excellent source of fiber (7-11%). In addition, rice bran contains much more nutrients and vitamins than other parts of rice. (Amagliani *et al.*, 2017; Kumar *et al.*, 2021).

Yamuangmorn & Prom-u-Thai, (2021) indicated that the functional properties of rice bran are ideal for commercial uses in the food and beverage industry, and the food and pharmaceutical industries. Recently, there has been increased interest in searching for new plant-based protein sources due to increasing consumer concerns about the safety of animal products and their derivatives. Moreover, they can be a better alternative to expensive animal products (Yan *et al.*, 2015; Wang *et al.*, 2021). Plant proteins have become a major source of dietary protein in developing countries. With the increasing interest in protein consumption and the problem of protein deficiency, it has become necessary to search for non-traditional sources of protein isolates (Liu *et al.*, 2019; Yu *et al.*, 2022).

Rice bran protein isolate has a high antioxidant potential due to its amino acid content, the nature of the acids, and their sequence, Research has shown the possibility of using many proteins isolated from plant sources as antioxidants, including fava beans, chickpeas, soybeans, and rice protein (Wouters *et al.*, 2016; Ghanghas *et al.*, 2022). The antioxidant activity of protein and protein isolate is primarily due to the inhibition and isolation of minerals that encourage oxidation and their ability to capture free radicals and reduce peroxides, i.e. increasing their stability and inhibiting oxidation by transforming the physical state of the food.



Natural antioxidants act as free radical scavengers and synthetic antioxidants are food additives and preservatives (Souza *et al.*, 2016; Piotrowicz *et al.*, 2020). Although synthetic antioxidants show stronger activity than natural compounds such as α -Tocopherol and Ascorbic acid, their use should be cautious due to potential health risks. Therefore, interest has increased in producing natural antioxidants as an alternative to synthetic ones. It has been found that protein isolates from animal or plant sources have antioxidant activity (Ranjan *et al.*, 2019; Hunsakul *et al.*, 2021).

Milk and dairy products are an ideal source of important nutrients for human health, such as calcium, magnesium, and phosphorus, in addition to major nutrients such as proteins, fats, carbohydrates, and some vitamins, but they are poor in some rare elements that are important for the body's vital functions, such as iron and zinc (Ocak & Kose, 2010).

The US Food and Drug Administration (FDA, 2011) defined yogurt as a food product produced by starter bacteria, which is a mixture of bacterial cultures containing lactic acid-producing organisms *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. It provides the body with many benefits as it is rich in many nutrients such as protein, calcium, fat, and vitamins such as vitamin D, riboflavin, vitamin B6, and vitamin B12. Yogurt is also more beneficial than milk, due to the presence of live therapeutic bacteria that are important for the digestive system, which can lead to health benefits when consumed in sufficient quantities (Cheng, 2010; AL-Abdulla & AL-Nasery, 2021).

Since yogurt is one of the most widely consumed foods in the world, which provides consumers with several micronutrients and macronutrients in the diet, it is a low-cost means of consumption, in addition to being a staple or semi-daily food for many people. In addition, to the importance of nutritional and functional plant proteins, this study aimed to introduce rice bran protein isolate to improve and reduce some problems of yogurt and extend its shelf life.

MATERIALS AND METHODS

Source of milk and rice bran

Rice bran variety Amber 33 was obtained from the Agricultural Research Department/Rice Research Station in Al-Mishkhab. Full cream dried milk type (Amazing, Sultanate of Oman) was used in making yogurt.

Preparation of protein isolate from defatted rice bran:

The method mentioned by Cho, (2020) was used with some modifications. It was mixed at a ratio of 1:10 (sample: water) and placed on a magnetic stirrer for 1 h. The pH of the resulting suspension was then adjusted to 9 (Using 0.1 NaOH 1N), the suspension was mixed for 1 h using a magnetic mixer, and then the suspension was transferred to a centrifuge at a speed of 5000 rpm for 20 min and at a cooling temperature of 4 C. Lower the pH of the filtrate to 4.5 (Using 0.1 HCl 1N), take the residue and wash it three times with distilled water Adjust the pH to 7 (Using 0.1 NaOH 1N). The protein was then dried and stored until use.

Functional yogurt manufacturing

Functional yogurt was prepared according to the method described in Tamime & Robinson.(1999) where a certain amount of milk was divided into five parts, the first part was



left untreated as negative control treatment Yc-, the second part was used with 200 mg/kg yogurt of BHT as positive control treatment Yc+, the third, fourth and fifth parts were supplemented with different proportions of protein isolate 100, 200 and 300 mg/kg yogurt respectively to prepare treatments Y1, Y2, and Y3 respectively. The milk was heat treated using a water bath at 85°C for 15 minutes and then cooled to 42°C. The freeze-dried starter cultures (*Lactobacillus delbrueckii* Ssp *bulgaricus* and *Streptococcus salivarius* Ssp *thermophilus*) were added directly to the milk according to the instructions of the supplier indicated by the French manufacturer Danisco (3%), and mixed well to ensure good distribution of the starter culture in the milk. The milk was then distributed directly into plastic cups under controlled conditions and the samples were incubated at 42°C until coagulation occurred (3-2.5) h. The samples were kept at a temperature of (5±1)°C for fifteen days for chemical and microbiological tests and sensory evaluation later.

pH estimation

The pH was estimated using a pH meter as stated in (A.O.A.C 2016).

Determination of acid degree value (ADV) and peroxide value (PV)

The value of Acid Degree was estimated as in method (Sadiq & Doosh, 2019) as well as the Peroxide value was estimated by method in Amagliani *et al.*, (2017).

Microbial content

Total Count of Bacteria

The method of pouring plates as described in (APHA, 1984) was followed using Nutrient Agar solid medium and the plates were incubated at 37°C for 48 h. This test was performed after manufacturing and throughout the storage period for all treatments.

Total coliform bacteria

The method of pouring plates was followed in (APHA, 1984) using MacConkey agar medium, the plates were incubated at 37°C for 48 h.

Total Psychrotrophic bacteria

The method mentioned by (Moghimi *et al.*, 2017) was followed. 0.1 ml of the prepared dilutions were taken and placed in sterile plates, Nutrient Agar was added to the culture medium, and the plates were incubated at 7°C for 10 days.

Total yeasts and molds

The method of pouring plates was followed in (APHA, 1984) using PDA medium, the plates were incubated at 22°C for 5 days. This test was carried out after manufacturing and throughout the storage period of each treatment.

RESULTS AND DISCUSSION

pH value

pH is one of the main factors in determining the extent of casein network development (Lucey & Singh, 1997; Lee & Lucey, 2010), so the change in pH of yogurt treatments was monitored during the cold storage period.

The results in Table 1 showed that the pH values of the different yogurt treatments ranged between 4.85 and 4.91 at the age of 1 day. These numbers are close to what (Ibrahim, 2015) found for yogurt samples, which was 4.59. As the cold storage process continued until day 21, it was noted that the pH of treatment Yc- reached 4.38 due to the increase in acidity



during storage. The least development in acidity was in treatment Y3, where the pH reached 4.56, followed by treatment Y2, where the pH was 4.48. As for the rest of the treatments, the pH decreased between 4.38-4.46.

Table (1): pH values of different yogurt treatments during storage at $(5 \pm 1)^\circ\text{C}$ for 21 days.

pH values	Storage period (day)				
	1	3	7	14	21
Yc-	4.88	4.82	4.67	4.49	4.38
Yc+	4.85	4.83	4.73	4.54	4.47
Y1	4.85	4.83	4.72	4.57	4.46
Y2	4.86	4.83	4.74	4.58	4.48
Y3	4.91	4.82	4.77	4.61	4.56
L.S.D.	NS 0.0796	NS 0.0762	NS 0.0708	NS 0.0459	NS 0.0845

These results are consistent with the results of (Darwish *et al.*, 2023) who indicated that the pH values of rice bran protein-enriched yogurt treatments decreased with the advancement of the storage period. The pH of yogurt decreased to levels below pH (4.2 - 4.4) after being refrigerated for 28 days. The decrease in pH during the storage period in yogurt is attributed to the continued activity of starter bacteria during storage but at a slow rate (Hammoud & Saddam, 2024).

Sengupta *et al.*, (2023) indicated that the pH values of yogurt enriched with sesame seed protein isolate ranged between (3.82-4.53) immediately after manufacturing, and these values decreased after 28 days of storage to reach between (3.70-4.40).

Peroxide value (PV)

Peroxide value is an indicator of lipid oxidation, lipid oxidation damage, food products with undesirable taste, and changes in the nature and strength of the product leading to product deterioration. The results of Table 2 showed the peroxide values of the yogurt samples represented by the yogurt treatment to which rice bran protein isolate was added. The PV value at the age of 1 day was close for all treatments, ranging between 0.22-0.34 mEq/kg fat. When the treatments were stored at a temperature of $(5 \pm 1)^\circ\text{C}$, the PV value increased with the advancement of the storage period to reach between 0.33-0.47 mEq/kg fat at the age of 3 days. As the storage period continued to advance to the seventh day, the PV values increased to 0.44-0.68 mEq/kg fat, while the Yc treatment was 0.88 mEq/kg fat. As for the 14th day of storage, the PV values ranged between 0.72-0.97 mEq/kg fat. These figures clearly show that the treatments to which rice bran protein isolate was added were the lowest. Exposure to oxidation compared to the control treatment, which indicates that the amount of peroxides produced in these treatments was the least, and the PV values increased more in treatments Y1 and Yc- to reach 1.36 and 1.43 mEq/kg fat, respectively, on the 21st day of storage. The reason for this development in the PV values is due to the oxidation of fats in the manufactured yogurt models (Amamcharla & Metzger, 2014; Shahidi & Zhong, 2005).

**Table (2):** Peroxide values of different yogurt treatments during storage at $(5\pm 1)^\circ\text{C}$ for 21 days.

Peroxide values	Storage period (day)				
	1	3	7	14	21
Yc-	0.34	0.47	0.88	0.97	1.43
Yc+	0.21	0.39	0.53	0.72	0.95
Y1	0.29	0.43	0.68	0.89	1.36
Y2	0.26	0.38	0.57	0.81	1.15
Y3	0.22	0.33	0.44	0.74	0.92
L.S.D.	0.0708	0.0762	0.0829	0.0845	0.1028

Acid degree value (ADV)

ADV values of different yogurt samples were estimated during the 21-day refrigerated storage period at a temperature of $(5\pm 1)^\circ\text{C}$ to monitor the fat decomposition in yogurt treatments. It is noted from Table 3 that the ADV values at the age of 1 day were close among all treatments, ranging between 0.40-0.43 mEq/100 g fat. As the storage process continued, a gradual increase in ADV values was observed, ranging between 0.51-0.59 and 0.61-0.78 and 0.73-0.92 at ages 3, 7, and 14, respectively. On day 21, the values increased between 0.89-1.25 mEq/100 g fat. The reason for this development in ADV values is due to the action of lipase enzymes present in milk before yogurt manufacturing, including lipoprotein lipase (LPL), called natural milk lipase or lipases of lactobacilli. For the cold that grows and multiplies at the refrigerator temperature, and since the yogurt samples were exposed to heat treatment during their manufacture, the LPL enzyme was inhibited by heat. Therefore, the lipases of cold-loving bacteria are the main responsible for the development of ADV values of yogurt samples during storage because they resist even sterilization temperatures (Jasim & Nasser, 2020).

Table (3): Acid degree value of different yogurt treatments during storage at $(5\pm 1)^\circ\text{C}$ for 21 days.

Acid degree value	Storage period (day)				
	1	3	7	14	21
Yc-	0.42	0.59	0.78	0.92	1.25
Yc+	0.43	0.52	0.63	0.74	1.16
Y1	0.41	0.54	0.69	0.83	1.12
Y2	0.40	0.53	0.66	0.77	0.97
Y3	0.42	0.51	0.61	0.73	0.89
L.S.D.	NS 0.0629	NS 0.0539	0.0459	NS 0.1054	0.1041



Microbial content

The results in Table 4 show the total bacterial counts measured in colony-forming units/g (Cfu/g) the coliform, Psychrotrophic bacteria counts, and the yeast and mold counts for the manufactured yogurt samples. It is noted that the total bacterial counts in the different yogurt treatments at the age of 1 day of storage ranged between 1.4×10^3 - 1.6×10^3 Cfu/g, indicating no significant differences in the bacterial counts between these treatments. The increase in the number of bacteria for different yogurt treatments was monitored during the 21-day refrigerated storage period at a temperature of (5 ± 1) C to identify the level of spoilage, as bacteria, when growing, consume food from the medium in which they grow and secrete different enzymes, which leads to spoilage in the medium. Therefore, the more bacteria there are, the faster the spoilage and corruption of yogurt increases (Kareem & Shakir, 2016).

The numbers in the table show that the number of bacteria gradually increased in all treatments, as it reached 5.4×10^3 , 4.8×10^3 , and 3.8×10^3 Cfu/g on the 21st day of storage, in treatments Y1, Y2, and Y3, respectively. These results show that the increase in the total number of bacteria was less in the treatments to which rice bran protein isolate was added compared to the control treatment Yc- and Yc+, which reached 6.2×10^3 and 6.1×10^3 Cfu/g, respectively. The results also show that the higher the amount of protein isolate added, the lower the total number of bacteria, but at rates that do not affect the characteristics of the dairy product, indicating the effective effect of this isolate in reducing the growth of microorganisms, which was confirmed by previous studies conducted by (Wang *et al.*, 2015; Jasim & Nasser, 2023).

The Iraqi standard specification for microbial limits for milk and its products No. 5/2270 of (2015) states that the total bacterial count in yogurt does not exceed 1×10^4 Cfu /g in good quality and does not exceed 1×10^5 Cfu/g in acceptable quality. It is noted from the above results that the treatments Yc-, Yc+, and Y1 were outside the accepted standard specifications for a storage life of 21 days, while treatments Y2 and Y3 remained within the acceptable limits of the standard specifications throughout the storage period.

The results in Table 4 also showed that all the studied yogurt treatments were free of coliform bacteria and Psychrotrophic bacteria, and this may be due to the positive effect of rice bran protein isolate in preventing the growth of coliform bacteria and Psychrotrophic bacteria, in addition to the manufacturing processes that were carried out in good and controlled conditions. Coliform bacteria are among the most common types of bacteria and are used as evidence of milk contamination. Its presence indicates insufficient thermal treatments used or failure to follow the correct manufacturing methods, and its presence affects the quality of the dairy product and causes many problems (Kousha *et al.*, 2017; Rahman, 2018). It is worth mentioning that the Iraqi standard specification for microbial limits for milk and its products No. 5/2270 for the year (2015) states that the number of coliform bacteria and Psychrotrophic bacteria in yogurt does not exceed 10 Cfu/ g in good quality and does not exceed 100 Cfu/ g in acceptable quality.

**Table (4):** Microbial content of different yogurt treatments during storage at (5±1) C° for 21 days

	Storage period (day)	Total number of bacteria	Psychrotrophic bacteria	coliform bacteria	Yeasts and molds
Yc-	1	1.6*10 ³	-	-	-
	3	2.7*10 ³	-	-	-
	7	2.9*10 ³	-	-	-
	14	4.8*10 ³	-	-	-
	21	6.2*10 ³	-	-	6.2*10 ³
Yc+	1	1.5*10 ³	-	-	-
	3	1.9*10 ³	-	-	-
	7	2.7*10 ³	-	-	-
	14	4.4*10 ³	-	-	-
	21	6.1*10 ³	-	-	6.1*10 ³
Y1	1	1.6*10 ³	-	-	-
	3	2.3*10 ³	-	-	-
	7	2.6*10 ³	-	-	-
	14	3.9*10 ³	-	-	-
	21	5.4*10 ³	-	-	5.7*10 ³
Y2	1	1.5*10 ³	-	-	-
	3	2.1*10 ³	-	-	-
	7	2.9*10 ³	-	-	-
	14	3.6*10 ³	-	-	-
	21	4.8*10 ³	-	-	-
Y3	1	1.4*10 ³	-	-	-
	3	1.7*10 ³	-	-	-
	7	2.2*10 ³	-	-	-
	14	2.7*10 ³	-	-	-
	21	3.8*10 ³	-	-	-
L.S.D.		0.6226			

When studying the change in the number of yeasts and molds, the results in Table 4 showed no growth of yeasts and molds in the treatments to which isolated protein was added during the storage period, while the growth of these yeasts and molds occurred on day 21 and in few numbers in two control treatments Yc-, Yc+ and treatment Y1. It is noteworthy that the Iraqi standard specification for microbial limits for milk and its products No. 5/2270 of 2015 stipulates that the number of molds and yeasts should not exceed 100 and 1000 Cfu/g in good and acceptable quality, respectively (Shamurad *et al.*, 2019).

CONCLUSIONS

Rice bran protein isolate can extend the shelf life of processed yogurt as well as add nutritional value to the product.



REFERENCE

1. A.O.A.C. (2016). International Official Methods of Analysis of A.O.A.C International—20th Edition, 2016; AOAC: Gaithersburg, MD, USA, 2016.
2. Abadi, F. A., & Naser, J. M. (2019). Effect of wet gluten addition on stalin characteristics of barley bread. *Iraqi Journal of Agricultural Sciences*, 50(1): 390-397.
3. Abdel-Hamid, M., Hamed, A. M., Walker, G., & Romeih, E. (2024). Yogurt fortified with various protein hydrolysates: Texture and functional properties. *Food Chemistry*, 140861.
4. Abood, S. C., & Mohammed, A. S. (2017). Preparation concentrate protein from Al-Zahdi dates pits and used for biscuit fortification. *Iraqi Journal of Market Research and Consumer Protection*, 9(2), 45-53.
5. AL-Abdulla, B. Y., & AL-Nasery, E. D. (2021). Studying the effect of flour and lupine protein concentrate incorporation on physical chemical and sensory properties of biscuit: studying the effect of flour and lupine protein concentrate incorporation on physical chemical and sensory properties of biscuit. *Iraqi Journal of Market Research and Consumer Protection*, 13(1): 85-94.
6. Amagliani, L., O'Regan, J., Kelly, A. L., & O'Mahony, J. A. (2017). Composition and protein profile analysis of rice protein ingredients. *Journal of Food Composition and Analysis*, 59, 18-26.
7. Amamcharla, J. K. & Metzger, L. E. (2014). Modification of the ferric reducing antioxidant power (FRAP) assay to determine the susceptibility of raw milk to oxidation. *International Dairy Journal*, 34(2), 177-179.
8. APHA (American Public Health Association). (1984). Compendium of methods for microbiological examination of foods. (2nd ed.), M.L. Speck (ed). Washington, D.C. *Australasian Journal of Animal Sciences*, 23(9), 1127-1136.
9. Cheng, H. (2010). Volatile flavor compounds in yogurt: A review. *Critical reviews in food science and nutrition*, 50(10), 938-950.
10. Cho, S. J. (2020). Changes in the antioxidant properties of rice bran protein isolate upon simulated gastrointestinal digestion. *Lwt*, 126, 109206.
11. Darwish, M. S., Gomaa, M. S., Elsherbiny, E. S., & Mostafa, M. S. (2023). Angiotensin-converting enzyme (ACE-1) inhibitory and antioxidant activities of probiotic yogurt enriched with rice bran. *Egyptian Journal of Chemistry*, 66(12), 353-365.
12. Essa, Y. R., Abd Elhady, R., Kassab, H., & Ghazi, A. (2015). Isolation and Characterization of protein isolated from sesame seeds (*sesamum indicum*) meal. *Weber Agricultural Research & Management*, 1(1), 1-9.
13. FAO (Food and Agriculture Organization). (2014). *Cereal production*. at 4/2019.
14. FDA (Food and Drug Administration). (2011). Yogurt and Low Fat Yogurt, and Nonfat Yogurt. Code of Federal Regulations. US Department of Health and Human Services, GMP Publications, Washington, DC. Part 131. pp. 31–39.
15. Ghanghas, N., MT, M., Sharma, S., & Prabhakar, P. K. (2022). Classification, composition, extraction, functional modification and application of rice (*Oryza sativa*) seed protein: A comprehensive review. *Food Reviews International*, 38(4), 354-383.



16. Hammoud, E. K., & Saddam, A. C. (2024). Improving nutritional and qualitative properties of wheat bread by using mallow (*malva neglecta* l.) leaves powder. *Iraqi Journal of Agricultural Sciences*, 55(1), 560-568.
17. Hunsakul, K., Laokuldilok, T., Prinyawiwatkul, W., & Utama-ang, N. (2021). Effects of thermal processing on antioxidant activities, amino acid composition and protein molecular weight distributions of jasmine rice bran protein hydrolysate. *International Journal of Food Science & Technology*, 56(7), 3289-3298.
18. Ibrahim, K. J. (2015). Purification and Characterization of Karadi Sheep's Milk Protein and its Relationship with Yoghurt Quality. Doctoral dissertation, MS Thesis. Sulaimani University.
19. Jasim, A. S., & Nasser, J. M. (2020). Functional properties of enzymatically modified wheat gluten. *Iraqi Journal of Agricultural Sciences*, 51(3), 777-788.
20. Jasim, A. S., & Nasser, J. M. (2023). The functional properties of chemically and enzymatically modified wheat gluten. *Iraqi Journal of Agricultural Sciences*, 54(5), 1279-1291.
21. Kareem, A. A., & Shakir, K. A. (2016). Study of the functional and nutritional properties of defatted okra powder and okra protein isolate and concentrate. *Iraqi Journal of Agricultural Sciences*, 47(3), 865-875.
22. Kousha, M., Yeganeh, S., & Keramat Amirkolaie, A. (2017). Effect of sodium selenite on the bacteria growth, selenium accumulation, and selenium biotransformation in *Pediococcus acidilactici*. *Food Science and Biotechnology*, 26, 1013-1018.
23. Kumar, K., Srivastav, S., & Sharanagat, V. S. (2021). Ultrasound assisted extraction (UAE) of bioactive compounds from fruit and vegetable processing by-products: A review. *Ultrasonics sonochemistry*, 70, 105325.
24. Lee, W. J., & Lucey, J. A. (2010). Formation and physical properties of yogurt. *Asian-Australasian journal of animal sciences*, 23(9), 1127-1136.
25. Liu, Y. Q., Strappe, P., Shang, W. T., & Zhou, Z. K. (2019). Functional peptides derived from rice bran proteins. *Critical reviews in food science and nutrition*, 59(2), 349-356.
26. Lucey, J. A., & Singh, H. (1997). Formation and physical properties of acid milk gels: a review. *Food research international*, 30(7), 529-542.
27. Moghimi, N., Khanjasi, A. & Mogadam, N.B. (2017). Effect of Whey protein isolate coating enriched with Black cumin essential oil and lysozyme on tjhe shell-life of chicken fillets during Refrigerated storage. *International Journal of Food Nutrition and Safety*, 8(1): 32-44.
28. MohammadAli, M. K., Hamza, J. H., & Ahmed, A. S. (2024). Effect of cultivars and harvest dates on some traits of yield in rice. *Iraqi Journal of Agricultural Sciences*, 55(Special Issue), 122-135.
29. Najamuddin, U., Gorji, S. G., & Fitzgerald, M. (2021). Genotypic variability in the composition of soluble protein from rice bran—opportunities for nutrition. *Journal of Food Composition and Analysis*, 103, 1477-1484.



30. Ocak, E., & Kose, S.(2010). The effects of fortifying milk with Cu, Fe and Zn minerals on the production and texture of yoghurt. *Journal of Food Agriculture and Environment*, 8,122-125.
31. Piotrowicz, I. B. B., Garcés-Rimón, M., Moreno-Fernández, S., Aleixandre, A., Salas-Mellado, M., & Miguel-Castro, M. (2020). Antioxidant, angiotensin-converting enzyme inhibitory properties and blood-pressure-lowering effect of rice bran protein hydrolysates. *Foods*, 9(6), 812.
32. Punia, S., Kumar, M., Siroha, A. K., & Purewal, S. S. (2021). Rice bran oil: Emerging trends in extraction, health benefit, and its industrial application. *Rice science*, 28(3), 217-232.
33. Rahman, S. A. (2018). Chemical composition and some functional properties of flour and isolated protein from mung bean seeds (*Vigna radiate*) cultivated in Iraq. *Iraqi Journal of Agricultural Sciences*, 49(3):418-425.
34. Ranjan, A., Sahu, N. P., Deo, A. D., & Kumar, S. (2019). Solid state fermentation of de-oiled rice bran: Effect on in vitro protein digestibility, fatty acid profile and anti-nutritional factors. *Food Research International*, 119, 1-5.
35. Reddy, C. K., Kimi, L., Haripriya, S., & Kang, N. (2017). Effects of polishing on proximate composition, physico-chemical characteristics, mineral composition and antioxidant properties of pigmented rice. *Rice Science*, 24(5), 241-252. review. *Food Research International*, 30(7), 529-542.
36. Sadiq, I. H., & Doosh, K. S. (2019). Study of the physicochemical, rheological and sensory properties of yoghurt fortified with microencapsulation iron. *Iraqi Journal of Agricultural Sciences*, 50(5). 1345-1355.
37. Santos, R. R., Faroni, L. R., Cecon, P. R., Ferreira, A. P., & Pereira, O. L. (2016). Ozone as fungicide in rice grains. *Revista Brasileira de Engenharia Agrícola e Ambiental*, 20(3), 230-235.
38. Sengupta, S., Basu, S., & Bhowal, J. (2023). Biochemical characterization and hypocholesterolemic properties of sesame yogurt made from deoiled edible quality sesame flour (DEQSF) supplemented with rice bran oil. *Food Production, Processing and Nutrition*, 5(1), 56.
39. Shahidi, F., & Zhong, Y. (2005). Lipid Oxidation: Measurement Methods. In Shahidi, F, (ed). *Baley's industrial oil and fat products*. 6th ed., P. 357-385. New Jersey: Joun Wiley and Sonc, inc.
40. Shamurad, H. Y., Khadom, M. J., Haider, F. A., & Shakir, K. A. (2019). Evaluation the antioxidant activity of sesame coat and sesame cake extracts. *Iraqi Journal of Agricultural Sciences*, 50(3). 776-782.
41. Shu, Z., Jia, W., Zhang, W., & Wang, P. (2021). Selected quality attributes of paddy rice as affected by storage temperature history. *International Journal of Food Properties*, 24(1), 316-324.
42. Souza, D., Sbardelotto, A. F., Ziegler, D. R., Marczak, L. D. F., & Tessaro, I. C. (2016). Characterization of rice starch and protein obtained by a fast alkaline extraction method. *Food Chemistry*, 191, 36-44.



43. Tamime, A. Y. & Robinson, R.K. (1999). *Yogurt: Science and Technology*, 2nd edn. Boca Raton, FL: CRC Press.
44. Wang, C., Xu, F., Li, D., & Zhang, M. (2015). Physico-chemical and structural properties of four rice bran protein fractions based on the multiple solvent extraction method. *Czech Journal of Food Sciences*, 33(3):283-291.
45. Wang, T., Chen, X., Wang, W., Wang, L., Jiang, L., Yu, D., & Xie, F. (2021). Effect of ultrasound on the properties of rice bran protein and its chlorogenic acid complex. *Ultrasonics sonochemistry*, 79, 1758-1766.
46. Whaib, E. S., & Mousa M. A. (2022). 'The impact of ozone gas treatment on the amylose/amylopectin ratio in Iraqi jasmine rice grains', *Eurasian Chemical Communications*, 4(9), 870-876.
47. Wouters, A. G., Rombouts, I., Fierens, E., Brijs, K., & Delcour, J. A. (2016). Relevance of the functional properties of enzymatic plant protein hydrolysates in food systems. *Comprehensive Reviews in Food Science and Food Safety*, 15(4), 786-800.
48. Xu, D., Hao, J., Wang, Z., Liang, D., Wang, J., Ma, Y., & Zhang, M. (2021). Physicochemical properties, fatty acid compositions, bioactive compounds, antioxidant activity and thermal behavior of rice bran oil obtained with aqueous enzymatic extraction. *Journal of Food Science and Technology*, 149, 111817.
49. Yamuangmorn, S., & Prom-u-Thai, C. (2021). The potential of high-anthocyanin purple rice as a functional ingredient in human health. *Antioxidants*, 10(6): 833-853.
50. Yan, Q. J., Huang, L. H., Sun, Q., Jiang, Z. Q., & Wu, X. (2015). Isolation, identification and synthesis of four novel antioxidant peptides from rice residue protein hydrolyzed by multiple proteases. *Food chemistry*, 179, 290-295.
51. Yu, Y., Gaine, G. K., Zhou, L., Zhang, J., Wang, J., & Sun, B. (2022). The classical and potential novel healthy functions of rice bran protein and its hydrolysates. *Critical reviews in food science and nutrition*, 62(30), 8454-8466.