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Improving the Quality Characteristics of Low-Fat Beef Burgers by Adding Different Levels of Rice Bran as a Source of Fibre

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Abstract: The study aims at improving the quality characteristics of low-fat beef burgers. This is done by adding rice bran due to its high fibre content, which reached 40.27%. The burger was prepared using four treatments: the first treatment was a control treatment, the second treatment was through adding rice bran by 10%, the third treatment by 20%, and the fourth treatment by 30%. The chemical content of the product was thoroughly studied. The product was stored in the freezer (-18 ±2) for 90 days. during which some qualitative characteristics were monitored, including moisture, protein, fat, ash, carbohydrates, fibre, and cholesterol. As well as the physical characteristics, which included water holding capacity, loss by dissolving, loss by cooking, shrinkage by diameter, cooking yield, retained moisture, and retained fat. Chemical indicators included thiobarbituric acid and sensory characteristics, as well as color, flavor, tenderness, juiciness, and general acceptability. The results brought to light an increase in the fibre content in the burger prepared by increasing the addition of rice bran. It increased from 10.52% when 10% rice bran to 14.12% and 18.88% when rise adding rice bran to 20% and 30% respectively. The concentration of cholesterol decreased from 68.96 in control to 64.57, 61.86 and 57.43 $mg.100^{-1}$ gm^{-1} when adding 10%, 20% and 30% rice bran respectively. Thiobarbituric acid decreased from 0.48 in control to 0.28 $m.kg^{-1}$ when adding 30%. The loss after thawing, the cooking, and the shrinkage in diameter was also decreased with adding rice bran. The ability to hold water, the cooking yield, the percentage of retained moisture, and retained fat also increased. The duration of storage also had a significant ($p<0.05$) effect on the studied traits. The treatments to which rice bran was added also obtained acceptable evaluation scores, close to the evaluation scores of the control treatment. Especially the treatments to which 20% rice bran was added. The results disclosed that the addition of rice bran improved all quality characteristics of the product.

Keywords: Chemical content, Chemical indicators, Physical properties, Rice bran.

Introduction

The meat products industry is one of the most important food industries in the world. One of the trends in developing the meat industry is the production of healthy products that are characterized by their low-fat content as well as high mineral, vitamin, antioxidant, and

dietary fibre content. (Bis-Souza *et al*., 2018). These products are manufactured by replacing part of the meat with plant-based ingredients such as plant proteins, dietary fibres, or natural antioxidants (Barone *et al*.,2021). Adding fiber to meat products affects some characteristics. It increases the percentage of remaining moisture. It also improves the stability of the emulsion. This is a very significant characteristic of meat products. It also reduces the fat content, Increases the cooking yield, improves the texture of meat products, and maintains the final appearance of the product even after heat treatment (cooking.). Fuller *et al*., (2016). Adding fibre reduces shrinkage by the diameter of the final product. Replacing fats with fibre in the diet contributes to reduce the calorie content of meat products (Hu & Yu 2015). Fibre can improve the ability to hold water and retain fat. It can act as stabilizers and emulsifiers. On this basis, they were used as fat substitutes in processed meat (Han & Bertram., 2017; Zhao *et al*., 2018).

In recent years, interest has deepened in developing the industry of meat products with good functional specifications by fortifying them with dietary fibres. They can upgrade the quality and nutritional value of the products as well as increase the yield (Zinina *et al*., 2019). Some meat products have been fortified with some plant sources rich in dietary fibre, such as wheat bran, rice bran. citrus peels, Avocado pulp (Rawaa *et al*.,2024), and others. These products are good alternatives to meat because of their functional and nutritional properties. In addition, eating these products reduces harmful cholesterol. It reduces the risk of nutritional problems such as obesity, digestive disorders, intestinal infections, and others. In addition, dietary fibre supplements increase the volume of the product and prevent loss during cooking with changes in texture properties by enhancing water-binding ability (Heck *et al*., 2017 ; Soliman, 2019). Dietary fibre is characterized by various functional properties, including solubility, viscosity, and the ability to form gels and binding water. This affects the quality and properties of the product. Due to these qualities, dietary fibre has been introduced into the mixtures of many meat products, such as patties and sausages (Sapwarobol *et al* 2021). Rice bran (*Oryza sativa*) is known as a vital by-product obtained during polishing and grinding. Brown rice and its conversion into white rice (polished rice). (Tan & Norhaizan., 2020;Yadav *et al*., 2021). Rice bran is a rich source of nutritional components such as fat, protein, dietary fibre, ash, and active compounds that include phenolic acids. such as ferulic acid, flavonoids, and anthocyanins such as Cyanidin glucoside. And these compounds have antioxidant activity as they are affected by the difference in the type of rice, and the degree of grinding. In addition, the manufacturing method. (Tan & Norhaizan., 2020). Rice bran contain soluble fibre, it is present in low levels and contains mineral elements, especially potassium, phosphorus, magnesium, selenium, and vitamins (Sapwarhol *et al*., 2021).

The aim of conducting the study is to prepare a low-fat beef burger by adding a vegetable

source rich in fibre to improve its qualitative characteristics and investigation of these characteristics during the storage period.

Materials and working methods

Raw materials: All raw materials used in the study, including meat, fat, table salt, spice mixture, black pepper, garlic, and frying oil, were purchased from local markets in Basrah Governorate in Iraq. The rice bran obtained from rice mills in Al-Mishkhab District in Al-Diwaniyah Governorate. It was cleaned and ground using an electric grinder at 28,000 rpm. Then, sift it several times to obtain a fine powder.

Preparation of methanolic extract.

Al-coholic extract was prepared by weighing 100 g of rice bran powder. It was dissolved in 500 mL of 98% methyl alcohol, mixed well, and left for 24 h at laboratory temperature (25-30°C). The extract was filtered using Whatman No.1 filter paper. The filtrate was then concentrated using a rotary vacuum evaporator (SH-PK-50L SH Scientific, Korea). in tightly sealed opaque containers and stored in the refrigerator until use (Elmastas *et al*. 2015).

GC MS report for rice bran

The components of the prepared rice bran extract were identified using a gas chromatograph connected to a mass spectrometer Japan, GC MS QP10 ULTRA, SHIMADZU in the GC/MS laboratory, College of Agriculture / University of Basrah. The injection process was carried out with the injection type SHIMADZU+s.

Gas Chromatography	Mass Spectrometer
Column Oven Temp: 40°C	Ion source Temp: 200.00°C
Injection Temp:250.00°C	Interface Temp: 250.00°C
Injection Mode: Split	Solvent Cut Time: 3.00min
Flow Control Mode: Linear Velocity	Start Time: 3.00min
Pressure:49.5Kpa	End Time: 28.00min
Total Flow:34.0ml/min	ACQ Mode: Scan
Column Flow:1.00ml/min	Event Time: 0.50sec
Linear Velocity: 36.1cm/sec	Scan Speed: 1000
Purge Flow: 3.0ml/min	Start m/Z: 50.00
Split Ratio:30.0	End m/Z: 500.00
Split Ratio:30.0	End m/Z: 500.00

Computer matching with the NSIT 20libarary.

Preparation of formula

Exactly (3) kg of beef was minced using an electric mincing machine with a hole diameter of 3 mm . Salt was added to it at a rate of 1.5% of the weight of the meat. A mixture of burger spices at a rate of 0.5% for the burger product mix, black pepper at a rate of 0.5%, and garlic at a rate of 0.25.%. Fat was also added to it at a rate of 10%, and it was divided into four sections at 750 g for each section.

Preparation of treatment

Four treatments were prepared at a rate of (750) grams for each treatment, according to the addition rates of rice bran:

First treatment: no addition

Second treatment: adding Rice bran by 10%

Third treatment: adding Rice bran by 20%

Fourth treatment: Adding Rice bran by 30%

The burgers (34 g) were placed in vacuum-sealed polyethylene bags. The tablet is separated from the other by a piece of wax paper. The bags are sealed well. As for the meatballs, they were placed in a cork dish in the Department of Food Science/College of Agriculture/University of Basrah, wrapped in polyethylene bags, wrapped well, and stored in the freezer (-18 ±2) for 90 days, during which changes in the chemical content, chemical indicators, physical characteristics, and sensory characteristics were monitored during the storage periods of 0, 30, 60, and 90 days.

Chemical Content

The percentage of moisture, protein, ash, and carbohydrates in rice bran, meat, and products were estimated according to the method mentioned in Paula *et al*(2019).

Determination of Crude Fibre

Crude fibre in rice bran was estimated according to the method mentioned in (Taly *et al.,* 2024) , by treating the sample with hot diluted sulfuric acid, 12.5%, as the first stage (acid digestion stage), then drying the sample, incinerating the precipitate, and calculating the percentage of fibre using the difference.

Determination of Cholesterol

Cholesterol was estimated according to the method mentioned in the kit issued by the French company Biolab .SA. 0.1 g of samples, the control sample, and 1 mL of distilled water were taken for the plank sample. Place them in test tubes, then add a mixture of R1 and R2 to the samples. 1 mL of R3 solution to the control sample, and 1 mL of distilled water to the plank sample. Then, it was placed in a water bath at a temperature of 37°C for 10 minutes. Then, the absorbance was measured at a wavelength of 500 nm, and then cholesterol was calculated according to the following equation:

$$TC\ \% = \frac{A_o}{A_S\ \times Cs} \times 100$$

Where TC % = Cholesterol (mg/g), A_o = Read the absorbance of the sample, Cs= Standard concentration.

Water Holding Capacity (WHC)

The water-holding capacity of the prepared products was estimated according to the method presented by Abdel Hassan *et al* (2022). A10 g of meat was weighed, and 20 ml of distilled water was added to it and mixed well with the sample. Then, the contents were transferred to a cylinder with a funnel and filter paper at the end. The filtrate was received, and its volume was recorded after 30 minutes. The ability to hold water was calculated as follows:

$$WHC = TWV_1 - TWV_2$$

Where WHC is water holding capacity (ml), TWV_1 is Total water volume (ml), and TWV_2 is the amount of water in the included cylinder (ml).

Calculating the percentage of weight loss after thawing

The percentage of loss by dissolution was estimated according to the method mentioned by Wang *et al*. (2021.). Weighing frozen

burger tablets after removing their wrappers. These samples were then left in the refrigerator (5 ± 1°C) for 24 h. The discs were reweighed after removing liquids from the surface of the samples using filter paper. he percentage of loss after dissolution was calculated according to the following equation:

$$LD\% = \frac{W_r - W_f}{W_c} \times 100$$

Where LD%= Loss after defrosting, W_r = weight of a frozen burger patty (g), W_f = Weight of a burger patty after thawing, Wc= weight of burger patty (g)

Cooking Loss and Cooking Yield

The percentage of weight loss during cooking was estimated according to the method mentioned in El-Zeny *et al*. (2019) . This is done by frying three pieces of each treatment in sunflower oil for five minutes on a hot plate. stirring achieved until the frying is completed. The percentage of weight loss was calculated according to the following equation:

$$CL\% = \frac{W_r - W_c}{W_r} \times 100$$

Where CL = Cooking loss (%), W_r= weight of burgers patties before cooking (g), Wc= weight of cooked patties (g).

By calculating the weight loss during cooking, the percentage of cooking yield was calculated according to the equation mentioned in El-Zeny *et al*. (2019).

$$CY\% = \frac{W_c}{W_r} \times 100$$

Where CY%= cooking yield %, Wc= weight of cooked patties (g), Wr= weight of burgers patties before cooking (g)

Shrinkage in diameter during cooking

The method mentioned in El-Zeny *et al*. (2019) was followed to calculate the percentage of shrinkage by measuring the diameters of the products before and after cooking. according to the following equation:

$$S\% = \frac{D_i - D_o}{D_i} \times 100$$

Where S = Shrinkage (%), D_i = Uncooked diameter (cm), D_o= Cooked diameter (cm).

Moisture Retention

The percentage of retained moisture was calculated using the method mentioned in Ibrahim *et al*. (2018) and according to the following equation:

$$RM\% = \frac{W_a \times M_a}{W_b \times Mb} \times 100$$

Where RM% = Retained moisture %, W_a = Weight of burger patties after cooking, M_a = moisture percentage in burger patties after cooking, W_b= The weight of the burger tablets before cooking, M_b = the moisture percentage in the burger tablets before cooking

Fat Retention percentage

The percentage of retained fat was calculated using the method mentioned in (Ibrahim *et al*., 2018) . by calculating the percentage of fat in the products before and after cooking . from which the percentage of retained fat was

calculated according to the following equation:

$$RF\ \% = \frac{W_a \times F_a}{W_b\ \times Fb} \times 100$$

Where RF% = Retained fat %, W_a = Weight of burger patties after cooking, F_a = percentage of fat in burger patties after cooking, W_b= The weight of the burger patties before cooking, F_b = the percentage of fat in the burger tablets before cooking.

Thiobarbituric Acid (TBA)

The method given by Paula *et al*. (2019) was followed by mixing 20 g of the sample with 100 mL of Trichloroacetic acid solution and mixing well with a magnetic stirrer for two minutes. Then, filter the homogeneous mixture using filter paper and add 5 mL of TBA reagent (0.02)M to 5 mL of the filtrate carefully using a test tube. The tube was placed in a water bath for 40 min. The absorbance of the resulting colour was then measured using a spectrophotometer at a wavelength of 538 nm. TBA values were calculated using the following equation:

$$TBA = \frac{0.016\ + 2.782}{10} - X\ \frac{mg}{100g}$$

Where X = absorbance of the sample at 538 nm.

Sensory evaluation of prepared Burger .

Sensory evaluation of all treatments and all specified storage periods was carried out by 9 specialists in the Department of Food Science/College of Agriculture/University of Basrah. Which included colour, flavor, tenderness, juiciness, and overall acceptability according to the sensory evaluation form mentioned in El-Zeny *et al*. (2019) .

Statistical analysis

The results analyzed by ANOVA using IBM SPSS Statistics (version25), and expressed as mean ± standard error. Differences between means with a p-value ≤ 0.5 considered to be significant (Three replicates were used for each sample).

Results and discussion

Chemical Content of Meat

The results in Table (1) announce the chemical content of beef (thigh area), which includes the percentages of moisture, protein, fat, and ash, which amounted to 72.56%, 22.7%, 2.46%, and 1.23%.

Table (1): Chemical content of meat (thigh area)

Chemical content (%)			
moisture	protein	fat	Ash
72.56±0.07	22.72±0.04	2.46 ± 0.03	1.23 ±0.04

Chemical Content of rice bran

The results in Table (2) suggests that there are significant differences (P<0.05) in the percentages of moisture, protein, fat, ash, carbohydrates, and fibre. The percentage of moisture, protein, fat, ash, and dietary fibre in rice bran reached 7.52%, 12.22%, 16.42%, 8.21%, 55.63%, and 40.27%, respectively.

The results of the chemical content of rice bran converged with the findings of Lavanya *et al* .(2017) when studied the physical, chemical, and functional properties of rice bran . It was found that the percentages of moisture, protein, fat, ash, carbohydrates, and dietary fibre for rice bran are 11.23%, 14.63%, 16.4%, 7.4%, and 51.7%, respectively.

Table (2): Chemical content of rice bran

Chemical content (%)					
moisture	protein	Fat	Ash	Carbohydrates	Dietary fiber
7.52±0.04	12.22±0.1	16.42±0.1	8.21±0.005	55.63±0.1	40.27±0.02

Identification of compounds in rice bran extract

The results in Figure (1) in Table (3) reveal the identification and diagnosis of the quantity and quality of rice bran components using Gas Chromatography-Mass Spectrometry (GC/MS) technology. The appearance of 15 peaks in rice bran, sequentially with their name and percentage of each compound. The highest peak was number 7, represented by the fatty acid Cis-13-Octadecadienoic acid. It constituted the highest percentage, amounting to 32.87% of the total compounds. The following peak No. 6, as shown in the Table, represented by the fatty acid 10E,12Z-Octadecaddienoic acid, or linoleic acid, with a percentage of 24.45%. The active compound n-Hexadecanoic acid in peak No. 3, which represented a percentage of 23.12%, or Palmitic acid. followed by peak No. 13, which is represented by the compound 9-Octadecenoic acid(Z)-,2,3- dihydroxy propyl ester, which represents a percentage of 7.18%. Followed by peak No. 11, which is represented. by the compound Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester, which represents a percentage, The peak No. 12, represented by the active compound 9,12-Octadecaddienoic acid(Z, Z)-, 2,3-hydroxypropyl ester, representing 2.66%. Peak number 15, represented by the compound Gamma-Sitosterol, representing 2.10%, followed by peak number 14, represented by the compound Stigmasterol. As for the other compounds, their percentages varied, and active compounds appeared in small percentages. These compounds which identified by (GC/MS) like limonen-6-ol, pivalate in peak 1, stigamasterol in peak 14 and Gamma-sitosterol in peak 15. These compounds are bioactive compounds have antioxidand activity there for it effects in reducing lipid oxidation. During storage of burger.(Lavanya *et al* .,2017). While, other peaks including fatty acids, there are very important especially omiga fatty acids.

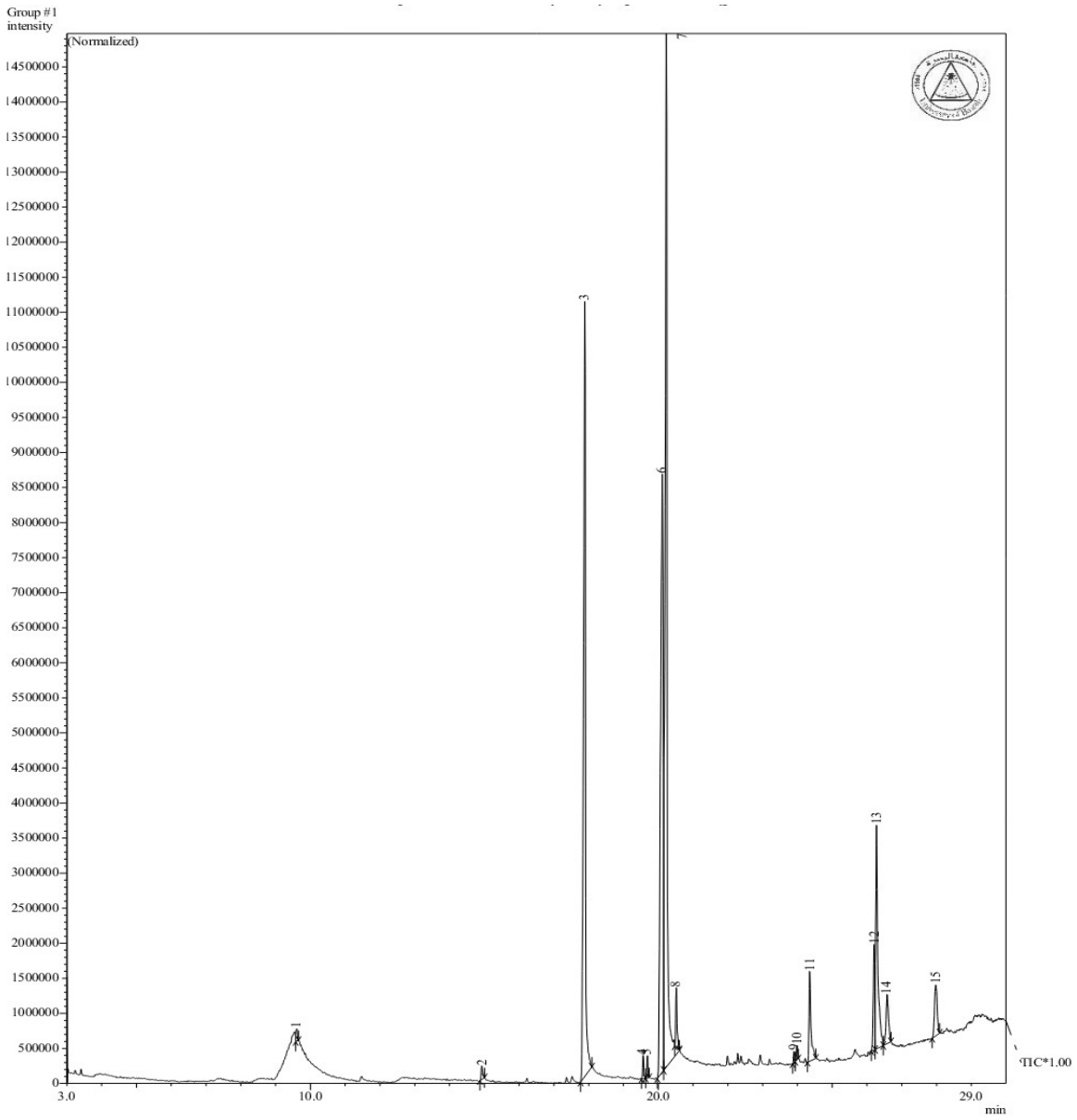

Figure (2): GC/MS diagram of rice bran extract components

Table (3): GC/MC report of rice bran extract components

Peak	R. Time	Area	Area%	Name
1	9.608	520605	0.28	Limonen-6-ol, pivalate
2	14.927	619768	0.33	Tetradecanoic acid
3	17.891	43397601	23.12	n-Hexadecanoic acid
4	19.567	771348	0.41	9,12- Octadecanoic acid, methyl ester
5	9.6891	691297	0.37	10- Octadecanoic acid, methyl ester
6	20.116	45901567	24.45	10E, 12Z- Octadecadienoic acid
7	20.233	61718203	32.873	Cis-13- Octadecenoic acid
8	20.518	2243590	1.20	Octadecanoic acid
9	23.901	341344	0.18	Bis(2-(Dimethylamino)ethyl) ether
10	23.988	511042	0.27	1-Hexadecanaminium, N, N, N-trimethyl-,octadecanoate
11	24.353	5022138	2.68	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester
12	26.204	5001391	2.66	9,12- Octadecadienoic acid(Z,Z)-,2,3-dihydroxypropyl ester
13	26.275	13479927	7.18	9- Octadecenoic acid(Z)-,2,3-dihydroxypropyl ester
14	26.579	3573795	1.90	Stigamasterol
15	27.978	3946422	2.10	Gamma-Sitosterol
		187740038	100.00	

The effect of adding rice bran on Moisture of burger

The results of the statistical analysis in Figure (2) tell that the moisture percentage when adding rice bran decreased compared to the control treatment. The results also showed that the moisture percentage was significantly affected ($P<0.05$) by increasing the addition rate. The moisture percentage in the burger fell from 68.21% in the control treatment to 65.82% in the treatment in which the rice bran was added by 10%, then to 63.31% in the treatment in which the rice bran was added by 20% and then to 61.88% in the treatment in which 30% rice bran was added. The reason for this shrinkage may be attributed to the reason for this decrease in moisture may be attributed to the high content of fibre and low moisture in rice bran compared with meat. The mixing of meat with rice bran due to decrease moisture content . This result agreeded with yadav *et al* .(2018) who noticed when adding carrot waste and wheat bran decreased the moisture content in the product.

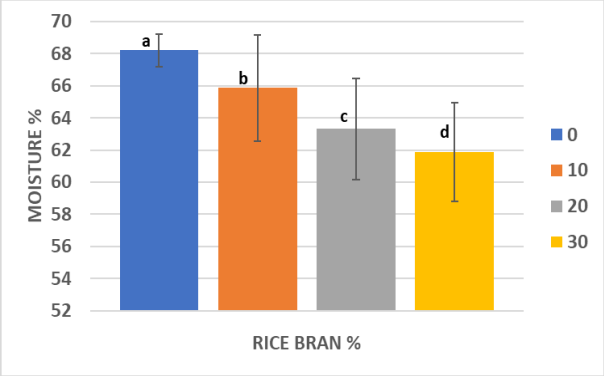

Figure (2): The effect of the addition percentage on the percentage of moisture in beef burgers. The effect of adding rice bran on Protein of burger

The results in Figure (3) revealed a fall in the percentage of protein when adding rice bran as a source of fibre. The results of the statistical analysis also showed a decrease in the percentage of protein as the addition rate increased. The percentage of protein in the burger decreased from 19.11% in the control treatment to 18.58%, 17.14%, and 16.81%, respectively.

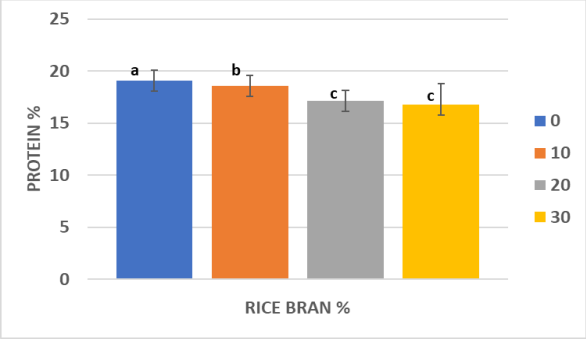

Figure (3): The effect of rice bran and the addition percentage on the percentage of protein in beef burgers.

The effect of adding rice bran on fat of burger

The results in Figure (4) display an increase in the percentage of fat in the treatments to which rice bran was added. It increased from 11.12% in the control treatment to 13.77% when the addition rates increased by 10%, then to 14.84% and 14.93% when the addition rates were 20% and 30%, respectively. The reason for the higher percentage of fat in beef burgers when rice bran is added can be explained by the higher percentage of fat in rice bran, which amounts to 16.42%. Therefore, it led to a high percentage of fat in the burger product, especially at the additional rate of 30%. These results didn't agree with El-zeny *et al*. (2019). This noticed that the addition 25%, 50% and 75% of chicory root powder to beef burger due to decrease the fat content from 11.97% and 7.63% respectively.

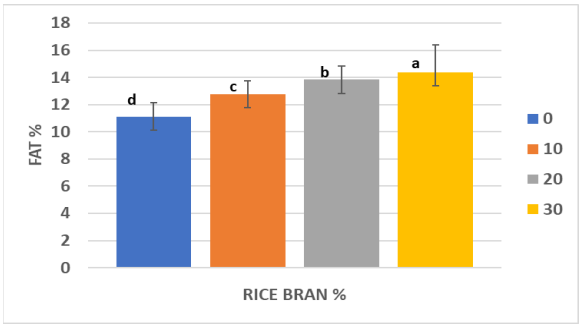

Figure (4): The effect of the addition percentage on the percentage of fat in beef burgers.

The effect of adding rice bran on ash of burger

The results are shown in Figure (5), where the percentages of ash in burgers to which rice bran powder was added multiplied from 1.22% in the control treatment to 2.25%, 2.45%, and 2.77% at addition rates of 10%, 20%, and 30%, respectively. These results were consistent with Paula *et al*. (2019) who noticed that the addition of 2%,4% and 8% of

chia seed to hamburgers increased the percentage of ash from 3.7% in the control to 3.8% , 3.9% and 4.1% in hamburger which adding the chia seed respectively.

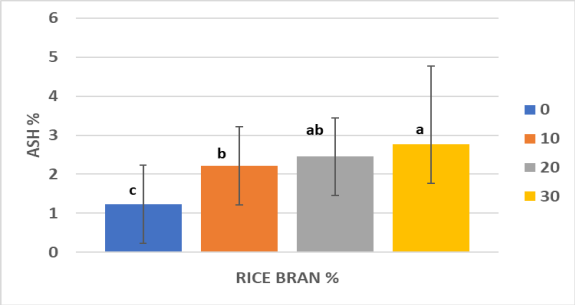

Figure (5): The effect of addition percentage on the percentage of ash in beef burgers.

The effect of adding rice bran on Carbohydrates of burger

The results are displayed in Figure (6), where a significant increase ($P<0.05$) was observed in the percentage of carbohydrates in the beef burger to which rice bran was added. It was noted that the percentage of carbohydrates increased with increasing addition rates from 0.33% in the control treatment to 2.58%, 3.33%, and 4.18% at addition rates of 10%, 20%, and 30%, respectively. These results agreed with the findings of Essa & Elsebie (2018) in their study on the effect of adding 25%, 50%, and 75% of date pit powder on the qualitative characteristics of beef burgers. They noticed that adding date pits in the proportions mentioned above increased the carbohydrate content in the prepared product significantly compared to the carbohydrate content in the control treatment 59.34%. The carbohydrate content in the treatments to which date pit powder was added in the above proportions reached 61.60%, 64.57%, and 66.20%, respectively.

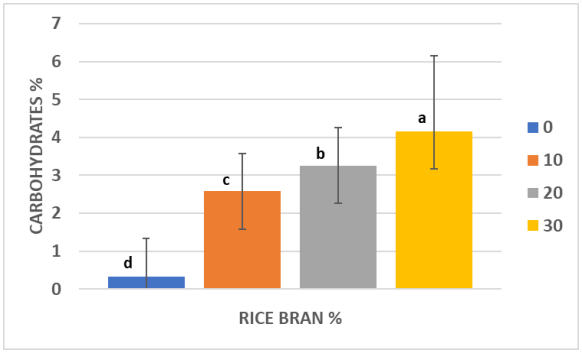

Figure (6) : The effect of the addition percentage on the percentage of carbohydrates in beef burgers

The effect of adding rice bran on Dietary fibre of burger

The results were illustrated in Figure (7), where an increase in the percentage of dietary fibre was observed in the treatments to which rice bran powder was added. The reason for this may be due to the high content of rice bran dietary fibre, which reached 40.27%. It was observed that the percentage of fibre increased with an increase in the addition rate, as the percentage of dietary fibre in burgers to which rice bran was added increased to 10.52% at the addition rate of 10%, then to 14.82% and 18.91% at the addition rates of 20% and 30%, respectively. These results agreed with El-Zeny *et al*. (2019) in their study on the effect of adding different levels of chicory root powder on the quality characteristics of beef burgers. They found that the percentage of dietary fibre increased significantly when adding chicory root powder at levels of 25%, 50%, and 75%. The percentage of dietary fibre was intensified in the treatments to which chicory

root powder was added in the above proportions to 2.98%, 3.78%, and 4.21%, respectively. In comparison, its percentage in the control treatment was 1.23%. Rice bran is a rich source of nutritional components such as dietary fibre which improve digestion in the intestines and stimulate the growth of beneficial bacteria (Elleuch et al ,2011 ; Tan & Norhaizan., 2020).

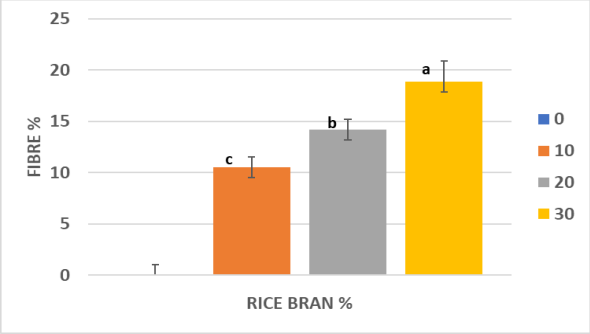

Figure (7): The effect of addition percentage on the percentage of Dietary fibre in beef burgers

The effect of adding rice bran on Cholesterol of burger

The results in Figure (8) signaled a decrease in cholesterol concentration in the treatments to which rice bran was added. It was also noted that the cholesterol concentration in the burger decreased significantly (P<0.05) with increasing addition rates. The cholesterol concentration in burgers to which rice bran was added decreased at an addition rate of

10% to 65.83 mg.100-1 gm-1, then to 62.77 and 57.46 mg.100-1 gm-1when the addition rates increased by 20% and 30%, respectively. The control treatment in which the cholesterol concentration was 69.72 mg.100-1 gm-1. The reason of the decrease in cholesterol may be attributed to rice bran free of cholesterol there for when it adding in high percentage to the meat products it was reduced the content of cholesterol in the products.

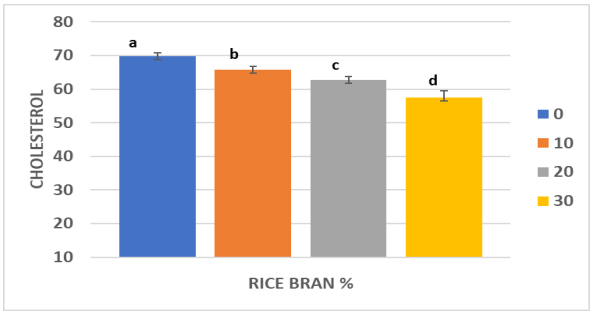

Figure (8): Shows the effect of adding rice bran and the addition ratio on the cholesterol concentration in beef burgers

The effect of adding rice bran on water holding capacity

Water-holding capacity is one of the important properties of meat by virtue of its relationship with juiciness and tenderness(Al-Temimi *et al*., 2023). The results in Figure (9) bring to light an increase in water holding capacity in the treatments to which rice bran was added. The results of the statistical analysis also showed that the addition ratios had a significant effect (P<0.05) on the water-holding capacity of the prepared burger. It was observed that the water holding capacity increased with increasing addition rates. These results agreed with Abdel Hassan *et al*. (2022) who noticed that the addition of 10%, 15%, and 20% of minced cowpeo there was increased in water holding capacity of chicken mortadella. It was increased from 18.55 in control to 19.67, 21,17 and 23.42% respectively. The water holding capacity of the burger to which rice bran was added

gradually rised from 14.66 ml in the control treatment to 16.62 ml at an addition rate of 10%, with increasing addition rates to 20% and 30% the water holding capacity increased to 18.13 ml and 19.88 ml respectively. The results of the statistical analysis showed that the water-holding capacity of the prepared burgers decreased significantly (P<0.05) as the storage period progressed in all treatments, and the decrease was more evident in the control treatment. It decreased from 14.66 ml before storage to 14.44 ml at the end of the storage period (90 days) of freeze storage. In the treatments to which 10% rice bran was added, the water holding capacity decreased from 16.62 ml before storage to 16.58 ml after 30 days of storage. It decreased to 16.52 ml and 16.45 ml after 60 and 90 days. And so on for the rest of the addition ratios. The reason of the decrease in water holding capacity during freezing may be attributed to the loss of water during thawing.

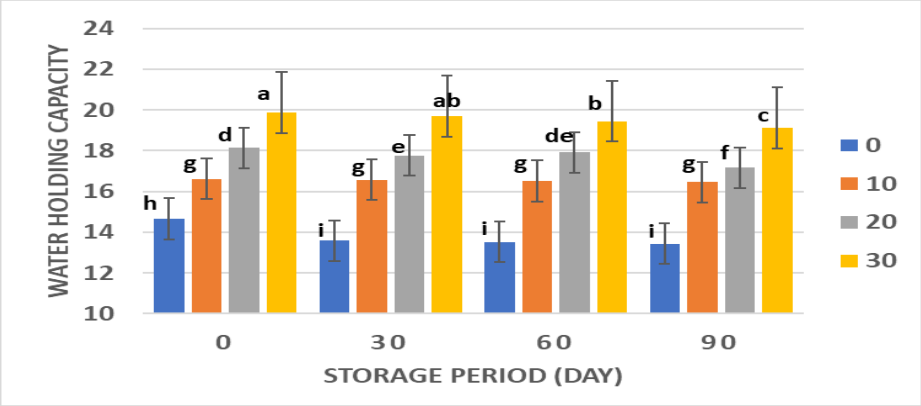

Figure (9): The effect of addition rate and storage duration on the water-holding capacity of meat burgers during storage periods

The effect of adding rice bran on percentage of weight loss after thawing

The results in Figure (10) show the percentage of weight loss after defrosting the prepared burger. It was observed that the percentage of weight loss fell by increasing the addition percentage in the burger treatments to which rice bran was added. It weakened from 6.68% in the control treatment to 5.86%, 5.18%, and 5.12% when adding 10%, 20%, and 30%, respectively. The reason for this dropped in the percentage of weight loss in burger patties prepared when adding rice bran may be attributed to the fiber content. Fibre is a substance that has a high affinity for binding water, so during thawing, there is less liquid in the burger patties. Therefore, the loss rate is less. It was noted from the results of the statistical analysis that the percentage of weight loss during thawing increased significantly (P<0.05) as the storage period continued. In the control treatment, it increased from 6.38% before storage to 10.75% after 90 days of freeze storage. The coefficients of burgers to which rice bran was added enlarged to

8.73%, 7.68%, and 7.12% when adding 10%, 20%, and 30%, respectively. This decreased in the percentage of weight loss after thawing due to the high loss of water after thawing the burger.

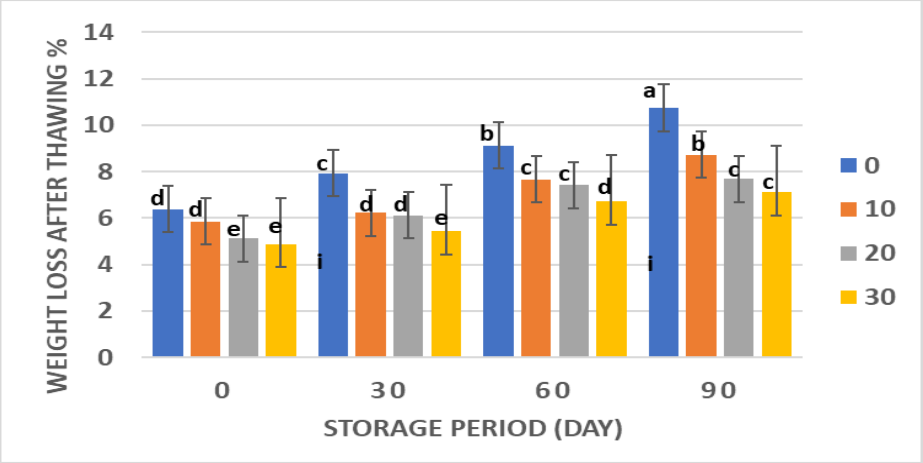

Figure (10): The effect of the addition rate and storage duration on the percentage of weight loss during thawing

The effect of adding rice bran on Percentage of weight loss while cooking

The results in Figure (11) exhibit a shrinkage in the percentage of weight loss during cooking in all treatments to which bran was added. The rate of loss during cooking was also significantly ($P<0.05$) affected by the addition rates. The percentage of loss during cooking in burger treatments to which rice bran was added fell from 27.12% in the control treatment to 20.86%, 15.76%, and 9.06% at addition rates of 10%, 20%, and 30%, respectively. It agreed with what El-Zeny *et al*. (2019) found in their study of the effect of adding chicory roots powder on the qualitative characteristics of beef burgers at levels 25% , 50%, 75%. Their addition led to a reduction in the percentage of weight loss of prepared burger, as the percentage decreased from 52.46% in the control to 46.92% and 42.18% and 37.70% when adding 25%, 50% and 75% of chicory roots powder, respectively. It was observed that there was a significant increase ($P<0.05$) in the percentage of weight loss during cooking as the storage period progressed. The increase in the rate of loss during cooking was more evident after 90 days of frozen storage, reaching 31.93% in the control treatment. The percentage of loss during cooking in burgers to which rice bran powder was added in the proportions of 10%, 20%, and 30% after 90 days reached 24.63%, 18.54%, and 13.46%, respectively. The reason for the high rate of loss during the storage period is that slow freezing leads to the formation of large ice crystals during freezing and the melting of these crystals and their loss in the form of water droplets during thawing and cooking the meat in addition to the loss of moisture from the surface of the meat during the storage period, which leads to a high percentage of weight loss.

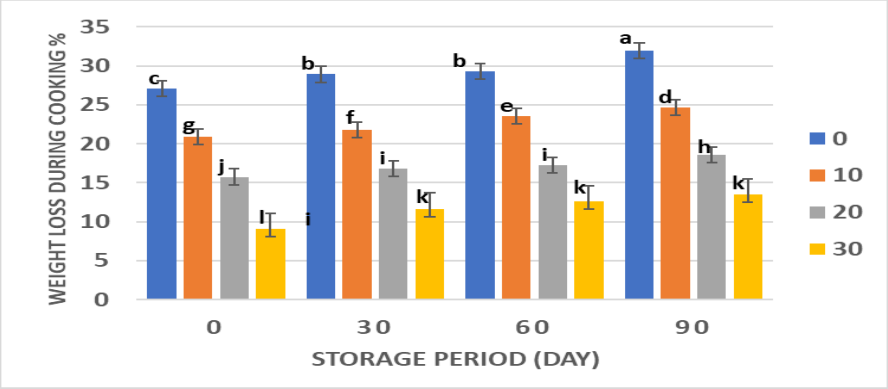

Figure (11): The effect of addition rate and storage duration on the percentage of weight loss during cooking

The effect of adding rice bran on Percentage of cooking Yield Percentage

The results in Figure (12) display a higher cooking yield in all treatments compared to the control treatment. The highest percentage of cooking yield was when rice bran was added. This is due to its high fibre content and water retention. Consequently, the loss decreases during thawing and cooking, which is reflected in the percentage of cooking yield. These results agreed with the results obtained previously for the water holding capacity and water holding capacity in the treatments to which rice bran was added. The reason for this is that as the percentage of waste added to the product increases, the percentage of fibre in it increases, and thus the ability to retain water increases. In addition, these wastes contain active compounds that possess functional groups that can bind to water. These results agreed with what was found by El-Zeny *et al*. (2019). Their study aimed to demonstrate the effect of adding different levels of chicory roots pit powder on the cooking yield of beef burgers. They noticed that adding of powder at levels of 25%, 50%, and 75% had a significant effect on the cooking yield of the prepared product. The cooking yield in the treatments increased to 53.08%, 57.82%, and 61.90%, respectively. While the cooking yield in the control treatment was 47.14%. The results showed that the cooking yield percentage was significantly affected ($P<0.05$) by the storage period. It was observed that the percentage of cooking yield in the prepared burgers decreased as the storage period progressed, and the decrease was higher in the control treatment. The percentage of cooking yield decreased from 72.88% to 67.07% after 90 days of freeze storage. As for the treatments to which rice bran was added, when 10% was added, it was 79.14%, decreasing to 78.18 after 30 days, then to 76.46% and 75.37% after 60 and 90 days of freeze storage. These results agreed with Ibrahim *et al*. (2018) in the study on the effect of storage on the percentage of cooking yield of minced meat patties, as they noticed a decrease in the percentage of cooking yield as the duration of freeze-storage continued. They noticed that cooking yield dropped from 66.05% before storage to 56.55% after storage period.

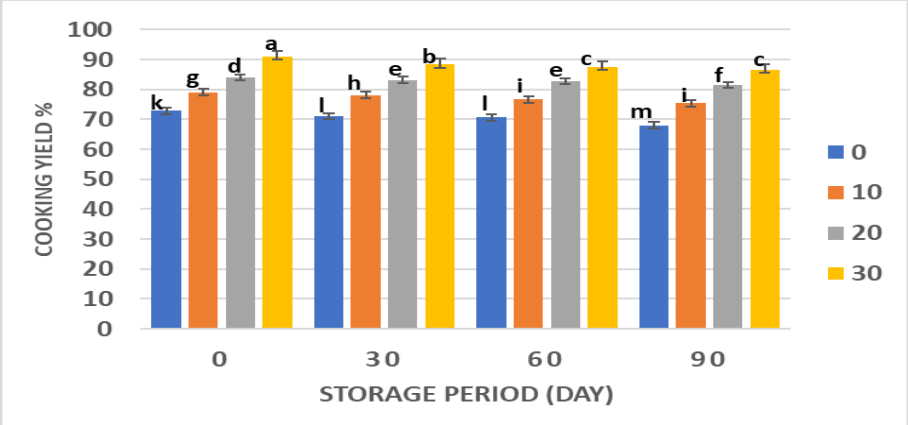

Figure (12): The effect of addition ratio and storage duration on the percentage of cooking yield

The effect of adding rice bran on Percentage of shrinkage Dimeter

The results in Figure (13) disclose that the percentage of diameter shrinkage in meat patties to which rice bran was added decreased from 15.72% in the control treatment to 13.56%, 11.78%, and 10.11% when 10%, 20%, and 30% were added, respectively. This is due to the decrease in water and fat loss during cooking and the percentage of adding plant waste to the fibre source, and this is reflected in the shrinkage of the pericarp discs. The results agreed with Paula *et al*. (2019) when they studied the effect of replacing part of the fat with chia seed powder on the diameter shrinkage rate in hamburger patties. They was found that the fall rate decreases in hamburger. This decrease increases with an increase in the replacement rate, as the shrinkage rate decreased from 12.6% in control to 11.2% and 10.8% with addition rates 4% and 8% of chia seed. The reason for these decreases was explained by the ability of chia seed to bind water and fats, thus reducing the loss during cooking, which in turn leads to a decrease in the diameter shrinkage rate in hamburger.

The results presented that the diameter shrinkage rate increased significantly ($P<0.05$) as the storage period increased. It increased in the control treatment from 15.72% before storage to 18.93% after 90 days of freeze storage. As for the burger tablets to which rice bran was added at a rate of 10%, it was 13.56% before storage, and it increased to 14.35%, 15.55%, and 16.87% after 30 days. 60 and 90 days of freeze storage, respectively. This result was in line with Ibrahim *et al*. (2018) who noticed that the shrinkage % increase in beef patties during storage .It increased from 11.66% in control before storage to 15.79% after storage , but when they adding 2% orange of shrinkage was less than control .It increased from 3.75% before storage to 5.47% after storage.

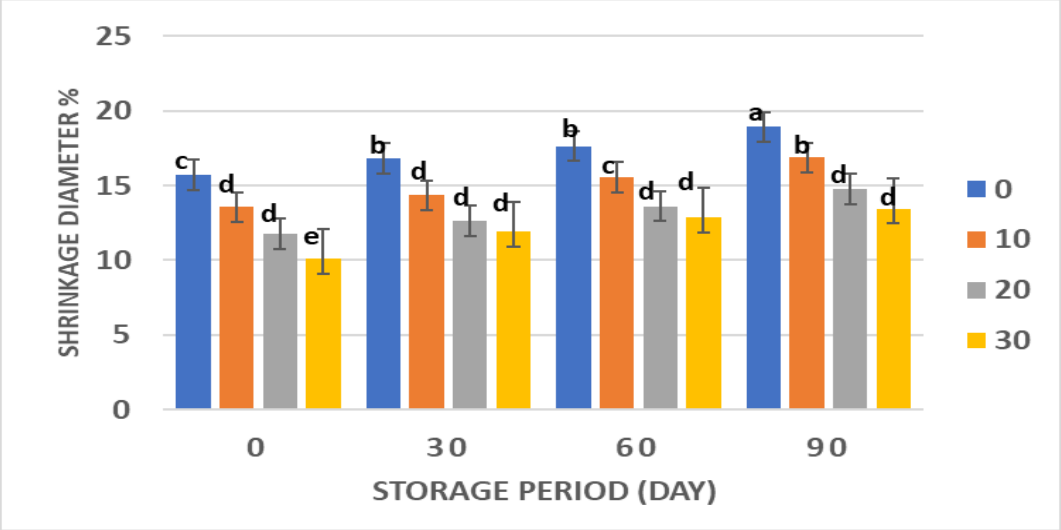

Figure (13): The effect of addition rate and storage duration on the shrinkage diameter rate

The effect of adding rice bran on Percentage of Moisture Retention

The results in Figure (14) demonstrate a higher percentage of retained moisture in all treatments to which rice bran was added compared to the control treatment. The reason for this may be due to the high percentage of fibre in rice bran, which has a high affinity for retaining water. The percentage of retained moisture was also affected significantly ($P<0.05$) by the addition rates, as the percentage of retained moisture increased with the increase in the addition percentage. In burger tablets to which rice bran powder was added, the moisture percentage increased from 61.92% in the control treatment to 64.86%, 66.56%, and 68.55% at addition rates of 10%, 20%, and 30%, respectively. I agree with the findings of Zhao *et al.*(2021) in their study on adding a 0.5%, 1.0%, 3.0%, 5.0% and 7.0% of insoluble dietary fibre from kiwi fruit pomace to retain moisture in beef burgers. They noticed that the percentage of retained moisture in the treatment to which the pomace was added increased according to increase the addition of pomace. The results of the statistical analysis also showed that there was a significant effect ($P<0.05$) of the storage period on the percentage of moisture retained in the beef burger. The percentage of retained moisture decreased significantly as the storage period progressed. In the control treatment, it fell from 61.92% before storage to 58.54% after 90 days of freeze storage. But when adding rice bran the decrease in percentage of moisture retention was less than control. It decreased from 68.55% before storage to 66.61% after storage in burger that the addition rate 30%.

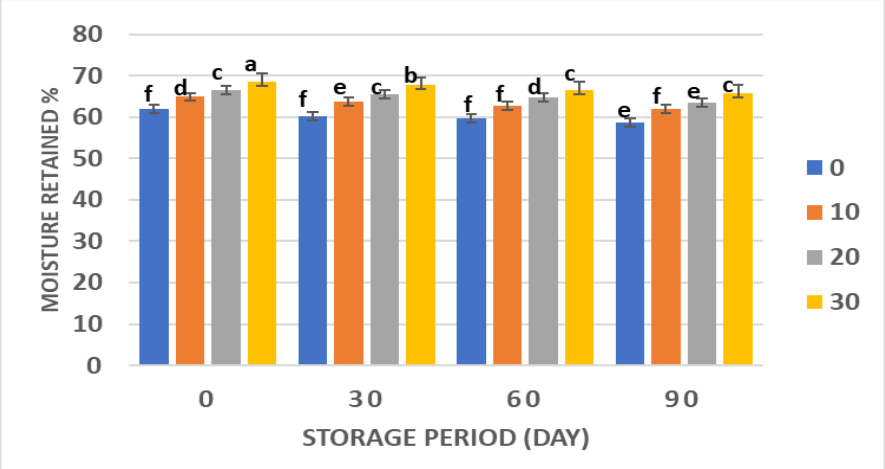

Figure (14): The effect of addition rate and storage duration on the percentage of moisture retained

The effect of adding rice bran on Percentage of fat Retention

The results of the statistical analysis in Figure (15) presented a rise in the percentage of retained fat with an increasing addition rate. It increased in the treatments to which rice bran powder was added from 67.97% when 10% was added to 72.92% and 78.82% when the addition rates were increased to 20% and 30%, respectively. The reason for this increase in the percentage of retained fat may be attributed to an increase in the percentage of fibre in the product due to an increase in the percentage of adding a fibre source. Consequently, the fat is absorbed by the fibres, and the minced meat mixture may interact to prevent the fat from leaving (Alakali et al., 2010). The percentage of retained fat decreased significantly ($P<0.05$) as the storage period progressed in burgers to which 10% of rice bran was added. It decreased from 67.97% before storage to 65.75%, 63.68%, and 61.97% for the periods mentioned above, respectively. The results agreed with Ibrahim et al. (2018), who noticed a decrease in the percentage of fat retained in beef patties when different percentages of orange and lemon peels were added. The decrease was more pronounced in the control treatment compared to the treatments to which orange and lemon peels was added. Their results exhibited that the fat retention percentage decreased from 58.14% to 44.62% in control. Fat retention percentage decreased from 65.46% to 57.01% when adding 2% orange peel, but when adding 2% 2% lemon peel it decreased from 65.81% before storage to 57.97% after storage. The reason was attributed to the fall in the percentage of fat in the burger during the storage period after cooking, in addition to the change that occurs in the weight of the burger patties before and after cooking. Calculating the percentage of retained fat depends on the weight of the burger patties and the percentage of fat in them before and after cooking.

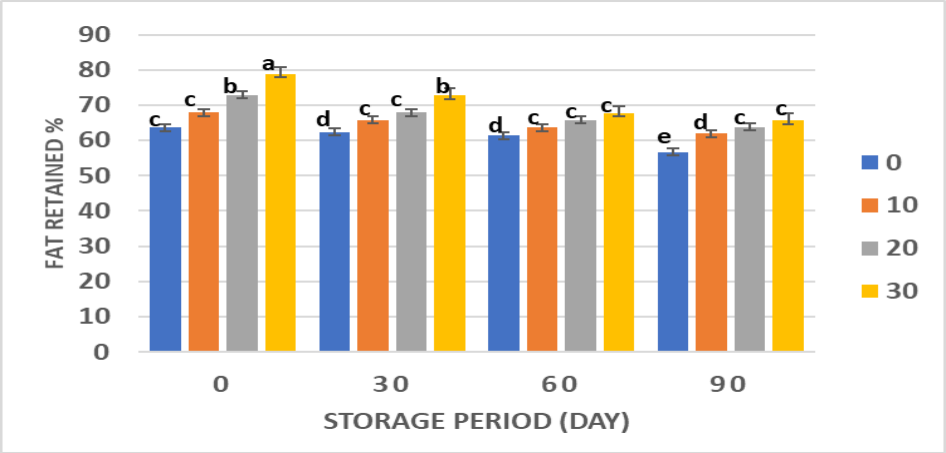

Figure (15): The effect of addition rate and storage duration on the percentage of fat retained

The effect of adding rice bran on Percentage of thiobarbituric Acid (TBA)

The results in Figure (16) show the shrinkage in the value of thiobarbituric acid in burgers prepared with rice bran added. The value of thiobarbituric acid decreased from 0.44 m.kg^{-1} when adding 10% to 0.32 and 0.26 m.kg^{-1} when adding rates increased to 20% and 30%, respectively. The reason for the fall in acid value may be as a result of the high content of phenolic compounds in plant wastes that have antioxidant activity, such as (Gamma-Sitosterol, Stigamasterol, and Phytosterol). These results agreed with what was found by Paula *et al*. (2019) reported in their study that a significant decrease in thiobarbituric acid values occurred when different levels of chia seeds were added to chicken burgers. The value of thiobarbituric acid in the control treatment was 2.5 mg malonaldehyde/kg. This value decreased in the treatments to which chia seeds were added at levels of 2%, 4%, and 8% to 1.4, 1.1, and 0.8 mg malonaldehyde/kg, respectively. The value of thiobarbituric acid was significantly affected ($P<0.05$) by the duration of storage. In the control treatment, it increased from 0.47 before storage to 2.52 mg malonaldehyde/kg after 90 days of freeze storage. These results agreed with Al-Baidhani & Al-Mossawi (2019). They found that the storage period significantly affected on the acid value. It increased from o.45 and 0.53 before storage to 1.11 and 1.57 mg malonaldehyde/kg after 90 day of storage. As for the burger to which rice bran was added, the acid value increased when 10%, 20%, and 30% were added. % from 0.44, 0.32, and 0.26 mg malonaldehyde/kg before storage to 2.41, 2.05, and 1.92 mg malonaldehyde/kg, respectively, after 90 days of freeze storage. These results agreed with what Yadav *et al*. (2018) found in their study of the effect of adding wheat bran and dried carrot waste on the qualitative characteristics of chicken sausage. The values of thiobarbituric acid increased in the control treatment and the treatments to which dietary fibre was added with increasing storage period. However, the increase was

more pronounced in the control treatment compared to the treatments to which rice bran was added. This is due to the presence of bioactive compounds in rice bran, which had an antioxidant effect that reduced acid values.

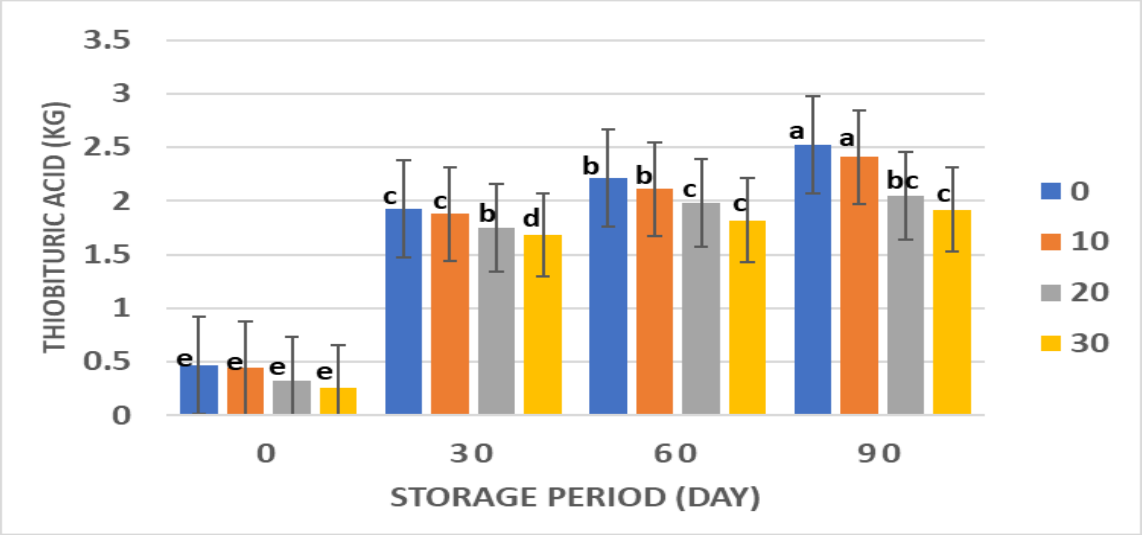

Figure (16): The effect of addition rate and storage duration on the percentage of thiobarbituric acid

The effect of Adding rice bran on Colour

The results are disclosed in Table (4), where the colour attribute evaluation score decreased to 6.33 when 30% was added to the burger to which rice bran was added. The control treatment was 7.00. It also agreed with what El-Zeny *et al*. (2019) found, in their study, influence on colour evaluation scores of beef burgers. Adding chicory root powder at levels of 25%, 50%, and 75% led to a decrease in the colour evaluation scores in the prepared burgers. The colour evaluation scores for the control treatment reached 8.04. In contrast, for the treatments to which dandelion root powder was added at the above levels, the scores reached 7.20, 7.11, and 6.95, respectively.

The results of the statistical analysis brought to light that the storage period had a significant effect ($P<0.05$) on the colour attribute evaluation score, as it gradually decreased as the storage period progressed. In the control treatment, it decreased from 7.00 before storage to 6.55 after 90 days of freeze storage. As for the burgers to which 10% rice bran powder was added, the percentage decreased from 6.88 before storage to 6.66, 6.33, and 6.11 during periods of 30, 60, and 90 days of frozen storage.

Table (4): The effect of rice bran, addition rates of rice bran, and storage duration on the colour characteristic of meat burgers during storage at a temperature of (-18±2) C for 90 days:

Storage period	Addition ratios			
	0 %	10 %	20 %	30 %
0	7.00±0.5a	6.88±0.04a	6.77±0.01b	6.33±0.01cd
30	7.00±0.5a	6.66±0.01b	6.55±0.02c	6.11±0.06e
60	6.88±0.03a	6.33±0.02	6.22±0.01de	5.77±0.01f
90	6.55±0.01c	6.11±0.06	6.00±0.5d	5.44±0.02g

The effect of adding rice bran on flavor

The results in Table (5) presented that the evaluation score decreased in the treatments to which rice bran was added compared to the control treatment. The flavor evaluation score decreased significantly ($P<0.05$) with an increase in the addition rate from 7.00 in the control treatment to 6.88 when 30% of rice bran powder was added to 6.11. The storage period had a significant effect ($P<0.05$) on the flavor evaluation score, as it decreased as the storage period progressed in burgers to which 20% rice bran was added, from 6.11 before storage to 5.33. As for the control treatment, the flavor evaluation score decreased from 7.00 to 6.33 at the end of the 90-day freezer storage period. The reason of this shrinkage in flavor degree during storage due to oxidation of fat especially after 90 day of storage.

The effect of Adding rice bran on Tenderness

The results in Table (6) revealed a lower degree of evaluation of the freshness

characteristic of the burger to which rice bran was added compared to the control treatment. The treatments to which rice bran was added were more tender and obtained the highest scores. Because the high content of fibre which have the ability to retain water or bind water may be help improve the texture. The freshness evaluation score also decreased with an increase in the addition rate, as it decreased from 6.77 to 6.55 when 10% of rice bran was added. With an increase in the addition rate to 20% and 30%, the score decreased to 6.33 and 6.11, respectively. The results of the statistical analysis showed the degree of evaluation of the tenderness characteristic of beef burgers. It gradually decreased as the storage period progressed. In the burger to which 10% of rice bran powder was added, the percentage fell from 6.55 before storage to 6.33, 6.00, and 5.66, respectively, during the storage period of 30, 60, and 90 days of freeze storage.

Table (5): The effect of rice bran, addition ratios of rice bran, and storage duration on the flavor of meat burgers during storage at a temperature of (-18±2) C for 90 days:

Storage period	Addition ratios			
	0 %	10 %	20 %	30 %
0	7.00±0.5a	7.00±0.5a	6.77±0.04bc	6.11±0.06d
30	6.88±0.04ab	6.55±0.02c	6.33±0.03cd	5.88±0.03e
60	6.55±0.02c	6.33±0.02cd	6.00±1.5de	5.33±0.01f
90	6.33±0.01cd	5.77±0.0	5.55±0.04f	5.33±0.07f

Table (6): The effect of addition rates of rice bran and storage duration on the tenderness characteristic of meat burgers during storage at a temperature of (-18±2) C for 90 days:

Storage period	Addition ratios			
	0 %	10 %	20 %	30 %
0	6.77±0.01a	6.55±0.01b	6.33±0.03c	6.11±0.06d
30	6.55±0.02b	6.33±0.02c	6.11±0.06d	5.77±0.03e
60	6.33±0.03c	6.00±0.5d	5.77±0.03e	5.55±0.01f
90	6.11±0.06d	5.66±0.03e	5.33±0.04g	5.11±0.06h

The effect of Adding rice bran on Juiciness The results in Table (7) display a lower degree of juiciness in burgers to which rice bran powder is added. The score decreased from 7.00 to 6.77, 6.55, and 6.33 at addition rates of 10%, 20%, and 30%, respectively. The results are consistent with the findings of El-Zeny et al. (2019). Who was found that there was a significant fall in the degree of juiciness values with an increase in the percentage of replacing fat with chicory root powder in beef burgers compared to the control treatment. The evaluation score reached 8.12 and shrank to 7.10 when the replacement percentage was 5%. The score reached 7.07, and 6.88 when the replacement percentages increased to 50. %, and 75% respectively. The reason for this decrease in evaluation scores during storage was attributed to the loss of water and fat in the products during storage. It was also found that the degree of evaluation of the characteristics of juiciness was high. It shrank as the storage period progressed, reaching 6.11, 5.77, and 5.55 in burgers to which 30% rice bran powder was added after 30, 60, and 90 days, respectively, of freeze storage

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Table (7): The effect of rice bran, addition rates of rice bran, and storage duration on the juiciness of meat burgers during storage at a temperature of (-18±2) C for 90 days:

Storage period	Addition ratios			
	0 %	10 %	20 %	30 %
0	7.00±0.5a	6.77±0.03ab	6.55±0.01b	6.33±0.01bc
30	6.77±0.01ab	6.55±0.01b	6.33±0.03bc	6.11±0.06c
60	6.55±0.01b	6.33±0.02	6.11±0.06c	5.77±0.04de
90	6.22±0.015	6.00±1cd	5.77±0.03de	5.55±0.01e

The effect of Adding rice bran on overall acceptability

The results in Table (8) exhibit a significant shrinkage ($P<0.05$) in the evaluation score of the burger patties to which rice bran was added compared to the control treatment. The addition rates also had a significant effect ($P<0.05$) on the general acceptance rating score. The general acceptability score fell with a rise in the percentage of toppings in burgers, to which rice bran was added by 30% and 6.11. While the general acceptance score in the control treatment was .7.00, as agreed with Abdel Hassan *et al*. (2022) in their study effect of adding different content ration of cowpea on sensory properties of chicken mortadella. there is a reduction in the general acceptance score of the prepared mortadella compared to the control treatment. This shrinkage was very clear when the percentage of cowpeo increased. The score declined from 7 in the control treatment to 6.77 and 6.42 when the replacement ratio went up to 15% and 20%, respectively.

Table (8): The effect of rice bran, addition rates of rice bran, and storage duration on the general acceptance characteristic of meat burgers during storage at a temperature of (-18±2) C for 90 days

Storage period	Addition ratios			
	0 %	10 %	20 %	30 %
0	6.88±0.02a	6.77±0.03ab	6.55±0.015b	6.11±0.06d
30	6.66±0.01ab	6.44±0.01bc	6.22±0.01cd	5.55±0.01ef
60	6.33±0.01cd	6.11±0.06d	5.88±0.02e	5.33±0.01fg
90	6.11±0.06d	5.77±0.5e	5.55±0.01ef	5.11±0.06g

Conclusions and Recommendations

This study has come up with the fact that the physical, chemical, and sensory properties can be improved by adding rice bran. The treatment to which 20% was added obtained the best scores for sensory evaluation. in addition to an increase in water holding capacity and a reduction in the oxidation process as a result of rice bran containing active compounds that have a high potential as antioxidants. This was demonstrated by the values of TBA, which were low compared to the control treatment. Therefore, it is recommended using rice bran in the manufacture of low-fat meat products. As it is rich in healthy dietary fibre and natural antioxidants and free of cholesterol.

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Contributions of authors

N. A. G., sample preparation and analysis, laboratory methodology, writing the manuscript, graphs, and statistical analysis.

AHM, choosing the study topic, fixing its title, checking and analyzing the data, and addressing the study's obstacles.

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Conflicts of Interest

The authors have not declared any conflict of interest.

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تحسين الصفات النوعية لبيركر اللحم البقري المنخفض الدهن بإضافة مستويات مختلفة من نخالة الأرز كمصدر للألياف

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المستخلص: هدفت الدراسة تحسين الصفات النوعية لبيركر اللحم البقري المنخفض الدهن وذلك بإضافة نخالة الأرز لمحتواها العالي من الالياف اذ بلغ 40.27% اذ تم تحضير البيركر بأربعة معاملات المعاملة الأولى معاملة السيطرة والمعاملة الثانية اضيف لها نخالة الأرز بنسبة 10% والمعاملة الثالثة بنسبة 20% والمعاملة الرابعة بنسبة 30% درس المحتوى الكيميائي للمنتوج و خزن المنتوج بالتجميد (−18 ±2) لمدة 90 يوماً تم خلالها متابعة بعض الصفات النوعية وشملت الرطوبة والبروتين والدهن والرماد والكاربوهيدرات والالياف والكوليسترول والصفات الفيزيائية وشملت سعة حمل الماء والفقد بالتذويب والفقد بالطبخ والانكماش بالقطر وحاصل الطبخ والرطوبة المحتجزة والدهن المحتجزة والمؤشرات الكيميائية ومنها حامض الثايوباربتيورك والصفات الحسية وشملت اللون والنكهة والطراوة والعصيرية والقبول العام. اظهرت النتائج ارتفاع محتوى الالياف في البيركر المحضر بزيادة إضافة النخالة اذ ارتفعت من 10.52 % عند إضافة 10% نخالة الأرز الى 14.12% و18.88% عند زيادة نسبة الإضافة الى 20%و30% وانخفض تركيز الكوليسترول من 68.96 ملجم /100 غم في معاملة السيطرة الى64.57 و 61.86 و 57.43 ملجم /100 غم عند إضافة 10%و20%و30% من نخالة الأرز على التوالي اما حامض الثايوباربتيورك فقد انخفض من 0.48 في معاملة السيطرة الى و0.28 عند إضافة 30% من نخالة الأرز كما انخفضت نسبة الفقد بالأذابة ونسبة الفقد بالطبخ ونسبة الانكماش بالقطر كما ارتفعت قابلية حمل الماء وحاصل الطبخ ونسبة الرطوبة المحتجزة والدهن المحتجزة كما كان لمدة الخزن تأثيراً معنوياً على الصفات المدروسة. كما حصلت المعاملات التي اضيف لها نخالة الأرز على درجات تقييم مقبولة ومقاربة لدرجات تقييم معاملة السيطرة وخاصة المعاملات التي اضيف لها 20% نخالة الأرز أوضحت النتائج ان إضافة نخالة الأرز حسنت جميع الصفات النوعية للمنتوج.

الكلمات المفتاحية: المحتوى الكيميائي، المؤشرات الكيميائية، الخصائص الفيزيائية، نخالة الارز