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Comparing the effects of hydrothermal and microwave processes on the physicochemical properties of rice bran

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Today, bran is considered a functional compound in the food industry. The aim study was to investigate different processing methods of rice bran to improve its physicochemical characteristics. Treatments were prepared in 12 groups, control (C0), 4 samples hydrothermal treated H1 and H2 (1 and 2 h at 30 °C, respectively), H3 and H4 (1 and 2 h at 80 °C, respectively), 4 samples microwave treated M1 and M2 (4 and 7 min at a 600 w, respectively), M3 and M4 ((4 and 7 min at a 600 w, respectively), 4 samples hydrothermal-microwave treated HM1 and HM2 (First, 1 and 2 h at 50 °C, respectively, then 4 min at 750 w), HM3 and HM4 (First, 1 and 2 h at 50 °C, respectively, then 7 min at 750 w). The results showed that the hydrothermal-microwave method was more effective in reducing phytic acid than the other two methods ($p<0.05$) so the HM4 treatment had the lowest amount of phytic acid ($p<0.05$). The color value test showed the lowest ΔE change was related to rice bran hydrothermal treated (H1 with ΔE equal to 6.36) ($p<0.05$). The hydrothermal-microwave process showed the highest retention of iron, zinc, and calcium ($p<0.05$). Most minerals were shown in HM1 (6.68, 1.56, and 106.43 ppm, respectively). The heavy metals test indicated that in all treatments, the number of heavy metals significantly decreased compared to the control ($p<0.05$). However, the microwave method was more effective than others ($p<0.05$). Therefore, it can be concluded that using the hydrothermal-microwave method provides better quality rice bran.

1-Introduction`

Rice is one of the main dishes globally, especially in Asia. Previous studies have shown that rice by-products from the grinding process contain a variety of nutrients and bioactive compounds that have beneficial health effects [1]. One of these products is rice bran, which accounts for about 10% of the rice grain, depending on the type of rice and the amount of grinding [2]. Rice bran contains 12% fiber (90% insoluble fiber including cellulose, hemicellulose and arabinoxylane), as well as a good source of high-quality proteins (e.g., albumin and globulin), high amounts of linoleic acid and polyunsaturated multiple fatty acids, essential minerals (e.g., potassium, calcium, magnesium and iron), water-and fat-soluble vitamins (e.g. thiamine, riboflavin, niacin and tocopherol), phenolic compounds and numerous antioxidants of rice stebus contain 12% fiber (90% insoluble fiber including cellulose, hemicellulose, and arabinoxylane), as well as a good source of high-quality proteins (e.g. , Albumin and globulin), high amounts of linoleic acid and polyunsaturated multiple fatty acids, are essential minerals (e.g., potassium, calcium, magnesium and iron), water-and fat-soluble vitamins (e.g. thiamine, riboflavin, niacin and tocopherol), phenolic compounds and numerous antioxidants, which is why the consumption of rice bran has gained a special place in the food industry as a super-beneficial compound[3,4]. Unfortunately, despite the high nutritional value of rice bran, it is considered as one of the agricultural waste due to the presence of anti-nutritional factors such as the oxidative enzyme lipoxygenase, phytic acid, etc., which reduces the nutritional value of Bran [5]. Rice bran, on the other hand, has a significant concentration of heavy metals including mercury, lead, chromium and cadmium, whose accumulation in the human body can cause irreparable effects such as decreased growth, decreased learning power, mental and respiratory disorders, reproductive disorders, blood sugar disorders, liver diseases, etc.Because heavy metals are usually no longer excreted after entering the body and are deposited in fatty tissues, muscles, bones, and joints [6]. In order to improve the oral and nutritional quality of Bran, a number of researchers focused on modifying the properties of Bran through methods such as reducing the size of the particles, soaking Bran, fermentation, enzymatic treatment, hydrothermal process and microwave process, which reduces phytic acid and improves the physicochemical properties of rice bran [7,8]. The hydrothermal process is one of the most effective ways to improve the characteristics of rice bran. In this method, the phytic acid in the rice shell is converted to free myoinositol and phosphorus after consecutive soaking, steaming and drying operations. In a process that begins during the soaking and heating process, the breakdown of the phytic acid structure is influenced by the activation of the intracellular phytase enzyme [4]. In this regard, sharma et al. (2004) showed that during the use of extrusion and hydrothermal methods, the extrusion pressure distortion, the protein chains in the rice bran are opened and formed into a spongy and filamentous state, which is released by the release of these connections, the phosphate and mineral groups are released, and phytic acid is also reduced [9]. Sharafi et al. (2019) also reported during the soaking phase in the hydrothermal process, as the soaking time increased, the removal of toxic metals increased. The main reason for this finding is that with increased soaking time (in other words, increased contact of rice bran with water), the water penetration rate to rice bran increases, which leads to more heavy metals being released into the water and their exit from the bran [10]. The use of microwaves is one of the newest heating methods and the most effective process in reducing the anti-nutritional compounds of Bran and can be used to prepare processed

Bran for use in food formulation [11]. Izadi et al. (2021) during the use of the fermentation process and microwave waves showed that in constant power, with increasing time, the intensity of the process is increased and the significant amount of phytic acid in rice bran is reduced. The researchers reported the presence of antioxidant properties in phytic acid because when using the microwave, phytic acid, due to its antioxidant properties, inhibits free radicals and breaks down as a result of its structure [3]. Due to the health effects of rice bran and its use as a super-beneficial compound, it is important to choose a method that leads to the maximum reduction of harmful compounds along with the maximum maintenance of its beneficial components. The study aimed to influence the hydrothermal process, microwave and finally a combination of these two methods on the physicochemical properties of rice bran.

2-Material and methods

2.1. Preparation of raw materials:

Rice bran in the amount of 5 kg was prepared raw from the global Kobe rice factory located in the Asalem section of Talesh city and was stored in air - resistant and moisture-resistant polyethylene packaging in the freezer (-18 °C). The chemicals used in the research were purchased from Merck (Germany).

2.2. Hydrothermal rice bran processing:

50 grams of rice bran with twice its volume the acetate buffer (7-4=pH) was soaked in a 500 ml Arlen Meyer and sealed with foil. Sample prepared in Avon (Drayers B9206; Wolverine crop. Little rock, AR, USA) with the temperature of the investigated treatments (30 and 50 and 80 degrees Celsius) was placed for 60-120 minutes, then the samples containing the acetate buffer were kept in the same conditions for 24 hours. Subsequently, the spicy samples from the Avon and the contents of the Arlen were washed several times with distilled water with a funnel and flat paper until its PHH reached the pH before the process, i.e. 6.2. Then the samples, in the Avon with a temperature of 50 ° C to reach a humidity of 10-11%, dried for 8 hours, after which they were packed in polyethylene packages at room temperature [12].

2.3. Microwave rice bran processing:

In the microwave process, 10 grams of Bran samples are poured into glass plates and under microwave waves model (EMS 820, Electron Microscopy Sciences Co. England) with powers of 600, 750 and 900 were placed for 4 and 7 minutes [3].

2.4. Rice bran processing by combination method (hydrothermal-microwave):

In this method, according to paragraphs 2-2, first the bran samples were subjected to the hydrothermal process (at a temperature of 50 ° C for 1 and 2 hours) and then to the microwave process (at a power of 750 W for 4 and 7 minutes) according to paragraphs 2-3 [3-12].

Table1.table of treatments

Treatment Code	Hydrothermal process	Microwave
C_0	Control (Rice bran)	Control (Rice bran)
H_1	30°C/1 h	-
H_2	30°C/2 h	-
H_3	80°C/1 h	-
H_4	80°C/2 h	-
M_1	-	600 w/ 4 min
M_2	-	600 w/ 7 min
M_3	-	900 w/ 4 min

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M_4	-	900 w/ 7 min
HM_1	50°C/1 h	750 w/ 4 min
HM_2	50°C/2 h	750 w/ 4 min
HM_3	50°C/1 h	750 w/ 7 min
HM_4	50°C/2 h	750 w/ 7 min

2.5. Measuring the amount of phytic acid in rice bran:

In order to determine the amount of phytic acid in Bran and flour, the titration method was used according to the method of sim et al. (2020). The basis of this method is the titration of the iron complex of the capacity that remains after the deposition of phytic acid [13].

2.6. Measurement of colored indicators of rice bran:

The color assessment of the samples was done using the HunterLab-US device and the L*, a* and b* components were measured. Overall color changes (ΔE) were calculated and reported from the relationship [14].

2.7. The color model (L*a*b*) is composed of three components:

The brightness component (L value) which has a range of zero to 100 and the other color component (range from -120 to 120) includes a component (with a green to red color spectrum) and the b component (with a blue to yellow color spectrum). According to the following Formula (ΔE), the difference between each of these components is calculated before and after the treatment is applied.

$$\Delta E=\sqrt{(L^*{}_2-L^*{}_1)^2+(b^*{}_2-b^*{}_1)^2+(a^*{}_2-a^*{}_1)^2}$$

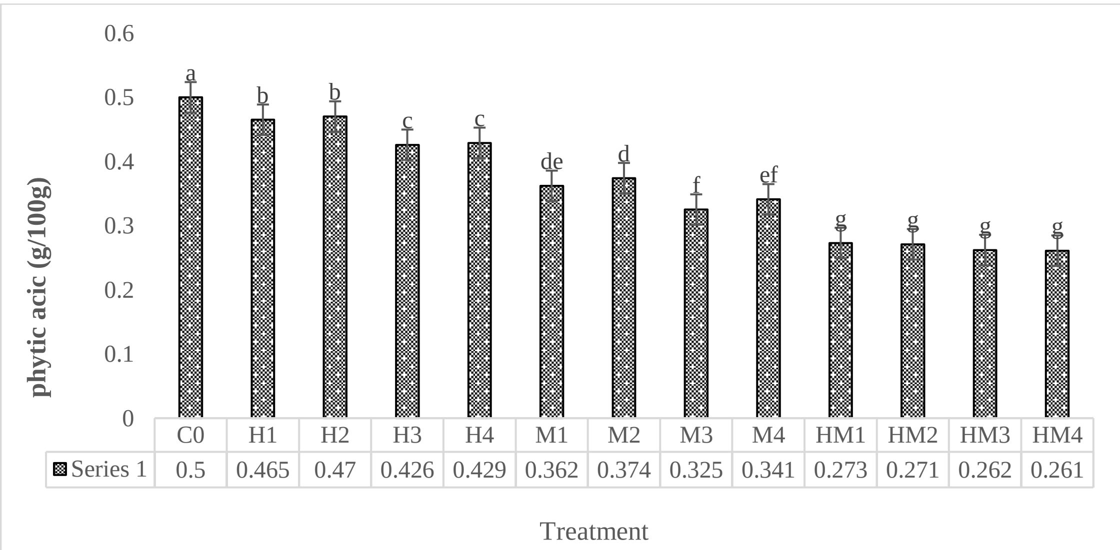
2.8. Measurement of minerals and heavy metals of rice bran:

First, the samples were washed with distilled water and placed in the oven at 105 degrees Celsius for 48 hours. The samples were then ground and 1 gram of the ground sample was transferred to the digestive balloon, 20 ml of acidinitric acid and 70% per gram per sample were added to each sample in a ratio of 3+1 per gram of the sample. In order to clarify the solution, it was placed on the heater for 45 minutes, the sample was digested with distilled water to a volume of 25 ml and smoothed with a flat paper. Finally, induction paired plasma mass spectrometry (AMETEK-Germany) was used to determine the amount of minerals (iron, zinc and calcium) and heavy metals (cadmium, lead, chromium and Mercury) [15].

Statistical analysis: To examine the significance and meaninglessness of the data in the form of a completely random scheme with 3 iterations, the analysis of the results obtained using the SPSS-16 software was analyzed and the comparison of the averages was carried out using the multidomain Duncan Test at the probability level of 5 percent. Charts and tables were also drawn by EXCEL software.

3- Results and discussion:

Evaluation of the effect of hydrothermal and microwave processes and their combination on the phytic acid content of rice bran: Phytate is considered an anti-nutrient due to their ability to interact with minerals, proteins, and starch, resulting in insoluble complexes that alter the function, digestion, and absorption of these dietary components [14]. The results of the effect of different treatments on the amount of phytic acid of the samples are shown in Figure 1. According to the results, the effect of the hydrothermal process, the microwave and its combination on the reduction of the amount of phytic acid was significant ($p<0.05$). Comparison of averages showed the highest rate of phytic acid was observed in the witness sample (0.5 g/100g) ($p<0.05$). There was no significant statistical difference between 1 and 2 hours in the use of the hydrothermal process ($p>0.05$). However, the increase in soaking temperature from 30 to 80 ° C caused a significant decrease in phytic acid in rice bran samples($p<0.05$). This is due to the increased dissolved phytates in water, as well as the inner phytase activity in the Bran during the cooking process and further hydrolysis of the phytates [11]. The effect of the microwave process on reducing phytic acid was significantly greater than the hydrothermal method ($p<0.05$). Because enzymatic hydrolysis and structural changes in phytic acid occur with greater power during microwave heating, resulting in a greater reduction in the amount of phytic acid in samples [4]. The results also showed a significant effect of reducing phytic acid in hydrothermal-microwave hybrid-treated Bran samples ($p<0.05$) comparing averages indicated a greater drop in phytic acid than independent methods (Figure 1). It seems that due to the relatively high thermal stability of phytic acid, higher temperatures are needed to decompose it, which may also decompose the phytase enzyme due to this long period of time. For this reason, the simultaneous use of microwaves and hydrothermals, which lead to heat exertion in less time, can be more effective in reducing phytic acid than independent methods [3]. In line with the results obtained, majzoobi et al. (2013) showed the effect of the hydrothermal process on the decrease in the content of phytic acid in wheat bran [12]. Alajaji et al. (2006) also showed that in microwave processing at constant power, the amount of phytic acid decreases more as time increases due to increased temperature, and the greatest decrease in power was observed at 900 W for 5 minutes. The researchers attributed this to the increased intensity of heat penetration in these conditions [16]. But another important reason for the microwave's effect on reducing phytic acid levels seems to be the presence of antioxidant properties in phytic acid. So when you use the microwave, phytic acid reduces free radicals because of its antioxidant properties, so its structure breaks down. So when using the microwave process, two heat factors and the antioxidant effect of phytic acid can reduce this compound. In fact, free radicals force phytic acid to degrade as antioxidants in the presence of free radicals and prevent oxidation of other compounds, which ultimately leads to a decrease in phytic acid [17]. Irakli et al. (2020) also showed a decrease in the amount of phytic acid in microwave-treated Bran samples, attributing its cause to the heat-sensitive nature of phytic acid and the formation of insoluble complexes between phytates and other components [18].



*Similar lowercase letters between treatments are not statistically significant at ($P>0.05$) level.
H: hydrothermal, M: microwave, HM: hydrothermal + microwave

Fig 1. Comparison of the amount of phytic acid in different processing methods

Evaluation of the effect of hydrothermal and microwave processes and their composition on the color indicators of rice bran:

Color is an impressive and decisive factor in the quality of food, which has a special effect on the choice of consumers for food products. The effects of different treatments on the color of rice bran are shown in Table 2. The results showed that hydrothermal, microwave and hybrid hydrothermal - microwave processes had a meaningful effect on the color factors of the samples ($p<0.05$). The highest brightness index was related to the control sample (61.95). A decrease in the brightness index was observed in all treated samples (Table 2). The average results showed the highest brightness, respectively, in samples under hydrothermal treatment (H1) > microwave-hydrothermal combination treatment (HM1) > microwave treatment (M1) reported ($p<0.05$). Reduced lighting in processed Bran by microwave methods can be due to a noticeable change in the content of Bran water as well as products from the Millard reaction that occur during the microwave process due to the intensity of pressure and heat and the fluctuation of the moisture content [19]. The color indicators also showed that the lowest rate of redness and highest yellowing was related to the sample, and the treatment of rice bran with the microwave was significantly less yellowing than other treatments, and among the processing methods, the highest redness index was observed in hydrothermal samples treated, and the microwave method caused a significant decrease in the redness index of the treatments ($p<0.05$). The study of color changes in Figure (2) also shows that samples processed by hydrothermal method had a lower rate of color changes than those under the microwave and the microwave-hydrothermal method ($p<0.05$). In line with the results obtained by Irakli and colleagues (2020) reported similar trends in the color changes of samples during the study of the effect of the microwave process on improving the characteristics of rice bran [18]. The lower amount of light can be attributed to the Heat used during the drying of the bran at 50 degrees Celsius, which causes the color to darken [12]. Akbari et al. (2021) also showed that hydrothermal processing of rice bran reduces its color changes, and that its low changes can be due to mild heat or several washing steps in this method [20]. Majzoobi et al. (2013) also reported that the heat and chemicals used in the hydrothermal process and several washing stages cause changes in the colored compounds of the bran, as well as the Heat used during drying the bran at 50 ° C causes noticeable color changes in it [12].

Table 2. Comparison of mean color in different processing methods

Treatment	L*	b*	a*
C_0	61.95 ± 2.20 ^{a}	19.34 ± 0.62 ^{a}	11.43 ± 0.60 ^{a}
H_1	56.07 ± 1.56 ^{b}	17.15 ± 0.33 ^{b}	56.07 ± 1.56 ^{b}
H_2	53.45 ± 0.61 ^{b}	18.02 ± 0.04 ^{b}	53.45 ± 0.61 ^{b}
H_3	53.61 ± 2.14 ^{b}	17.12 ± 0.20 ^{b}	53.61 ± 2.14 ^{b}
H_4	55.06 ± 3.63 ^{b}	18.49 ± 3.63 ^{b}	55.06 ± 3.63 ^{b}
M_1	19.92 ± 1.78 ^{ef}	3.54 ± 1.12 ^{e}	19.92 ± 1.78 ^{ef}
M_2	20.52 ± 0.50 ^{ef}	1.90 ± 0.83 ^{f}	20.52 ± 0.50 ^{ef}
M_3	19.31 ± 0.57 ^{f}	1.20 ± 0.15 ^{f}	19.31 ± 0.57 ^{f}
M_4	22.62 ± 1.64 ^{e}	6.53 ± 1.64 ^{d}	22.62 ± 1.64 ^{e}
HM_1	43.27 ± 1.47 ^{c}	18.13 ± 1.83 ^{b}	43.27 ± 1.47 ^{c}
HM_2	38.84 ± 0.75 ^{d}	14.70 ± 0.50 ^{c}	38.84 ± 0.75 ^{d}
HM_3	22.37 ± 1.14 ^{e}	6.19 ± 0.55 ^{d}	22.37 ± 1.14 ^{e}
HM_4	21.12 ± 0.74 ^{ef}	4.61 ± 1.10 ^{e}	21.12 ± 0.74 ^{ef}

*Similar lowercase letters between treatments are not statistically significant at ($P>0.05$) level in each column

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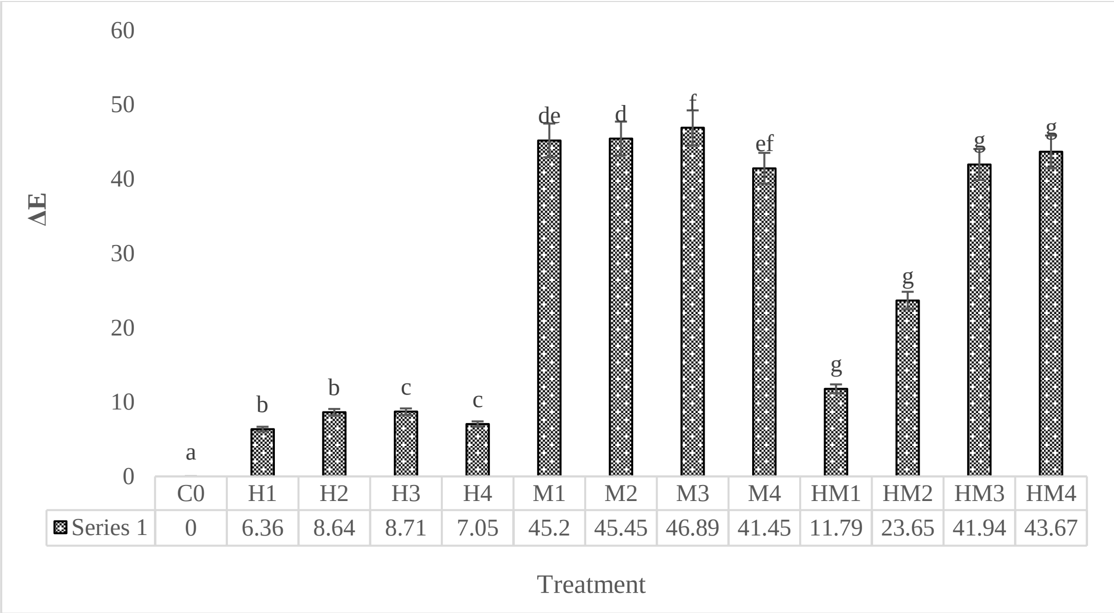

*Similar lowercase letters between treatments are not statistically significant at (P>0.05) level.

Fig 2. Comparison of the amount of ΔE in different processing methods

Evaluation of the effect of hydrothermal and microwave processes and their combination on heavy metals of rice bran:

Among the heavy metals examined in accordance with the results in Table (3), the amount of cadmium in all samples was not detectable before and after the process was applied. it seems that the high solubility of cadmium in water and its relatively high mobility and small initial amounts can be among the reasons that have made it easier to get out of the bran [21]. But rice bran treated with any of the hydrothermal, microwave and hydrothermal - microwave combined methods caused a significant reduction in lead, chromium and Mercury in the bran samples ($p<0.05$). To measure the risk of each heavy metal, the most appropriate criterion is to compare its concentration in food consumed and their tolerance limit according to the standard. According to the standard for the maximum tolerance of heavy metals, the maximum virtual amount of each of them is consumed in human and livestock feed, which does not cause any harm to human health in the short or long term [6]. According to the results of Table (3), the highest chromium content in the witness sample (ppm 0.20) was the application of Bran processing treatments, reducing the Chromium concentration to about 50% of the witness sample, which is a significant drop and comparing the results obtained with the standard of daily intake tolerance shows that the Chromium concentration in all treatments was between 7 and 16% of the daily intake limit.

A study of the results of lead values shows that the concentration of lead in the treatment of the witness is higher than the daily allowance and all processing methods lead to a decrease in lead compared to the witness sample, but despite this decrease, its concentration compared to Chromium shows significant values relative to the standard of tolerance. So, among the samples, after ppm 0.29, the highest lead levels were reported in HM3 and H2 treatments (0.21 and 0.22 ppm, respectively), which are still higher than the standard value. Of course, microwave processing can significantly reduce lead, so that microwave processing methods reduce the amount of lead to less than 70% of its concentration in the witness sample, and microwave treatment with any power and intensity reduces lead to less than the standard of tolerance. Naseri et al. (2018) reported that despite the fact that the proximity of water can reduce the content of heavy metals in Bran, This decrease has been more for some heavy metals and less for others [22]. The decrease in the content of heavy metals caused by thermal processing is in the form of Ni> Cd>Pb> Cr in other words, lead will face a greater decrease compared to chromium in the vicinity of heat. Therefore, given that all M1 to M4 treatments were lower than the standard level than the witness sample, it can be said that the microwave method is a more suitable method to reduce lead levels. Li et al. (2013) also stated that compared to other thermal methods, moderate-intensity microwave treatment is more effective in reducing heavy metals, especially reducing cadmium and lead. This could be because microwaves stimulate the movement of most heavy metals and their exit from Bran tissue compared to other thermal methods, such as hydrothermal. In fact, if the sample is processed with less moisture, it will be more effective in removing heavy metals than when the sample contains a lot of moisture (such as water immersion or soaking methods) [23].

Table 3. Comparison of minerals (ppm) in different processing methods

Treatment	Pb (ppm)	Cr (ppm)	Hg (ppm)
C_0	0.29 ± 0.02^{a}	0.20 ± 0.01^{a}	0.069 ± 0.34^{a}
H_1	0.12 ± 0.01^{c}	0.11 ± 0.00^{cde}	0.067 ± 0.00^{a}
H_2	0.22 ± 0.03^{a}	0.07 ± 0.00^{e}	0.050 ± 0.00^{d}
H_3	0.06 ± 0.00^{e}	0.10 ± 0.00^{e}	0.054 ± 0.00^{c}
H_4	0.09 ± 0.00^{d}	0.11 ± 0.00^{cde}	0.050 ± 0.00^{d}
M_1	0.09 ± 0.07^{d}	0.08 ± 0.00^{f}	0.050 ± 0.00^{d}
M_2	0.07 ± 0.08^{de}	0.11 ± 0.00^{cd}	0.050 ± 0.00^{d}
M_3	0.08 ± 0.00^{de}	0.08 ± 0.00^{fg}	0.050 ± 0.00^{d}
M_4	0.06 ± 0.00^{e}	0.11 ± 0.01^{de}	0.050 ± 0.00^{d}
HM_1	0.12 ± 0.00^{c}	0.08 ± 0.00^{fg}	0.060 ± 0.00^{b}
HM_2	0.09 ± 0.00^{d}	0.16 ± 0.01^{b}	0.060 ± 0.00^{b}
HM_3	0.21 ± 0.02^{a}	0.11 ± 0.00^{de}	0.050 ± 0.00^{c}
HM_4	0.08 ± 0.00^{de}	0.12 ± 0.00^{c}	0.050 ± 0.00^{c}
Standard	0.15 ± 0.00	1.00 ± 0.00	0.225 ± 0.00

*Similar lowercase letters between treatments are not statistically significant at (P>0.05) level in each column

The mercury results also showed that mercury concentrations in all treatments were at least 70% below the standard daily intake tolerance limit (0.255 ppm). The highest concentration of mercury in treatment was H1 (0.67 ppm), but in all microwave-treated samples (M1-M4) Mercury was at the lowest level ($p<0.05$) and there was no significant difference between microwave treatments with different power and intensity. Kenawy et al. (2018) showed that the microwave method is a good way to remove mercury, due to the increase in the correction process in the microwave radiation method due to the increase in temperature in a short time [25]. The results also showed that among the processing methods, mercury concentration-reducing treatments are directly related to the phytic acid-reducing treatments in the samples. According to these results, Kumar et al. (2010) also showed that acidophytic derivatives are directly related to the concentration of heavy metals, especially Mercury, so that by creating a Mercury complex and trapping it, they can lead to mercury out of the grain. As the water temperature rises, soaking or vaporizing for a long time increases, the release of acidific acid in the water increases, and the ease of mercury out of the bran increases [24]. In general, although all treatments have been effective in reducing the amount of heavy metals to less than the witness sample and less than the daily allowance, the use of microwaves has shown a more significant positive effect in reducing heavy metals, and in treatments that were applied solely to the independent hydrothermal process, a more significant amount of heavy metals remains, which cannot be ignored due to their irreparable long-term effects [6].

Evaluation of the effect of hydrothermal and microwave processes and their combination on rice bran minerals:

The mineral survey in the treated samples compared to the witness sample is shown in Table 4. According to the results, a significant effect of various treatments on minerals was observed. The results show that the hybrid hydrothermal-microwave method was more effective in preserving minerals than independent processing methods. So that the highest concentration of all the minerals studied (iron, zinc and calcium) was seen in the combined treatment of HM1 (6.68 and 1.56 and 106.43 ppm, respectively). Comparison of independent methods showed that hydrothermal method was more effective in preserving iron and zinc, so the lowest amount of iron and zinc was seen in the treatment of M2 (1.94 and 0.55 ppm respectively), but in calcium protection the hydrothermal method was weaker than the microwave method, so that the lowest amount of calcium was seen in the treatment of H3 (52.53 ppm). A lower decrease in calcium concentration in microwave treatments than hydrothermal treatments can be due to the breakdown of the relevant salts and its ion release due to microwave radiation [5]. In conjunction with the results of the study, majzoobi and colleagues (2013) reported that the application of independent thermal methods, such as hydrothermal or microwave processes alone, reduces the mineral salts in the Bran due to the intensity of the operation. While in combined processes, more minerals can be preserved by reducing the heating time or reducing the power of the waves consumed . It also seems that in the hydrothermal process, it is likely that due to the presence of several washing stages, there is also a decrease in the compounds in the bran, including some minerals or even proteins, among which the decrease in calcium during the hydrothermal process was higher than in the rest of the minerals [12]. Rizk et al. (1994) showed that microwave rice bran processing alone reduces minerals such as iron and zinc, which can be caused by burning samples, followed by increased power or process time [26].

Table 4. Comparison of mean heavy metal (ppm) in different processing methods

Treatment	Fe(ppm)	Zn(ppm)	Ca(ppm)
C_0	7.19 ± 0.01 ^{a}	1.57 ± 0.13 ^{a}	80.06 ± 0.22 ^{e}
H_1	6.13 ± 0.13 ^{d}	1.07 ± 0.01 ^{bcd}	73.10 ± 0.19 ^{g}
H_2	5.58 ± 0.02 ^{e}	0.92 ± 0.02 ^{d}	68.75 ± 0.03 ^{j}
H_3	4.03 ± 0.03 ^{i}	0.65 ± 0.02 ^{f}	52.53 ± 0.16^{l}
H_4	5.38 ± 0.02 ^{f}	1.06 ± 0.02 ^{d}	68.34 ± 0.05 ^{k}
M_1	6.06 ± 0.04 ^{d}	1.07 ± 0.01 ^{bcd}	69.15 ± 0.06 ^{i}
M_2	3.91 ± 0.02 ^{j}	0.55 ± 0.04 ^{f}	71.69 ± 0.15 ^{h}
M_3	4.94 ± 0.03 ^{g}	1.26 ± 0.02 ^{bc}	92.38 ± 0.24 ^{b}
M_4	4.27 ± 0.04 ^{h}	1.30 ± 0.02 ^{b}	87.55 ± 0.12 ^{c}
HM_1	6.68 ± 0.02 ^{b}	1.56 ± 0.02 ^{a}	106.43 ± 0.23 ^{a}
HM_2	6.05 ± 0.04 ^{d}	0.67 ± 0.49 ^{ef}	80.56 ± 0.14 ^{d}
HM_3	6.36 ± 0.03 ^{c}	0.93 ± 0.01^{d}	74.50 ± 0.24 ^{f}
HM_4	6.32 ± 0.03 ^{c}	0.90 ± 0.02 ^{de}	80.62 ± 0.22 ^{d}

*Similar lowercase letters between treatments are not statistically significant at (P<0.05) level in each column

4-Conclusion:

The study examined the effect of independent hydrothermal, microwave and hydrothermal-microwave hybrid processes on improving the properties of rice bran and reducing phytic acid in it. According to the results, all the methods studied led to an improvement in the properties of the bran compared to the sample .But comparing the

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treatments, it was found that hydrothermal - microwave combined methods were more effective in reducing acidification, and color tests also showed that hydrothermal-processed Bran had the least color changes to other treatments. In reducing the concentration of heavy metals, the microwave method was more effective than other methods, although in combined methods, it was also acceptable to reduce heavy metals in the independent hydrothermal method. The mineral concentration survey also showed that although all processing methods led to a decrease in the amount of salts in the bran compared to the sample, the hydrothermal-microwave combined method performed better in mineral preservation. In addition, due to the dramatic reduction of phytic acid during hydrothermal – microwave hybrid processing, the acceptable reduction of heavy metals and the possibility of enriching flour with lost minerals, it seems that hydrothermal-microwave hybrid processing can be a good solution for preparing spices with acceptable physicochemical properties to consumers.

5-Reference

[1] Sapwarobol, S., Saphyakhajorn, W. and Astina, J., 2021. Biological functions and activities of rice bran as a functional ingredient: A review. Nutrition and metabolic insights, 14, pp.1-11.

[2] Faustino, M., Veiga, M., Sousa, P., Costa, E.M., Silva, S. and Pintado, M., 2019. Agro-food byproducts as a new source of natural food additives. Molecules, 24(6), p.1056.

[3] Izadi, Z., Mazaheritehrani, M. and Shahidi, F., 2021. Effect of fermentation and microwave radiation processes on physicochemical properties of wheat bran. Innovative Food Technologies, 9(1), pp.63-79. [in Persian].

[4] Tayefe, M., Shahidi, S.A., Milani, J.M. and Sadeghi, S.M., 2020. Development, optimization, and critical quality characteristics of new wheat-flour dough formulations fortified with hydrothermally-treated rice bran. Journal of Food Measurement and Characterization, 14, pp.2878-2888.

[5] Mohammadzadeh Milani, J., Fallah Nim Chahi, P. and Ahmadi, F., 2017. Optimization of the Stabilization of Rice Bran with Different Temperature and Time Treatments. Journal of Food Science and Technology78 (15), pp.253-263. [in Persian].

[6] Nasrollah Zadeh Masouleh, A., Ghorbani-HasanSaraei, A., Amiri, E. and Habibi, F., 2021. Comparison the effect of nitrogen fertilizer and parboiling process on heavy metals of rice grain. Journal of food science and technology (Iran), 18(114), pp.359-370. [in Persian].

[7] Messia, M.C., Reale, A., Maiuro, L., Candigliota, T., Sorrentino, E. and Marconi, E., 2016. Effects of pre-fermented wheat bran on dough and bread characteristics. Journal of Cereal Science, 69, pp.138-144.

[8] Coda, R., Kärki, I., Nordlund, E., Heiniö, R.L., Poutanen, K. and Katina, K., 2014. Influence of particle size on bioprocess induced changes on technological functionality of wheat bran. Food microbiology, 37, pp.69-77.

[9] Sharma, H. R., Chauhan, G. S., & Agrawal, K. (2004). Physico-chemical characteristics of rice bran processed by dry heating and extrusion cooking. International Journal of Food Properties, 7(3), 603-614.

[10] Sharafi, K., Yunesian, M., Nodehi, R. N., Mahvi, A. H., Pirsaheb, M., & Nazmara, S. (2019). The reduction of toxic metals of various rice types by different preparation and cooking processes–Human health risk assessment in Tehran households, Iran. Food chemistry, 280, 294-302.

[11] Kaur, S., Sharma, S., Dar, B.N. and Singh, B., 2012. Optimization of process for reduction of antinutritional factors in edible cereal brans. Food science and technology international, 18(5), pp.445-454.

[12] Majzoobi, M., Nematolahi, Z. and Farahnaky, A., 2013. Effect of hydrothermal treatment on decreasing the phytic acid content of wheat bran and on physical and sensory properties of biscuits. Iranian Journal of Nutrition Sciences & Food Technology, 8(3), pp.171-178. [in Persian].

[13] Sim, G.Y., Lee, S.U. and Lee, J.W., 2020. Enhanced extraction of phytic acid from rice hulls with enzymatic treatment and production of ethanol from reducing sugars in hydrolyzed rice hulls after extraction of phytic acid. Food science and technology (LWT), 133, p.110111.

[14] Khalajian, S. and GHIASSI, T.B., 2021. Effects of Extrusion on Phytic Acid Reduction of Hydrothermal and Fermented Wheat Brans.

[DOI: 10.22034/FSCT.201.153.116]

Iranian Journal of Nutrition Sciences & Food Technology, 16(3), pp.75-84. [in Persian].

[15] Mohammadi, F., Marti, A., Nayebzadeh, K., Hosseini, S.M., Tajdar-Oranj, B. and Jazaeri, S., 2021. Effect of washing, soaking and pH in combination with ultrasound on enzymatic rancidity, phytic acid, heavy metals and coliforms of rice bran. Food chemistry, 334, p.127583.

[16] Alajaji, S.A. and El-Adawy, T.A., 2006. Nutritional composition of chickpea (Cicer arietinum L.) as affected by microwave cooking and other traditional cooking methods. Journal of Food Composition and Analysis, 19(8), pp.806-812.

[17] De Boland, A.R., Garner, G.B. and O'Dell, B.L., 1975. Identification and properties of phytate in cereal grains and oilseed products. Journal of Agricultural and Food Chemistry, 23(6), pp.1186-1189.

[18] Irakli, M., Lazaridou, A. and Biliaderis, C.G., 2020. Comparative evaluation of the nutritional, antinutritional, functional, and bioactivity attributes of rice bran stabilized by different heat treatments. Foods, 10(1), p.57.

[19] Asad, S., Jabeen, A., Aga, M.B., Majid, D., Jan, N., Amin, T. and Mehraj, F., 2021. Microwave stabilization and process optimization of rice bran cultivar Jhelum. Journal of Food Processing and Preservation, 45(7), p.e15659.

[20] Akbari, E. and Jahadi, M., 2021. The Effect of Replacing Low Phytate Rice Bran on Physicochemical Properties of Burger Chicken. Journal of food science and technology (Iran), 18(118), pp.237-247.

[21] Shindoh, K. and Yasui, A., 2003. Changes in cadmium concentration in rice during cooking. Food science and technology research, 9(2), pp.193-196.

[22] Naseri, M., Rahmanikhah, Z., Beiygloo, V. and Ranjbar, S., 2018. Effects of two cooking methods on the concentrations of some heavy metals (cadmium, lead, chromium, nickel and cobalt) in some rice brands available in Iranian Market. Journal of Chemical Health Risks, 4(2).

[23] Li, S., Li, R., Tang, Y. and Chen, G., 2019. Microwave-induced heavy metal removal from dewatered biosolids for cost-effective composting. Journal of Cleaner Production, 241, p.118342.

[24] Kumar, V., Sinha, A.K., Makkar, H.P. and Becker, K., 2010. Dietary roles of phytate and phytase in human nutrition: A review. Food chemistry, 120(4), pp.945-959.

[25] Kenawy, I.M.M., Abou El-Reash, Y.G., Hassanien, M.M., Alnagar, N.R. and Mortada, W.I., 2018. Use of microwave irradiation for modification of mesoporous silica nanoparticles by thioglycolic acid for removal of cadmium and mercury. Microporous and Mesoporous Materials, 258, pp.217-227.

[26] Rizk, L.F., Doas, H.A. and Elsakr, A.S., 1994. Chemical composition and mineral content of rice bran of two egyptian rice varieties heated by microwave. Food/Nahrung, 38(3), pp.273-277.

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مقایسه تاثیر فرایند هیدروترمال و مایکروویو بر خصوصیات فیزیکوشیمیایی سبوس برنج

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چکیده

امروزه سبوس به عنوان یک ترکیب فراسودمند در صنایع غذایی مورد توجه است. این پژوهش با هدف بررسی روش‌های فرآوری سبوس برنج برای بهبود ویژگی‌های فیزیکوشیمیایی آن انجام شد. تیمارها در ۱۲ گروه به شرح زیر آماده شدند: ٤ نمونه تیمار شده با روش هیدروترمال H_1 و H_2 (به ترتیب به مدت ۱ و ۲ ساعت در دمای ۳۰ درجه سانتی‌گراد)، H_3 و H_4 (به ترتیب به مدت ۱ و ۲ ساعت در دمای ۸۰ درجه سانتی‌گراد)، ٤ نمونه تیمار شده با روش مایکروویو M_1 و M_2 (به ترتیب به مدت ٤ و ۷ دقیقه در توان ٦۰۰ وات)، M_3 و M_4 (به ترتیب به مدت ٤ و ۷ دقیقه در توان ۹۰۰ وات) و ٤ نمونه تیمار شده با روش ترکیبی هیدروترمال-مایکروویو HM_1 و HM_2 (به ترتیب ابتدا ۱ و ۲ ساعت در دمای ۵۰ درجه سانتی‌گراد سپس ٤ دقیقه در توان ۷۵۰ وات)، HM_3 و HM_4 (به ترتیب ابتدا ۱ و ۲ ساعت در دمای ۵۰ درجه سانتی‌گراد سپس ۷ دقیقه در توان ۷۵۰ وات) و یک نمونه شاهد (C_0). نتایج آزمایشات نشان داد روش ترکیبی هیدروترمال-مایکروویو در کاهش اسید فیتیک نسبت روشهای مستقل موثرتر بود بطوریکه تیمار HM_4 کمترین میزان اسید فیتیک را نشان داد. همچنین فرآیند ترکیبی هیدروترمال-مایکروویو بیشترین حفظ مواد معدنی را نیز نشان داد ($p<0.05$) و بیشترین میزان آهن و روی و کلسیم نیز در تیمار HM_1 (به ترتیب ٦.٦۸ و ۱.۵٦ و ۱۰٦.٤۳ppm) دیده شد. کمترین *میزان* تغییرات رنگ مربوط به سبوس فراوری شده با روش هیدروترمال ($H1$ با ΔE برابر ٦.۳٦) بود. بررسی فلزات سنگین نیز نشان داد روش مایکروویو در کاهش آنها ، موثرتر از سایر روش‌ها بود هرچند کلیه تیمارها منجر به افت قابل ملاحظه ای از فلزات سنگین شدند . بطور کلی می‌توان نتیجه گرفت استفاده از روش ترکیبی هیدروترمال- مایکروویو سبوس برنجی با خواص فیزیکوشیمیایی بهتری ارئه می‌دهد.