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Effect of microwave treatment on approximate properties and color indices of composite flours prepared from a mixture of wheat flour, wheat bran and date seed powder

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ABSTRACT

Microwave radiation (MW) is an environmentally friendly technology and a physical method to enhance and modify the properties of flour. Dietary fiber-rich compounds in flour composition, such as date seed powder and wheat bran, can contribute to the health-promoting effects of the resulting flour and its derived products, such as bread. The present study aims to evaluate the impact of microwaves (750 watts for 120 seconds) on the combination of wheat bran and date seed powder (WB-DSP) and investigate the effects of its substitution on the physicochemical characteristics of wheat flour. To achieve this, wheat bran at various levels (3%, 6%, and 9%) and date seed powder (2%, 4%, and 6%) were combined (WB-DSP) and treated with microwave (WB-DSP$_{MW}$). These mixtures were then substituted with wheat flour in proportions of 5%, 10%, and 15%. The produced flour samples were assessed for their physicochemical properties, color parameters (L*, a*, b*), and overall color difference (ΔE) compared to wheat flour as the control sample. The results revealed that microwave treatment led to lower moisture content and higher levels of ash and protein in the combination of wheat bran and date seed powder. Flour samples containing WB-DSP$_{MW}$ and WB-DSP showed higher water absorption capacity than the control sample ($p < 0.05$). Substituting WB-DSP combination with wheat flour significantly reduced L* and b* values and increased ΔE in flour samples compared to the control ($p < 0.05$). Based on the obtained results, it can be concluded that microwave application and substitution of wheat bran-date seed powder mixture with wheat flour plays a significant role in altering the physicochemical properties of wheat flour. Furthermore, further research is necessary to examine changes in other properties, such as functional properties and nutritional value of the resulting flour.

1-Introduction

Composite flours at first perceived as a combination of multiple flours employed in the making of dough breads, baked products without dough, porridge, snacks, etc. Composite flour is a type of flour that is created by blending varying amounts of multiple non-wheat flours, either with or without wheat flour. This blending process results in the production of both unleavened and leavened baked goods, which are typically made using wheat flour. The primary objective of using composite flour is to enhance the nutritional value of these baked products by incorporating additional essential nutrients into the human diet.

Incorporating a specific quantity of bran into flour is employed as a straightforward and manageable technique for producing flour with elevated levels of dietary fiber. Wheat bran is a food source that is rich in vegetable fiber. It contains high amounts of mineral salts, as well as vitamins from the B and E groups. Wheat bran can have a significant effect on weight loss diets and may also be beneficial for treating digestive diseases, particularly constipation [2]. Bran plays a role in formation and expansion the gluten network, which in turn affects the mechanical and physicochemical qualities of the dough and bread. For example, the presence of bran in dough leads to high water absorption, disrupting gas retention, inactivating yeast, and reducing gas production, ultimately causing a decrease in porosity in samples containing more than 11% bran. In general, wheat bran is commonly incorporated into bakery formulations to enhance the quality and nutritional value of baked goods. Despite this, the presence of bran has posed challenges for the bakery industry in utilizing whole flour, as it affects the technological properties (causing darkening of bakery products and irregular grain expansion in bread kernels) and nutritional properties (due to the high concentration of phytic acid) [3]. In their research, Boita et al. (2016) explored the influence of wheat bran on the qualities of pan bread dough. The outcomes indicated that the presence of bran contributed to bread with elevated specific volume, moisture content, water activity, and hardness. Additionally, bread with 75% bran enrichment exhibited superior nutritional value [1].

Dates, scientifically known as Phoenix dactylifera L., possess significant quantities of both sugar and fiber, making them highly valuable from an economic standpoint [4]. Date fruit is composed of an epicarp, a fleshy mesocarp or pulp, and an endocarp that contains seeds, also known as kernels [5]. The date industry generates approximately 1 million tons of date kernels each year, which can be repurposed as a source of edible oil and incorporated into functional food products. Date seeds are also a valuable source of dietary fiber, phenolic compounds, and essential fatty acids [6]. The fruit's date kernels are a great source of plant chemicals, including phenols, sterols, carotenoids, anthocyanins, procyanidins, and flavonoids. On average, the weight of date kernels ranges from 5.6 to 14.2 percent [7].

Bran pretreatment can be achieved through various methods such as ultra-fine grinding, extrusion, heat treatment, and biological methods [8, 9] and the most widely used method for treating bran involves heat treatment. Various methods such as dry heat, steam, roasting, infrared radiation, and microwave heat treatment can be used to deactivate enzymes in bran, thereby extending its shelf life [10, 11]. Heat treatment of bran has a significant impact on the stability and rheological properties of high dietary fiber flour. When comparing unheated bran to flour with heated bran, it was observed that the latter demonstrated increased stability over time, with flour made from heat-treated bran exhibiting lower water absorption [12]. In Liu et al.'s (2021) research, they investigated the effects of microwave waves on the moisture content and antioxidant properties of wheat bran. The study found that exposing bran to microwaves decreased its moisture content and increased antioxidant properties. In this research, it was found that the optimal condition was using a power of 7.5 kW for 120 seconds [29].

Enriching flours used in grain industries with fiber sources like wheat bran is a suitable method. However, the presence of phytic acid can be a limiting factor in using this compound for making bakery products naturally. Adding date kernels to cereal products is possible due to their soluble fiber content and beneficial health effects. This study suggests that using pretreatments, such as microwave, can enhance the functional properties of date kernel and wheat bran. These improvements include increased water absorption and better reaction with other compounds in flour. The findings of this study could be significant for the industrial use of bran and date kernel in Iran. The objective of this investigation is to analyze how microwave power (750 W) and treatment duration (120 seconds) affect the physicochemical properties of different proportions of wheat bran-date kernel mixture with wheat flour.

2.Materials and methods

1.1. Materials used

To achieve the objectives of the present study, White Flour (Morvarid Company, Bandar Abbas, Iran), wheat bran (Mana Company, Alborz, Iran), date kernel powder (Mino Date Sugar Company, Fars, Iran), yeast (Feriman Company, Razavi Khorasan), Iran) and refined salt (Sudeh Company, Sabzevar, Iran) were prepared. The chemicals used included boric acid, sulfuric acid, and catalyst tablets manufactured by Merck Germany and Sigma Aldrich.

1.2. Preparation of flour samples and applying microwave treatment

In the beginning, wheat bran (WB) and date kernel powder (DSP) underwent grinding with an electric mill (model (BEST) 1000A, Taiwan) to achieve an average particle size of 300 microns [13]. First, the samples of wheat bran and date kernel powder were treated separately in a microwave oven (MW) (Noval model MWO-266, Turkey) with a power of 750 watts and for 120 seconds [14], and then after being cooled in a tray for 30 minutes to reach room temperature, the samples were placed in polyethylene bags and stored in a cool place until use [15]. The study involved the incorporation of wheat bran at various proportions (3%, 6%, and 9%) and date kernel powder at levels of 2%, 4%, and 6% combined with each other to substitute (5%, 10%, and 15%) of wheat flour (WF) according to table (1). Two treatments were prepared from each flour blend, with one group undergoing microwave treatment and the other group without microwave treatment; Through this method, six different flour combinations were created, in addition to one batch of white flour that was not treated with a microwave, which was used as a control sample.

Table 1. Flour treatments prepared in the present study

Treatment number	Code of treatments	Wheat flour (%)	Wheat bran (%)	Date seed powder (%)	Microwave treatment (750 W, 120 s)
F1/MW	WF/WB+DSP_5 (MW)	95	3	2	+
F2/MW	WF/WB+DSP_{10} (MW)	90	6	4	+
F3/MW	WF/WB+DSP_{15} (MW)	85	9	6	+
F4	WF/WB+DSP_5	95	3	2	-
F5	WF/WB+DSP_{10}	90	6	4	-
F6	WF/WB+DSP_{15}	85	9	6	-
F7	WF_{Cont} (Control sample)	100	-	-	-

WF: wheat flour; WB: wheat bran; DSP: date kernel powder; MW: Microwave

2. Investigating the physicochemical properties of composite flours

2.1. Moisture content

The oven and hot air flow method were used to determine the moisture content of flour samples. For this purpose, 2 grams of samples were transferred to containers that had already reached a constant weight and were weighed. After being placed in an oven (Memmert UM model, Germany) with hot air, the samples were dried for 2 hours at 103°C until they reached a constant weight. Following that, the container and its contents were cooled inside a desiccator, and their weight was determined. Finally, the moisture percentage was calculated from equation (1) [16]:

equation (1)

$$\text{Moisture percentage} = \frac{\textit{Weight of plate and sample after oven} - \textit{Weight of plate and sample before oven}}{\textit{Weight of empty plate} - \textit{weight of plate and sample before oven}} \times 100$$

2.2. Ash content

The ash content of flour samples was obtained through an electric furnace (Electric Furnace model, Iran). To serve this purpose, each sample was weighed to approximately 5 grams and then placed in separate pots. The samples were subsequently subjected to a controlled burning process over the flame, ensuring they were positioned under the hood until the smoke completely dissipated. Afterwards, the plants were transferred to the furnace, which was heated to 550 degrees Celsius, to observe light ash and achieve a constant weight. Subsequently, the sample was cooled in a desiccator to prevent moisture absorption and then weighed to determine the ash content. Finally, the amount of ash was calculated as a percentage from equation (2) [16]:

equation (2):

$$\textit{Ash (percentage)} = \frac{\textit{Weight of empty plant} - \textit{weight of plant and sample after furnace}}{\textit{Weight of empty plant} - \textit{weight of plant and sample before furnace}} \times 100$$

2.3. Determining the amount of protein

To determine the protein content of flour samples, the Keldahl method was utilized through three stages including digestion, distillation, and titration. At the end of the titration stage, until the pink color of the titer is reached, the percentage of total nitrogen was obtained from equation (3):

equation (3)

$$Nitrogen\ (percentage) = \frac{N\ x \frac{1}{4}\ x\ V2}{m} \times 100$$

where N is the normality of sulfuric acid, V_2 is the milliliter of acid consumed in the sample and m is the weight of the sample in grams. In order to obtain the protein percentage of the samples, the amount of nitrogen was multiplied by the protein factor of 6.25, and the amount of protein was expressed in terms of dry matter [16].

2.4. Determining the water absorption rate

The determination of water absorption in flour samples involved dissolving 2.5 grams of the obtained flour sample in 8 ml of distilled water at a temperature of 30 degrees Celsius. The mixture was stirred continuously for 30 minutes in a 50 ml tube and subsequently centrifuged at 17000 × g for 10 minutes to obtain the desired results. The supernatant was subsequently transferred into an aluminum container and dried using an oven. The remaining gel was weighed, and the amount of water absorption was calculated from its weight according to equation (4) [17]:

equation (4)

$$Water\ absorption\ index = \frac{Sediment\ weight}{Dry\ solids\ weight}$$

2.5. Color Index Evaluation (L*, a* and b*)

To determine the color indices of the flour samples, the Huntlab machine (Lavibond System 500 model, England) was used. The test was repeated 3 times for each sample. The color indices of the samples were quantified by utilizing the Hunterlab colorimeter, which measured the reflection of the samples' color. This measurement was expressed in terms of three parameters: L* (lightness), b* (yellowness), and a* (redness). Total color difference (ΔE) between control and treated samples was calculated using equation (5) [14]:

equation (5) $$\Delta E = \sqrt[n]{(\Delta L*)2 + (\Delta a*)2 + (\Delta b*)2}$$

3. Statistical Analysis

All the experiments were performed in three repetitions. The evaluation of flour samples was carried out through statistical analysis using SPSS version 19 software, and the findings were reported as mean ± standard deviation. To highlight the differences in the data, one-way analysis of variance (ANOVA) was employed, along with Duncan's test ($p<0.05$) to ascertain the variance in means. The graphs were generated using Microsoft Excel software version 2016.

4. Results and discussion

4.1. Examining the physicochemical properties of flour samples

Table (2) presents the outcomes obtained from the analysis of alterations in moisture content, ash, protein, and water absorption coefficient observed in the flour samples. The outcomes of the study revealed that the F3(MW) treatment had the least moisture content, measuring at 14.36%±0.08%. This value exhibited a significant difference when compared to the moisture content observed in the other treatments ($p<0.05$). Substituting wheat flour with different levels of WB-DSP composition led to a marked decrease in the moisture content of the flour samples ($p<0.05$). It is worth mentioning that the control sample recorded the highest moisture content at 15.45% ± 0.05. The ash and protein content in the control flour sample (WFCont) were recorded at 0.48±0.03 and 13.44±0.07%, respectively, which were significantly lower than those observed in the other treatments ($p<0.05$). The utilization of WB-DSP combination, coupled with the implementation of microwave treatment on WB-DSP, led to a substantial rise in the levels of ash and protein found in the flour samples ($p<0.05$). On the other hand, the augmentation of the substitution ratio of wheat flour with WB-DSP combination led to a substantial enhancement in the quantities of ash and protein present in the flour treatments ($p<0.05$). The control sample (WFCont) exhibited the lowest water absorption rate at 58.30±0.24, showing a significant difference compared to the other treatments ($p<0.05$). The addition of WB-DSP combination, with or without microwave treatment, resulted in a significant rise in the water absorption capacity of the flour samples ($p<0.05$). Nevertheless, it is important to note that the application of microwave did not cause any significant alterations in the water absorption level of the flour samples.

Table 2. Examining the changes of some physicochemical characteristics of flour samples by replacing wheat bran with date seed powder treated under microwaves*

Flour treatments	Moisture (%)	Ash (%)	Protein (%)	Water absorption (%)
WF/WB+DSP$_5$ (MW)	15.06±0.07^{c**}	0.67±0.04^{c}	13.44±0.07^{e}	71.27±0.30^{b}
WF/WB+DSP$_{10}$ (MW)	14.64±0.05^{d}	0.74±0.02^{b}	14.40±0.05^{c}	73.28±0.31^{a}
WF/WB+DSP$_{15}$ (MW)	14.36±0.08^{e}	0.84±0.01^{a}	15.76±0.06^{a}	73.32±0.28^{a}
WF/WB+DSP$_5$	15.22±0.06^{b}	0.64±0.03^{c}	13.16±0.09^{f}	68.56±0.29^{c}
WF/WB+DSP$_{10}$	15.12±0.05^{bc}	0.71±0.03^{bc}	13.84±0.07^{d}	72.89±0.27^{a}
WF/WB+DSP$_{15}$	15.01±0.12^{c}	0.70±0.06^{bc}	14.79±0.10^{b}	73.30±0.27^{a}
WF$_{Cont}$	15.45±0.05^{a}	0.48±0.03^{d}	12.12±0.08^{g}	58.30±0.24^{d}

* The data are reported as (mean ± standard deviation) in three replicates.

**Unsimilar lowercase letters (a-g) in each column indicate a significant difference ($P<0.05$) between the data based on Duncan's test

Wheat bran, a byproduct of the wheat milling industry often utilized in animal feed, boasts a plethora of nutritional components and promising applications in human nutrition, capturing the attention of the market. Nevertheless, the task of ensuring its safety for effective utilization remains challenging [18]. Thus, the current research involved modifying wheat bran before substituting it with wheat flour. The wheat bran was initially combined with varying proportions of date kernel powder and then treated with microwave radiation (750 W for 120 seconds). Following this treatment, the wheat bran was mixed with wheat flour at 5%, 10%, and 15% levels to produce composite flours. The study focused on evaluating the alterations in moisture content, ash content, protein content, water absorption capacity, and color parameters of the composite flours before and after the microwave treatment.

Composite flours at first perceived as a combination of multiple flours employed in the making of dough breads, baked products without dough, porridge, snacks, etc. Composite flour is a type of flour that is created by blending varying amounts of multiple non-wheat flours, either with or without wheat flour. This blending process results in the production of both unleavened and leavened baked goods, which are typically made using wheat flour. The primary objective of using composite flour is to enhance the nutritional value of these baked products by incorporating additional essential nutrients into the human diet [19]. The reason for combining different types of flours can be attributed to either economic or nutritional factors. Conversely, it is imperative to ascertain the functional properties of these composite flours, which encompass moisture levels, protein content, ash content, water absorption rate, oil absorption rate, and more. For instance, the determination of water content or moisture levels in food, along with the measurement of dry matter or total solids, is essential. This process not only establishes a framework for expressing the quantities of other components based on wet or dry weight, but also serves as a critical factor in maintaining the stability and quality of the food product [20]. The present study on the production of composite flour samples revealed a significant increase in the levels of ash, protein, and water absorption coefficient in comparison to the control sample ($p<0.05$). In the present study, "reducing the moisture content of flour samples by replacing wheat flour with WB-DSP combination, especially the microwave-treated combination", suggest that the decrease in moisture content in the composite flour may be a direct result of the heat treatment process, leading to alterations in the overall moisture composition of the mixture. Several research studies have investigated the development of composite flours using either wheat flour or rice flour and have found that the chemical composition of these flours is influenced by the additives used during production. For instance, when rice flour was replaced with Amaranth flour, millet flour, and soybean flour at proportions of 70%, 50%, and 40% respectively, variations in moisture content were observed. It is worth mentioning that the composite flour containing 60% soybean flour [20] as a substitute for rice flour displayed the lowest moisture content, which aligns with the findings of the present study. In another study, the moisture content of composite flours exhibited a decline as the substitution level of wheat flour with Breadfruit tree flour and Cassava starch increased [21]. Furthermore, resembling the present research, there was a significant difference in the moisture content of different composite flours (replacing wheat flour with cassava, potato and soybean flours) and it was significantly lower than the control (wheat flour) [22].

The ash content found in food offers insights into the overall concentration of mineral elements it contains. This content reflects the complete mineral composition that remains subsequent to the removal of moisture and organic substances (such as fats, proteins, and carbohydrates) [23] through oxidation or combustion in a furnace. The ash content in a food sample is significant in determining the levels of essential minerals [24]. The present study shows that there is an increase in the ash content of composite flour samples as the replacement ratio of wheat flour with WB-

DSP or WB-DSP (MW) increases. When wheat bran and date kernel powder are added to wheat flour, the ash content can increase. However, this increase in ash content can also lead to an increase in the amount of minerals present in the composite flour. Minerals are crucial micronutrients that play significant roles in metabolism and are also essential components of biomolecules such as hemoglobin, deoxyribonucleic acid (DNA) and adenosine triphosphate (ATP) [25]. Studies conducted in line with the current research have yielded comparable findings. For instance, the addition of cornflower flour, millet flour, and soybean flour to rice flour [20] has been found to increase the ash content, similar to the results of our study. Furthermore, the ash content of wheat flour containing Breadfruit tree flour and cassava starch [21] has also shown an increase, aligning with previous research.

Proteins possess various functional properties that play a crucial role in a wide range of food products. These properties include the ability to foam (like whipped cream), emulsify (like ice cream and mayonnaise), gel (like gelatin and custard), thicken, texture, form dough, bind to water, add flavor, and create desirable sensory characteristics. These functionalities are vital for the development and quality of numerous food items [20]. Analyzing the protein content in food ingredients is a critical step. The study aimed to explore the protein characteristics of composite flour samples. It was found that supplementing wheat flour with wheat bran and date kernel powder led to a rise in protein content. These results are consistent with previous research conducted by other researchers [20-22].

The water absorption capacity refers to the capability of a food item to bind with water when subjected to conditions where water availability is limited. Absorbed water refers to water that has been absorbed on the surface of macromolecular colloids, including proteins, pectins, starches, and cellulose. The water absorption capability of proteins is a vital characteristic in several food products, such as dough, soup, and baked goods [20]. The ability of water absorption is contingent upon the presence of hydrophilic groups that enable the bonding of water molecules, along with the gel formation capacity of macromolecules [26]. The findings of this research indicate that the water absorption capacity of wheat flour samples was significantly increased upon the addition of wheat bran and date kernel powder ($p<0.05$). The enhanced water absorption capability associated with the inclusion of WB-DSP compound in wheat flour is likely due to the higher concentration of hydroxyl groups present in the fiber structure of wheat bran, which promotes increased water interaction via hydrogen bonding. The observed outcomes may also be associated with the existence of arabinoxylans in wheat bran, which have the ability to strongly bind water within the dough matrix, consequently limiting the amount of water accessible for the formation of the gluten network [27]. Consistent with the present study, a report has been documented elucidating the influence of wheat bran on heightening water absorption, particularly in relation to microwave treatment [28]. Numerous studies have indicated that composite flours demonstrate enhanced water absorption when compared to wheat flour alone [29-31]. The presence of hydrophobic amino acids may be responsible for the enhanced water absorption capacity observed in composite flours as the substitution level increases [20].

4.2. Color indexes

The color indicators for brightness (L*), red-green (a*), and yellow-blue (b*) were used to assess the color of the flour samples. Figure (1) shows the overall color difference (ΔE) in the samples. The data from figure (1) indicates that the replacement of wheat flour with WB-DSP combination and the use of microwave caused a significant decrease in the lightness index (L*) and yellowness index (b*) of the flour samples when compared to the control sample (WF_{Cont}) ($p<0.05$). However, there were no significant changes in the redness index (a*) between the flour samples ($p>0.05$). The control sample exhibited the highest level of brightness index at 86.67±2.51, while the F3 (MW) treatment showed the lowest level at 67.33±2.08(Figure A1). By examining the redness index (a*) based on figure (B1), it was observed that the treatment F2 (MW) displayed the highest value (4.67±1.15), while treatments F4 and F6 demonstrated the lowest values (3±1). In Figure (C1), it is evident that the control sample (WF_{Cont}) obtained the highest value in the yellowness index (b*) at 11.00±1.00, whereas the F4 treatment had the lowest value at 6.00±0.00. Significant changes in the ΔE parameter were observed with increased substitution of wheat flour with WB-DSP combination, as well as the use of microwave (See Figure D1).

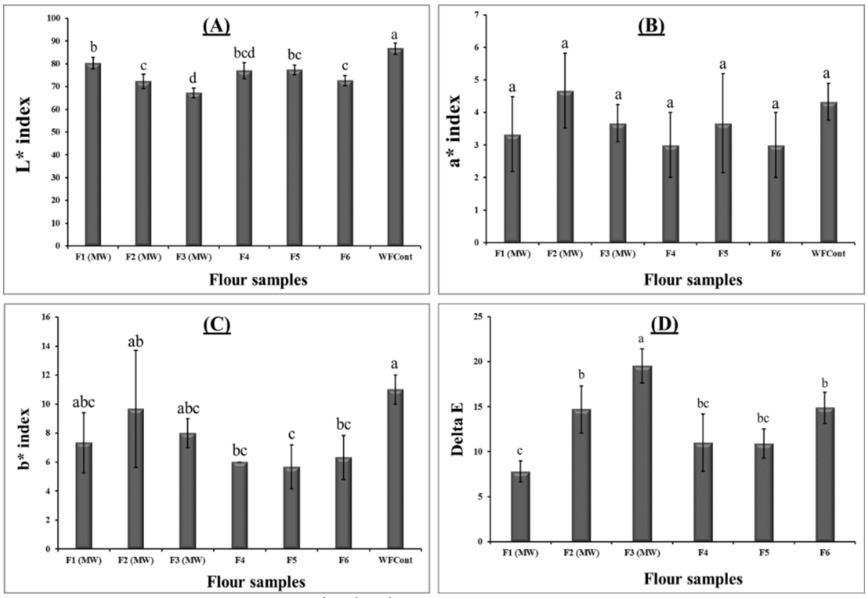

Figure 1. Examining changes in color indices (L*, a*, b*) and overall color difference (ΔE) in flour samples by replacing wheat bran-date kernel powder treated under microwaves

Non-similar lowercase letters (a-d) on each column indicate a significant difference (P < 0.05) between the data based on Duncan's test.

Color plays a crucial role in influencing consumer perception and acceptance of a product. By substituting microwave-treated and/or untreated WB-DSP combination for wheat flour, the color characteristics of the resulting product were altered. Specifically, there was a reduction in the L*, a*, and b* indices, indicating a decrease in lightness, redness, and yellowness, respectively, compared to the control sample. Additionally, the EΔ value increased, suggesting a significant change in color perception. The decline in the brightness index (L*) may be attributed to the browning process occurring in the WB-DSP combination when exposed to elevated temperatures. With a higher degree of non-enzymatic browning and caramelization, the color of the combination intensifies [32]. The production of pigmented compounds is possible through Maillard reactions and caramelization reactions at the beginning of thermal processing [33]. Various research investigations have shown that altering the duration of microwave exposure and power levels can result in a decline in brightness index alongside an elevation in red-green and yellow-blue indices [34]. Interestingly, these findings do not align with the outcomes observed in the current study. This discrepancy is likely attributed to the incorporation of date kernel powder, which diminishes color indicators, consequently causing a reduction in red and yellow tones within the flour. As a result, the flour sample transitions to a brown hue. n a research investigation, oat bran underwent modifications through three distinct techniques: steam, microwave, and hot air. The objective was to evaluate the impact of these methods on color alterations. The findings revealed that the utilization of hot air resulted in the highest brightness index when compared to the other two techniques. Furthermore, in the steam method, the red-green and yellow-blue indexes exhibited the highest values in comparison to both the control sample and the other two methods. Ultimately, the researchers concluded that the color of steamed oat bran offers specific advantages over the color produced by the other methods [35]. A study conducted on the impact of power and duration of microwave treatment on the color of wheat bran revealed that the highest observed color difference (EΔ) after microwave application was 4.05. This finding suggests that microwave treatment could potentially serve as an effective method to mitigate the negative consequences of non-enzymatic browning in wheat bran, while minimally altering its original color [14]. The examination of wheat bran demonstrated that the L* index experienced a decline in three treatment methods when compared to the control sample. Conversely, the combined method resulted in an increase in both the a* and b* indices. However, the fermentation method did not exhibit a significant change in the a* index when compared to the control sample [36]. The substantial color difference (EΔ) identified in the flour samples examined in this research indicates that the incorporation of date kernel powder could be responsible for notable color modifications in flour samples with WB-DSP combination. On the contrary, the discrepancies in color indices identified in the present investigation in contrast to the referenced studies are likely a result of the inclusion of date kernel powder in lieu of wheat flour. Furthermore, the utilization of microwave treatment led to a deepening of color in the WB-DSP mixture, thus indicating shifts in color intensity based on the proportion of wheat flour replaced in the mixture.

5. Conclusion

Research was conducted to explore the pre-treatment of a combination of wheat bran and date kernel powder in the microwave as a potential substitute for wheat flour. The outcomes revealed a decrease in moisture content and an increase in ash, protein, and water absorption capacity of the resulting composite flour samples. However, the utilization of microwaves in treating the combination of wheat bran-date kernel powder resulted in a significant increase in the replacement rate. This increase, in turn, led to a noticeable darkening of the color of the composite flour samples. The darkening effect was primarily attributed to the reduction in the color parameters of lightness (L*), red-green (a*), and yellow-blue (b*) color indices. The rise in ash and elevated protein content signifies the enhancement in the nutritional worth of the composite flours generated in the current investigation, which could serve as a beneficial measure in utilizing pre-treated composite flours. Nevertheless, further research is imperative to comprehensively assess the impact of microwave treatments on the efficacy of composite flours and their suitability in the production of flat and voluminous breads.

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مقاله علمی_پژوهشی

تأثیر تیمار مایکروویو بر مخلوط پودر دانه سبوس گندم و خرما: ارزیابی اثرات جایگزینی بر خواص فیزیکوشیمیایی آرد گندم

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چکیده

تشعشعات مایکروویو (MW) به عنوان فناوری سازگار با محیط زیست و به عنوان روش فیزیکی در بهبود و اصلاح خصوصیات آرد استفاده می‌شود. علاوه بر این استفاده از ترکیبات دارای فیبرهای رژیمی مانند پودر هسته خرما و سبوس گندم در ترکیب آرد می‌تواند اثرات سلامتی بخش آرد حاصل و محصولات تهیه شده از آن مانند نان را افزایش دهد. هدف از مطالعه حاضر ارزیابی تأثیر امواج مایکروویو (۷۵۰ وات به مدت ۱۲۰ ثانیه) بر ترکیب سبوس گندم – پودر هسته خرما (WB-DSP) و بررسی تاثیر جایگزینی آن بر خصوصیات آرد گندم می‌باشد. بدین منظور سبوس گندم در سطوح مختلف (۳، ۶ و ۹ درصد) و همچنین پودر هسته خرما (۲، ۴ و ۶ درصد)، به صورت تیمار نشده (WB-DSP) و تیمار شده با مایکروویو ($WB\text{-}DSP_{MW}$) با یکدیگر ترکیب و به نسبت‌های ۵، ۱۰ و ۱۵ درصد با آرد گندم جایگزین شد. نمونه‌های آرد تولید شده از نظر خصوصیات فیزیکوشیمیایی، پارامترهای رنگی (L^* و a^*, b^*) و همچنین اختلاف کلی رنگ (ΔE) در مقایسه با آرد گندم به عنوان نمونه شاهد مورد ارزیابی قرار گرفتند. نتایج نشان داد که تیمار ماکروویو سبب محتوای رطوبت پائین‌تر و میزان خاکستر و پروتئین بالاتر ترکیب سبوس گندم – پودر هسته خرما می شود. نمونه‌های آرد حاوی ($WB\text{-}DSP_{MW}$) و (WB-DSP) در مقایسه با نمونه شاهد دارای ظرفیت جذب آب بالاتری بودند ($p<0.05$). جایگزینی آرد گندم با ترکیب WB-DSP باعث کاهش معناداری در شاخص‌های L^* و b^* و افزایش ΔE نمونه‌های آرد در مقایسه با نمونه شاهد گردید ($p<0.05$). با توجه به نتایج حاصل می‌توان اظهار نمود که اعمال مایکروویو و جایگزینی ترکیب سبوس گندم–پودر هسته خرما با آرد گندم نقش مهمی در تغییرات خصوصیات فیزیکوشیمیایی ارد گندم دارد، همچنین لزوم انجام تحقیقات به منظور بررسی تغییر سایر خواص مانند خواص عملکردی و ارزش تغذیه ای آردهای حاصل ضروری بنظر می رسد.