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Investigation of the effect of using palm kernel powder in bread flour on quality parameters of flour

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Abstract: In this study, the effect of palm kernel powder (PKP), a vegetable waste, on the quality parameters of bread and dough was investigated. For this purpose, farinograph and extensograph values of doughs made from PKP-flour (2.5, 5, 7.5 and 10%) mixed flours were investigated. Weight, volume, specific volume, crust color, inner color and firmness values were investigated in bread made from mixed flour. The results showed that the water absorption, development time, stability, resistance to extension and maximum resistance values of the dough increased with the increase in the amount of PKP. It also decreased in degree of softening, extensibility and energy levels. The change in softening degree and stability values were found to be statistically significant ($p<0.05$). PKP additive caused a firmer structure in bread samples. It was observed that the weight, volume, specific volume, first-day hardness and third-day hardness values of the bread increased with the increase in PKP. L^* and a^* values of bread crust color and inner color decreased with the addition of PKP. The increase in PKP had a positive effect on bread quality by increasing dough stability and bread volume values.

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1. INTRODUCTION

Wheat is a type of grain in the Graminea (Poaceae) family. The grain consists of three parts; the bran, endosperm and germ (embryo) in the outer layer. It contains components such as water, carbohydrates (starch), proteins, lipids, mineral substances, enzymes, vitamins, amino acids and fatty acids (Elgün & Ertugay, 2002; İlerigiden *et al.*, 2020). Wheat grain contains approximately 10% water, 60-75% starch, 10-18% protein, 1.5% lipid and 1.5% mineral matter (Ashraf, 2014). Wheat growing is carried out in large areas with different climate and soil characteristics. Due to the variety and environmental effects, there are differences between the physical, chemical and technological properties of wheat. Bread wheat, called *Triticum aestivum* L. is the most commonly produced type of wheat. red-colored and hard-grained varieties are considered to be the highest quality bread wheat (Elgün & Ertugay, 2002).

Cereals and their products are among the food groups that have an important place in human nutrition. Especially in our country, the consumption amount is high because flour is a cheap source. In societies where bread is consumed as a basic nutritional element, vitamins, minerals

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and amino acids are added to flour in order to increase the flavor and product variety and to enrich its nutritional value. The distribution of the chemical components of wheat varies according to the morphological parts of the grain. Wheat causes a change in its chemical structure while being processed. When separation processes are performed, the amount of some nutrients decreases. In addition, the applications during the process cause changes in the nutrients themselves. For this reason, in many countries of the world, cereal products, especially bread, are enriched with vitamins and minerals that decrease during the processing and especially grinding of wheat (Karagül & Ercan, 1993; McKevith, 2004).

Nutrition is a fundamental aspect of human life, as it is essential for individuals to consume various food items in sufficient and balanced quantities in order to support their growth, development, and active continuation of life (Traş & Gökçen, 2021). However, in today's world, the disregard for proper dietary conditions has resulted in various eating disorders, primarily obesity and excessive eating (Traş & Gökçen, 2021), which in turn can lead to the emergence of several associated health conditions such as cancer, diabetes, lactose intolerance, digestive difficulties, cardiovascular diseases (Ertaş *et al.*, 2019), and even certain neurological (autism and ADHD) and psychological disorders (such as GAPS) (Çıkılı *et al.*, 2019).

In recent years, there has been a growing interest in healthy and functional food products aimed at meeting high nutritional demands with minimal consumption, which has led to the utilization of functional and alternative ingredients in many food items. Particularly, the incorporation of substitute ingredients rich in vitamins, minerals, and antioxidants, found naturally in their composition, has gained attention (Demir & Kılınç, 2019). This trend has emerged alongside discussions surrounding the negative effects of food on health, prompting the exploration of healthier and functional food products.

Date (*Phoenix dactylifera* L.) is a food source, building material and traditional folk medicine that has been used by humans since ancient times. In addition to the economic value of this plant, it is important to know its health-related aspects (Aktürk & Işık, 2012). It is a herbal product produced in Egypt. However, it is also cultivated in Middle Eastern countries and arid regions of Southwest Asia and North Africa (Diab & Aboul-Ela, 2012). Date fruits are marketed worldwide as a fruit product with rich nutritional content (Al-Farsi & Lee, 2008). Date seeds have generally not received much attention due to their popularity and lack of commercial application. In the Arab world, for centuries, date beans have been marketed as a decaffeinated beverage and decaffeinated coffee (Baliga *et al*., 2011). Although its biological value is low, it is known that the protein content of the palm kernel is between 7.13-10.36% and the oil content is between 6.32-9.28% (Gabrial *et al*., 1981). While there is 0.2-0.5% oil in the fleshy part of the date, the oil rate in the kernel is between 7.7-9.7%. The kernel is 5.6-14.2% of the weight of the date. There are 14 types of fatty acids in its core. 8 of these are also found in small amounts in the meat part. Unsaturated fatty acids include "palmitoleic", "oleic", "linoleic" and "linolenic" acids. The amount of oleic acid in the palm kernel varies between 41.1 and 58.8%. Therefore, they can be used as a source of oleic acid. In addition, the date kernel contains 0.5% potassium and various amounts of aluminum, cadmium, chloride, lead, and sulfur (Al-Shahib & Marshall, 2003).

Palm kernels can be used in different industrial areas. Activated carbon obtained from palm kernel waste is used to clean chromium, a poisonous substance, from liquids (El Nemr *et al*., 2008). Date seeds are also rich in phytohormones. For this reason, the hormonal effects of dates are also used in the beauty industry (Bauza *et al*., 2002).

2. MATERIAL and METHODS

2.1. Material

Bread wheat flour and dates (*Phoenix dactylifera* L.) used in the research were obtained from the Balıkesir bazaar. The palm kernels were removed and ground in a grinder.

2.2. Methods

2.2.1. *Obtaining Flour from Wheat and Date Kernel Samples*

Palm kernel was ground to pass through a sieve no 70, 90% of which was 212 µm, in order to be close to the grain size of the flour used in the experiments (Anonymous, 1999) and stored in glass jars with lids to be used when necessary. The powders were stored in a cool, dry environment with the lid closed, away from sunlight, at room temperature. Then, palm kernel powder (PKP) was added to the wheat flour at the rates of 2.5, 5.0, 7.5 and 10% by displacement. Flour without PKP was used as a control sample.

2.2.2. *Determination of Physical, Chemical and Technological Properties on Flour Samples*

The analyses were performed according to the method of AACC (2000). Moisture analysis in wheat flour and PKP was carried out according to the AACC method 44-19, raw ash analysis was performed according to the AACC 08-01 method. Determination of Wet Gluten and Gluten Index was determined according AACC 38-12 method using Glutomatic-2200 and Glutork 2020 (Perten Instruments AB, Huddinge, Sweden) devices. The falling number value was measured by using AACC 56-81b method (AACC, 1990). Zeleny sedimentation test was carried out according to Özkaya & Kahveci (1990). Delayed sedimentation values determination, different from the Zeleny sedimentation test, was determined by measuring after bromine phenol blue was added and left for 2 hours (Greenaway *et al*., 1965). L^* value on the color scale [(0) black-(100) white] using Hunter Lab Color Quest II Minolta CR-400 (Minolta Camera, Co., Ltd., Osaka Japan) device in flour, PKP, flour-PKP mixture and bread, a^* value [(+) red- (-) green] and b^* values [(+) yellow-(-) blue] were measured (Francis, 1998).

The water holding capacity, dough development time, stability, and degree of softening (12 minutes after the maximum value on the curve) in the control and flour blends were determined according to the AACC 54-21 method used by Brabender Farinograph (Brabender, Duisburg, Germany) device (AACC, 2000). The dough's resistance to extension, dough's maximum resistance, extensibility and energy values were determined by using Brabender Extensograph (Brabender, Duisburg, Germany) according to AACC 54-10 method (AACC, 2000). Both rheological analyses were based on 300 g flour.

2.2.3. *Analysis of Bread Samples*

Bread made from control and blended flours was made by modifying the method given in AACC 10-10 (AACC, 1990). Accordingly, on the basis of 100 g flour; dough mixture was prepared by using 3% yeast, 1.5% salt and water as much as the farinograph removes. Doughs kneaded until the maturation phase (Hobart N50, Canada) were rested at 30 °C at 80-90% relative humidity for 50 minutes and baked at 230°C for 25 minutes. Weight and volume were measured after the bread cooled and they were put into polyethylene bags after 1 hour (Elgün *et al*., 2001). Crust and crumb color was also determined by measuring L^*, a^*, and b^* values with a Hunter color measuring device (Francis, 1998; Rossel *et al.*, 2006). Bread volume and specific volume measurements were made according to Elgün *et al*. (2015).

The baked breads were kept at 20–25°C and 40–45% relative humidity for 3 days, and the moisture changes of the samples were measured every day, and the hardness change was measured twice with a texture analyzer (TA Plus, Lloyd Instruments, UK) on the 1st and 3rd days (Abd Karim *et al.*, 2000).

2.3. Statistical Analysis

The samples were analyzed with 2 replications and the difference between the means was determined using analysis of variance (ANOVA), and the level of difference between samples was made using Duncan's test, one of the Multiple Comparison tests

3. RESULTS

3.1. Flour Blend Analysis

The results of the control sample and flour blends are given in Table 1. Parallel to the increasing PKP ratio, a decrease was detected in the protein ratios of the flour samples. The protein ratio may also vary depending on the type of blended product. The seeds of date varieties contain an average of 6.5% protein, 10.4% oil, 22.0% fiber, 1.1% ash, and 60.0% carbohydrates in dry matter (Sawaya, 1984). Due to the fact that the content of the palm kernel is rich in fiber and carbohydrates, it proportionally decreased the protein ratios in the PKP mixture. The increase in the ash content with the increase in PKP indicates that the flour is rich in minerals (Table 1). In a similar study, they observed that the amount of dietary fiber and ash increased significantly ($p<0.05$) in muffins to which they added palm seed flour and palm seed flour hydrolysate (Ambigaipalan and Shahidi, 2015). Falling number, gluten, gluten index, sedimentation, and delayed sedimentation tests could not be obtained in flour with PKP addition. Palm kernel powder (PKP), differs from flour derived from wheat or other traditional grains in terms of its composition. Therefore, due to the different gluten content and potential for gluten network formation in PKP-added flours, the desired results cannot be obtained from tests such as falling number, gluten, gluten index, sedimentation, and delayed sedimentation.

The farinograph analysis provides important information for evaluating the gluten structure and strength of flour, as well as the processing properties and quality of dough. The results of the farinograph test are used to assess factors such as dough resistance, extensibility, expansion capacity, water-holding capacity, and overall workability. Some parameters (water absorption, development time, stability and softening degree) of farinograph analysis are shown in Table 2. It is seen that as the PKP value increases in flour mixtures, the dough development time and stability ($p<0.05$) value increase and the softening value decreases. Iqbal *et al*. (2015) stated that dough development time is affected by the concentration and quantity of wheat protein. Long dough development time is a desirable property for bread. The obtained results show that the addition of PKP has a positive effect on the dough development time. High water holding capacity and stability are the feature required by bakers as it facilitates dough processing (Sahin *et al*., 2019). The increase in the PKP ratio did not significantly affect the water holding capacity and also did not even cause a decrease. In addition, as the PKP ratio increases, the stability also increases, which indicates that the dough rheology is positively affected. It shows good quality flour with its high water holding capacity and low softening degree (Biel *et al*., 2021). The findings obtained in this study also confirm the information given in previous studies.

With the increase in the amount of PKP, an increase in the resistance to extension and maximum resistance values, and a decrease in the energy and extensibility values were observed (Table 2). However, it was determined that this change was not statistically significant ($p>0.05$). The excess of fiber (22%) in the palm kernel content (Sawaya, 1984) decreased the extensibility and energy values of the dough (Table 2). Similar results have been shown in studies with an increase in meal (fiber) in flour, and a decrease in energy values and extensibility (Bilgiçli *et al*., 2007; Gül, 2007; Erdoğan, 2010).

Table 1. Chemical properties of flour blends[1]

PKP Ratio	Moisture (%)	Ash[2] (%)	Protein[3] (%)	Falling number (s)	Gluten (%)	Gluten index (%)	Sedimentation (cc)	Delayed sedimentation (cc)
Control[4]	9.84±0.03[b]	0.44±0.05	10.95±0.3	352±21.5	27±0.9	99±0.1	40±1.0	49±1.0
%2.5 PKP	9.88 ±0.03[ab]	0.53±0.05	10.82±0.29	….	….	….	….	….
% 5.0 PKP	9.24±0.01[c]	0.54±0.01	10.66±0.29	….	….	….	….	….
% 7.5 PKP	10.14±0.11[a]	0.55±0.02	10.38±0.28	….	….	….	….	….
% 10 PKP	10.02±0.13[ab]	0.56±0.04	10.34±0.28	….	….	….	….	….

[1]: Means marked with the same letter and without letters are not statistically different from each other ($p>0.05$); means given with different letters are statistically different from each other ($p<0.05$).
[2]: Ash content in dry matter.
[3]: Protein contents were calculated by multiplying the total nitrogen amounts by 5.7 for the control bread and 6.25 for the other samples.
[4]: Flour without palm kernel powder.

Table 2. Farinograph and Extensograph analysis parameters of control and flour blends[1].

PKP Ratio	Farinograph values				Extensograph values[2]			
	Water absorbtion[3] (%)	Development time (min.)	Stability (min.)	Softening degree[4] (BU)	Energy (cm^2)	Resistance to Extension (BU)	Extensibility (mm)	Maximum Resistance (BU)
Control[5]	60.75±0.62	1.8±0.00	7.65±0.65[c]	58.5±6.36[a]	100±7	765±47	107±7.5	841±7.5
%2.5 PKP	61.4±0.45	1.9±0.10	11.1±0.40[b]	47.5±7.78[ab]	93±0.50	777±54.5	99.5±9	855±9
% 5.0 PKP	61±0.55	1.95±0.25	12.7±0.40[a]	41.0±1.41[b]	89.5±8	800.5±84	94±8	864.5±8
% 7.5 PKP	61.15±0.62	2.0±0.20	13.45±0.15[a]	38.5±3.53[b]	89±6	810±66.5	93±10.5	879±10.5
% 10 PKP	61.15±0.67	2.05±0.15	13.5±0.10[a]	37.5±7.77[b]	89±3	816.5±1	90.5±8.8	885±4

[1]: Means marked with the same letter and without letters are not statistically different from each other (p>0.05); means given with different letters are statistically different from each other (p<0.05).
[2]: Extensograph values are the values measured after 135 minutes.
[3]: Based on 14% humidity.
[4]: BU: Brabender Unit and ICC/12 min. later.
[5]: Flour without palm kernel powder.

Table 3. Bread analysis results.

PKP Ratio		Control[2]	2.5%	5.0 %	7.5%	10.0%
Weight (g)		129±0.26[d]	130.41±0.30[c]	131.69±0.09[b]	132.75±0.14[a]	133.42±0.00[a]
Volume (cc)		411±1.0[e]	424.5±2.50[d]	436.5±1.5[c]	469±2.00[b]	485±5.00[a]
Specific volume (cc/g)		3.18±0.01[d]	3.25±0.02[cd]	3.31±0.01[c]	3.53±0.02[b]	3.63±0.03[a]
Crust	*L**	61.46±0.36[a]	54.15±0.14[b]	51.15±0.82[c]	48.01±0.76[d]	45.58±0.53[e]
	*a**	10.9±0.11[a]	9.65±0.20[ab]	9.23±0.10[ab]	8.21±0.25[b]	7.28±0.17[c]
	*b**	29.46±0.41[a]	26.97±0.17[ab]	26.53±0.29[ab]	24.79±0.01[b]	22.99±0.09[c]
Crumb	*L**	73.92±0.09[a]	66.6±0.19[b]	62.66±0.19[c]	58.99±0.25[d]	56.11±0.35[e]
	*a**	-0.88±0.10[e]	1.18±0.03[d]	2.54±0.05[c]	3.075±0.05[b]	4.45±0.12[a]
	*b**	14.11±0.36[a]	13.18±0.26[b]	12.08±0.06[c]	10.91±0.11[d]	10.29±0.12[d]
Hardness (g)	1st day	454.82±2.70[c]	560.88±17.37[b]	620.27±16.86[ab]	657.18±5.36[ab]	865.41±12.26[a]
	3rd day	641.72±2.05[e]	1015.48±45.78[d]	1196.16±27.93[c]	1363.65±30.82[b]	1666.66±4.82[a]

[1]: Means marked with the same letter and without letters are not statistically different from each other ($p>0.05$); means given with different letters are statistically different from each other ($p<0.05$).
[2]: Flour without palm kernel powder.

3.2. Bread Analysis Results

Some physical analysis results of bread samples obtained from control and flour blends are summarized in Table 3. When the results are examined, it is seen that the bread weight and volume increase as the PKP ratio increases. In another study in which different proportions of menenges flour were added to bread wheat flour, bread volume increased in parallel with the increase rate (Ünüvar, 2013). The increase in the specific volume value is also compatible with the bread volume value. Color is one of the most prominent features in physical analysis. The color characteristics of the raw material used are reflected in the final product. One of the most important factors affecting consumer choice is the visual feature of the product. In this study, it was determined that the brightness value *(L* value)* of both the crust and the inner color of the bread decreased in parallel with the increasing usage rate. On the other hand, *a* value* decreased in the crust part as the PKP ratio increased, but increased in the crumb (Table 3). The reason for this situation may be due to the reaction that develops because of the Maillard reaction that occurs on the surface of the bread during baking (Demir *et al*., 2006).

When the hardness measurements were carried out, it was determined that the hardness value increased due to the increased PKP ratio on the 1st and 3rd days (Table 3). The amount of fiber in the components that make up the bread affects the nutritional value of the bread as well as its hardness and staling mechanism. Dursun, (2016) used fish meat for the purpose of enriching the bread in his study and stated that the hardness of the bread increased as time passed (24-48-72 hours). The result obtained in our study is similar to this literature.

4. DISCUSSION and CONCLUSION

In this study, the effects of palm kernel powder (PKP) on dough rheology and bread properties were investigated. The results showed that the increase in PKP and some farinograph values showed a statistically significant difference ($p<0.05$), and as a result, the bread value was also positively affected. The purpose of additives made on the basis of the displacement principle in foods is to improve the quality of the final product and to increase the nutritional and functional value. Studies conducted for this purpose are aimed at determining the optimum ratios of the additives to be used. Since there is limited literature on the use of PKP as a functional food, the original value of this research is thought to be high. It is important to increase this and similar reviews in terms of making a positive contribution to the environment by evaluating the waste and improving the nutritional and technological properties of bread.

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Declaration of Conflicting Interests and Ethics

The authors declare no conflict of interest. This research study complies with research and publishing ethics. The scientific and legal responsibility for manuscripts published in IJSM belongs to the authors

Authorship Contribution Statement

Yavuz Yuksel: Investigation, Resources, Visualization, Software, Analysis, Original draft. **Mustafa Kursat Demir**: Supervision, and Validation, Analysis, Reading and writing the manuscript, Editing.

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