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Research Article

Enrichment of wheat bread with carob molasses pulp, a dietary fiber source: Impact on bread quality and acceptability

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ABSTRACT

Carob is one of the most important plant sources of dietary fiber, which is essential for human health and must be consumed daily. Carob molasses (pekmez) obtained from carob fruit contains many beneficial components for health. Although the molasses pulp that comes out as waste in the production of molasses contains a large amount of fiber, it is not evaluated. In this study; purification, drying and grinding of the crude carob fiber (CCF) from raw molasses pulp was carried out. The obtained CCF flour was added to the bread. After baking bread, the effects of the addition of 1 to 5 % CCF flour on chemicals (moisture, ash and protein) and also textural (hardness, color) and sensory properties (acceptability, taste, softness, appearance) of the bread samples were investigated. The results showed that the addition of CCF up to 4 % into the bread dough had no significant effect compared with the control group on these properties. Therefore, a brad formulation can be developed which is a fibrous bakery product with reduced fat for health and which has better sensory appreciation.

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1. INTRODUCTION

The part of the carob fruit that can be eaten is rich in nutritive components like minerals (calcium, potassium, phosphorus, iron, etc.), carbohydrates (glucose, fructose, and sucrose), and polyphenolic compounds with an antioxidant activity and beneficial components like crude fiber (Ozcan et al., 2007; Kıroglu, 2001). The sweet, edible portion of the carob fruit can be eaten fresh, or it can be used in the production of molasses (known as pekmez in Turkish) via either traditional or industrial processes. The use of carob fruit directly in the form of flour (Aydın et al., 2017; Papaefstathiou et al., 2018) or its addition into various food products is not a preferable method because it causes a loss in the organoleptic characteristics of the foods. In recent years, there has been a rise in the awareness of the benefits that carob molasses has for human health, which has led to an increase in the commercial production of the carob molasses. Although the carob pulp that is left over after the production of carob molasses contains a sizable quantity of carob fibre in its raw form, it is not utilized in the production of carob-based foods (Ozdemir et al., 2022).

Functional foods are those that are consumed as part of a regular diet, contain no synthetic ingredients, have nutritive effects, and reduce the risk of disease formation due to multiple factors. (Biesalski, 2005) Dietary fiber is one of the functional food components. Dietary fiber is one of the major components of edible plant parts that are resistant to digestion and absorption in the human small intestine and undergo complete or partial fermentation in the large intestine (Harris and Ferguson, 1999). Although dietary fibers are subdivided into numerous subgroups, FAO and WHO have examined them as soluble and insoluble fibers based on their water solubility (Ramulu and Rao, 2003). Insoluble fibers cannot form a gel despite absorbing 20 times as much water as soluble fibers (Tamer et al., 2004). Soluble fibers bind water and form a gel when combined with water. Water-insoluble fibers; lignin, cellulose, and water-insoluble pentosans, whereas water-soluble fibers; pectins and gums (Knuckles et al., 1997).

Glucose and insulin metabolism are improved by soluble fibers. In addition, they reduce the concentration of low-density lipoprotein (LDL) cholesterol in the serum (Gül, 2007). However, water-insoluble fibers have beneficial effects on bowel movements (Kahlon et al., 2001). Dietary fibers have a sedative effect by increasing stool volume and water content. Due to the water-binding property of dietary fibers, stool volume has increased. This prevents constipation (Ekici and Ercoşkun, 2007). It has been discovered that dietary fiber prevents colon cancer in significant ways. It achieves this effect by altering the colon's bacterial flora, preventing the production of toxic metabolites, and shortening the time these metabolites spend in contact with intestinal cells (Anonymous, 1990). There is an inverse correlation between consuming water-insoluble fiber and developing colon cancer. (Anonymous, 1983) suggests increasing consumption of high-fiber foods like wheat and corn bran.

Diabetes is believed to be one of the diseases linked to a lack of dietary fiber. A high consumption of dietary fiber reduces serum glucose concentration. According to (Anderson, 1980), it reduces the need for insulin in diabetics, thereby providing health benefits (Villanueva-Suarez et al., 2003). Soluble fibers regulate blood sugar by allowing glucose to enter the bloodstream slowly, thereby regulating blood sugar levels.

Dietary fiber products are gaining prominence in the concept of healthy nutrition in the modern world. It is well known that dietary fibers play a crucial role in preventing the development of obesity, cardiovascular disease, diabetes, and certain types of cancer (Aksoy, 2000). Therefore, a comprehensive understanding of the chemical and nutritional properties of dietary fiber is essential for expanding its applications.

The addition of fibers to food products began in the 1970s with the production of a few white and wheat breads containing fiber addition (Burdurlu and Karadeniz, 2003). Since this type of bread contains fewer calories than standard products, this procedure is performed for the health benefit of weight loss. The functional aspects of dietary fibers have been identified and developed during this time. As a result of the numerous advancements that have been made, it is now utilized in a wide variety of products. (Tamer et al., 2004) Numerous categories in the food industry now consider fiber to be a crucial and valuable ingredient. The possible use of an additive carob fibre to rye bread, which had a positive impact on human health, was first examined by Haber et al., 2002. They have shown that a 6% addition of carob fibre to rye bread has a positive effect by lowering cholesterol levels, especially LDL (Rozylo et al., 2017).

In this study, it was aimed to increase the nutritional value of bread consumed daily. For this purpose, carob crude fiber (CCF) was used in the production of traditional or industrially produced bread. The effects of CCF supplement on chemicals (moisture, ash and protein) texture, color and sensory properties of bread were investigated and new formulations developed by using different amounts of CCF instead of wheat four

2. MATERIALS &METHODS

2.1. Materials

In this study, carob molasses pulp obtained from a company producing carob molasses in Mersin was used. Carob molasses pulps were dried, ground, and sieved through 450-micron mesh. Dietary fiber obtained from carob molasses pulp has been used in bread production. Wheat flour, salt, and yeast used in bread making were obtained from "Food Studies Application and Research Center" in Mersin University. Ingredients have been stored at +4 ^{o}C. Nitric acid, acetic acid, sulfuric acid, trichloroacetic acid, petroleum ether and acetone were obtained from Sigma (Sigma-Aldrich, St. Luis, Mo, USA).

2.2. Methods

2.2.1. The process of drying and grinding the carob molasses pulp

The raw carob molasses pulp was dehydrated in an oven (J,P, Selecto, Spain) at temperatures ranging from 50 ^{o} C to 55 ^{o} C for a duration of seven hours. Following the step of drying, the products were milled using a laboratory mill (IKA, M20, Labortechnik, Staufen, Germany), and the fraction of this flour was separated using sieves 450 μm in size. This flour was referred to as carob molasses pulp flour, and after it was produced, the flours were placed in airtight plastic containers and kept at a temperature of 4 ^{o}C until further analysis.

2.2.2. Carob fiber purification from carob molasses pulp flour

The ISO 6541:1981 method for crude fiber isolation from carob molasses pulp flour was modified (ISO,1981). 10 grams of flour were weighed and placed in a flask of boiling water. 150 mL of boiling extraction solution (70 mL of 70 % acetic acid, 5 mL of concentrated nitric acid, and 2 g of trichloroacetic acid solution) was added to a boiling flask, and the mixture was stirred. In a perpendicularly connected refrigerated boiling flask, the mixture was boiled at 220 ^{o}C. for 90 minutes. After boiling, the resulting mixture was filtered through filter paper with a 40 m pore diameter (Whatman Grade). The residues that remained were then washed with 500 mL of hot distillated water. The residue was washed three times with 50 mL of pure acetone solution and once with 50 mL of pure petroleum ether after being cleaned with hot distillated water. After the final washing, the residue was dried in an oven for 10 hours at 105 ^{o}C. The powdered substance is known as crude carob fiber (CCF) flour (Keçeli, 2016).

1.3. Preparation of bread samples

The traditional method of making bread was used, but instead of flour, various quantities of CCF were incorporated into the bread-making process. The mixtures obtained in accordance with the formulations given in Table 1 were adjusted to mixer speed 2 and mixed for 3 minutes to obtain bread dough. After shaping the dough, it was left to rest for 10 minutes. The rested dough was left to ferment for 30 minutes in an incubator with a temperature of 35 °C and a relative humidity of 85 %. The doughs that came out of the incubator were baked at 220 ^{o}C for 20 minutes.

1.4. Proximate Evaluation

Official methods were used to determine the moisture, protein, and ash content of control samples and bread samples made with CCF flour (AOAC, 1990). Moisture was measured using a moisture analyzer (Mettler Toledo Moisture Analyzer, HX204, Switzerland), protein was measured using a protein analyzer (Kjeldatherm, Spain), and ash was measured using a gravimetric method (using furnace Carbolite Parsons Lane, England).

1.4.1. Color Analysis

Automatic colorimeter readings were taken of the bread samples to determine their outer crust color values (ColorQuest XE Hunter Lab., USA). The findings were reported using the CIELAB system with the parameters L*, a*, and b*, which indicated lightness (+ve) to darkness (-ve), redness (+ve) to greenness (-ve), and yellowness (+ve) to blueness (-ve), respectively. The color evaluations of the bread samples were performed thrice, with each run consisting of two repetitions.

1.4.2. Texture

For texture analysis, hardness values of bread samples were determined using the AACC 74-09 (AACC, 1999) method in a Texture Analyzer (Stable Micro Systems, England). The maximum force in the force-deformation curve obtained as a result of the test expresses the degree of hardness of the sample. Texture analysis was applied to both the outer and inner parts of the samples, which were kept at 25 ^{o}C for 1 hour after baking. Experiment 3 repetitions were performed in 2 parallels.

1.4.3. Volume and Weight Losses

The bread volume determination method was used for volume analysis (AACC, 1995). After the bread samples had been baked for one hour at room temperature, the test was conducted. The test is based on the principle of rapeseed displacement. The principle of the experiment; Rapeseed seeds are filled to the marked level in a measuring cylinder. It was then emptied again. The loaves were placed in the cylinder, and rapeseed was added once more. The level is populated until it reaches the size indicated. The remaining rapeseed seeds' volume was measured. Three repetitions of the experiment were conducted in two parallels. The weight loss of the bread samples was measured before and after baking

1.5. Acceptability in general and sensory qualities

A trained panel of 11 judges evaluated the acceptability and sensory qualities of bread samples using a seven-point hedonic scale (1: dislike to 7: extremely like) (Ekıcı et al., 2015). Staff members, graduate students from the department of food engineering, and experts in food sensory evaluation were chosen as the panelists. It was intended to identify the bread formulations, with various amounts of CCF added, that were sensory equivalent to the control sample. Between samples, water and bread were offered to help with palate cleaning.

1.6. Stastical Analysis

The findings of the study were evaluated with the help of the statistical analysis program SPSS version 16.0, which was developed by SPSS Inc. in Chicago, Illinois. In situations where

Table 1. Formulations of breads

Ingredients	Control	CCF18	CCF27	CCF35	CCF43	CCF65
CCF (g)	0	1	2	3	4	5
Flour (g)	100	99	98	97	96	95
Salt (g)	1.5	1.5	1.5	1.5	1.5	1.5
Bread yeast (g)	4	4	4	4	4	4
Water (ml)	60	60	60	60	60	60

there were more than two groups that needed to be compared with each other, the One-Way ANOVA was used to determine the difference in mean between the groups. For the purpose of carrying out statistical analysis on the fiber samples, a t-test was conducted.

3. RESULT &DISCUSSION

3.1. Proximate Analysis of Bread Samples

Ash, moisture and protein values of bread samples with and without CCF added are given in Table 2. In general, an increase was observed in the ash, moisture and protein values of the bread samples with the addition of CCF, and this increase was found to be statistically significant (p≤0.05). On the other hand, there is a 16% increase in moisture level compared to the control, especially according to the added CCF ratio. This increase is thought to be proportional to the water absorption capacity of the fiber. A much smaller increase was observed in the amount of protein and ash.

(Ozdemir et al., 2021) reported that carob molasses pulp crude fiber was purified, and some chemical parameters were analyzed. Accordingly, the percentages of moisture, ash, protein, lignin, and other insoluble fibers in crude fiber were calculated to be 6.79, 10.95, 3.03, 52.03, and 27.20 %, respectively. (Owena et al., 2003) determined the amounts of soluble fiber (pectin), insoluble fiber (cellulose, hemicelluloses, lignin, and water-insoluble polyphenols), and water-soluble polyphenols (condensed tannins) in the commercial carob fiber CaromaxTM to be 6.2 %, 68.54 %, and 2.84 %, respectively. In a patent study, the carob fiber's lignin, cellulose, hemicelluloses, pectin, and tannins percentages were reported as 50-65 %, 15-25 %, 0.5-2 %, and 3-7 %, respectively.

(Ragaee et al., 2011) examined the effects of fiber supplementation on bread's antioxidant capacity and nutritional value. According to the results, the addition of fiber increased the ash content. According to the Turkish Food Codex, the max. humidity value is 38%. However, in our study, the moisture content of the bread prepared with the traditional method was found to be 39.63%. It is thought that the reason for this is the use of the inside of the breads for moisture determination. This increase can be cause of is that the added fiber has a moisture content of 6.79%. It can be said that another reason for the increase in humidity is the storage conditions. (Gomez et al., 2003) analyzed bread with microcrystalline cellulose, pea, cocoa, coffee, orange and two types of wheat bran fiber. It was determined that when the fiber samples were added to the bread at the rate of 2% (except for the orange fiber), the other fibers did not cause a change on the moisture. It was observed that the moisture values increased as the amount of added fiber increased.(1): Different letters in the same column indicate that, there is a statistically significant difference between the values in the same column.

Table 2. Proximate analysis of bread samples with and without CCF

Sample No	% CCF	Ash (%)	Moisture (%)	Protein (%)
Control	0	0.96±0.01^{f}	39.63±0.26^{e}	7.75±0.04^{b}
CCF18	1	1.13±0.03^{e}	43.47±0.19^{d}	7.79±0.12^{b}
CCF27	2	1.26±0.04^{d}	44.88±0.06^{c}	7.82±0.03^{b}
CCF35	3	1.33±0.00^{c}	44.37±0.09^{c}	7.84±0.04^{a}
CCF42	4	1.43±0.02^{b}	45.62±0.28^{b}	7.85±0.11^{a}
CCF63	5	1.54±0.02^{a}	46.23±0.46^{a}	7.88±0.01^{a}

(1): Different letters in the same column indicate that, there is a statistically significant difference between the values in the same column.

(2): Results are calculated on dry basis. Values given are the mean ± standard deviation of three replicates.

lues in the same column that differ significantly (p≤0.05) are indicated by different superscripts.

3.2. Color

CIELAB system color values for control and CCF added outer crust bread samples are given in Table 3. As can be seen in the table, there is a decrease in L* (brightness), a* (redness) and b* (yellowness) values compared to the control sample. In general, the slight decrease in color values is in parallel with the increase in CCF % ratio. This decrease in breads with added CCF was found to be statistically significant (p≤0.05). It is thought that crude fiber obtained from molasses pulp causes a decrease in L values because it contains polyphonic compounds, even if it are small. The type of flour and the additives added play an important role in the color values of the breads. (Seres et al., 2005); In a study they carried out, they added dietary fiber obtained from sugar beets to bread wheat. The researchers determined that there was a decrease in the L*, a*, b* values of the breads depending on the fiber color.

3.3. Texture

The force values applied for the outer crust and crump hardness measurements of bread samples prepared with the addition of CCF are given in Table 4. As can be seen from the table, as the CCF ratio increases, the force applied to both the outer crust and the crump of the bread samples increases. When the outer crust hardness was added at the rate of 1 to 4%, the degree of hardness was not statistically significant compared to the control bread. However, if 5% is added, the outer crust of the bread forms a significant hard structure.

On the other hand, the force applied to the inner part of the seedlings was found to be statistically significant between the samples with CCF added. This difference was also found to be statistically significant with the increase in the amount of CCF. It is thought that the reason for applying more force in the crump is that it is more in the crump of the bread than in the outer crust (Ozdemir et al., 2021) reported that the crude fiber purified from carob molasses was found

Table 3. Color value of outer crust bread samples with and without CCF

Sample No	% CCF	L*	a*	b*
Control	0	69.76 ± 1.09^{a}	5.64 ± 0.31^{a}	18.48 ± 0.15^{a}
CCF18	1	61.25 ± 1.16^{b}	4.85 ± 0.29^{b}	16.00 ± 0.37^{b}
CCF27	2	58.13 ± 1.70^{c}	4.79 ± 0.15^{b}	14.29 ± 0.44^{c}
CCF35	3	56.42 ± 0.79^{d}	4.76 ± 0.31^{b}	14.02 ± 0.09^{c}
CCF42	4	55.19 ± 0.58^{d}	4.70 ± 0.15^{b}	12.95 ± 0.37^{d}
CCF63	5	51.08 ± 0.69^{e}	4.13 ± 0.06^{c}	11.77 ± 0.41^{e}

*Values in the same column that differ significantly (p≤0.05) are indicated by different superscripts.

Table 4. Texture analysis of crust and crumb samples with and without CCF

		Max Force (N)	
Sample No	**% CCF**	**Crust**	**Crumb**
Control	0	19.82 ± 1.31^{c}	12.66 ± 0.83^{f}
CCF18	1	22.80 ± 1.68^{c}	16.82 ± 1.01^{e}
CCF27	2	$24.81 \pm 4.91^{b,c}$	24.06 ± 2.46^{d}
CCF35	3	$25.71 \pm 5.64^{b,c}$	35.57 ± 2.48^{c}
CCF42	4	30.29 ± 5.31^{b}	42.51 ± 3.41^{b}
CCF63	5	63.42 ± 5.34^{a}	45.89 ± 2.74^{a}

*Significant differences between values in the same column are indicated by various superscripts (p≤0.05).

to be 52.03 % lignin and 27.20 % other insoluble fiber. Therefore, it can be said that the hardness in the internal structure of bread comes from lignin and insoluble fibers.

(Shehzad et al., 2011) observed the effect of adding dietary fiber to bread on the rheological properties of dough. According to the study, the addition of dietary fiber decreases the amount of water in the viscoelastic gluten network structure of dough. Since this prevents the expansion of gas bubbles at the interface, it results in the formation of breads with a firmer texture.

(Wang et al., 2002) investigated the effects of adding a combination of chickpea fiber, carob fiber, and inulin fiber to the flour used to make bread. According to the research, it has been determined that the mentioned ingredients cause softening of the bread crust.

(Gomez et al., 2003); added 1%, 2%, 3% and 10% of the fibers obtained from coffee and cocoa to wheat flour. When the textural properties of the bread samples with dietary fiber were examined, no statistically significant difference could be determined within the samples themselves. However, it was determined that the sample containing 10% dietary fiber differed from the control sample, although it did not have a negative effect on its textural properties.

3.4. Volume and weight losses

Volume and weight losses of bread formulations with and without added CCF are given in Table 5. As the CCF ratio in bread increases, there is a decrease of up to 10% in volume compared to the control sample. As can be seen from the table, breads with 1 to 3% CFF additives differ significantly from control breads. In the case of adding 4 to 5%, the difference was found to be statistically significant ($p \leq 0.05$) compared to both control and bread with up to 3% CCF added. On the other hand, there was no statistically significant ($p \leq 0.05$) difference between all bread samples before and after baking.

Table 5. Volume and weight losses values of control sample and bread samples with CCF added

Sample No	% CCF	Volume (cm^3)	Weight Losses, g
Control	0	485.50±11.26^{a}	22.41±0.57^{a}
CCF18	1	453.33±21.26^{b}	22.43±0.35^{a}
CCF27	2	450.00±0.00^{b}	22.46±0.30^{a}
CCF35	3	447.50±12.50^{b}	22.52±0.44^{a}
CCF42	4	421.67±6.29^{c}	22.61±0.40^{a}
CCF63	5	413.33±6.29^{c}	22.68±0.36^{a}

*Different superscripts denote differences between values in the same column that are statistically significant ($p \leq 0.05$).

Table 6. Sensory analysis of control sample and bread samples with CCF added

Sample No	% CCF	Appearance	Softness	Taste	Color	Adhesiveness	Overall acceptability
Control	0	5.20±0.84^{a}	5.20±0.84^{a}	5.80±0.84^{a}	5.20±1.30^{a}	5.40±0.55^{a}	5.80±0.45^{a}
CCF18	1	5.00±0.71^{a}	5.20±0.84^{a}	5.40±0.55^{a}	4.60±1.14^{a}	5.40±0.55^{a}	5.40±0.55^{a}
CCF27	2	4.60±0.55^{a,b}	5.00±0.71^{a}	5.40±0.55^{a}	4.60±1.14^{a}	5.20±0.84^{a,b}	5.00±1.22^{a}
CCF35	3	4.20±0.45^{a,b}	5.00±0.71^{a}	4.40±1.14^{a}	4.40±0.55^{a}	4.80±0.45^{a,b,c}	4.80±0.84^{a}
CCF42	4	3.80±0.84^{b}	4.40±0.89^{a,b}	4.00±0.00^{a}	4.20±0.84^{a,b}	4.20±1.09^{b,c}	3.60±0.55^{b}
CCF63	5	2.60±1.14^{c}	3.20±1.48^{b}	2.40±0.55^{b}	2.80±1.26^{b}	4.00±0.71^{c}	2.60±1.14^{b}

*Different superscripts indicate statistically significant differences between values within the same column ($p \leq 0.05$).

Water provides the ideal fermentation environment for dough. Moreover, dietary fiber has a high-water holding capacity. Additionally, a certain amount of water is required for the formation of the gluten network. Since the amount of water required for the formation of the gluten network structure was lacking in the medium, the gas bubbles that formed during fermentation were unable to be retained in the bread's structure. It is believed that this circumstance results in a reduction in bread volume due to the increased CCF ratio. In their research, (Miguel et al., 1999) added between 2-30% peach fiber to cake samples. It was determined that there was no difference in volume values when compared to the control group, as the addition of dietary fiber to samples containing 20% or less of gluten had no effect on the gluten structure.

3.5. **Sensory Evaluation**

The sensory properties of food have an important effect on the commercialization of that food. The scores of hedonic sensorial characteristics of bread in terms of appearance, softness, taste, color, adhesiveness, and acceptability were presented in Table 6. It was observed that bread enriched with CCF was not found statistically different than the control sample and CCF substitution had no significant effect on sensory properties ($p>0.05$), except for 5 % CCF added.

(Sangnark and Noonhorm, 2004) extracted dietary fiber from sugarcane and substituted it for 0-15% of wheat flour. They identified that as the amount of sugar cane used increased, the bread's sensory appeal diminished. (Gomez et al., 2003) added 2% fiber derived from coffee and cocoa to wheat flour and compared it to control bread. Researchers have found that consumers have a low preference for breads containing fiber.

4. CONCLUSION

In this study, a functional product was produced by using crude fiber (CCF) purified from the waste from the production of carob molasses for the formulation of bread that is consumed frequently on a daily basis. Thus, a type of food waste was evaluated industrially, contributing both environmentally and economically. Thanks to the fact that CCF is rich in dietary fibers, which are high in its structure, the composition of the bread is enriched and a product with higher nutritional value is obtained. Adding up to 4 % CCF to the bread formulation does not affect the sensory properties of bread such as appearance, softness, taste, color and adhesiveness. The results of this study indicated that carob crude fiber may be used in bread manufacture by bakery products to improve health parameters.

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