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Investigation of The Effect of Using Whole Wheat Flour and Different Additives in Bread Kadayif on Acrylamide and Hydroxymethyl Furfural (HMF)

Ekmek Kadayıfında Tam Buğday Unu ve Farklı Katkı Madde Kullanımının Akrilamid ve Hidroksimetil Furfural (HMF) Üzerine Etkisinin Araştırılması

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ABSTRACT

In this study; In this study, it has been experimentally investigated to add nutritional and functional properties to bread kadayif, which is a local product, with the addition of whole flour, and to reduce the content of acrylamide and HMF, which may occur as a result of some reactions, with the application of heat treatment in bread kadayif. For this purpose, 3 different additives (L-cysteine, citric acid, $NaHCO_3$) and 2 different ratios (0 and 30%) whole flour were added to the bread kadayif formulation at 3 different rates (0, 1.5% and 3%). At the end of production, the samples were subjected to acrylamide and HMF analyzes as well as viscosity, pH, aw, moisture, color and sensory analyzes. 3 additives (L-cysteine, citric acid, $NaHCO_3$) added to the bread kadayif dough caused an increase in acrylamide level in the samples without whole flour compared to the control. In the samples using whole flour, 3 additives added to the formulation provided a decrease in acrylamide levels compared to the control. In HMF content, L-cysteine and $NaHCO_3$ decreased the amount of HMF in samples without and with whole flour added to the formulation compared to the control, while citric acid caused an increase in HMF content compared to the control. When we evaluated the sensory analysis results, increasing the level of whole flour caused a decrease in outer appearance, interior color, taste and smell values. The most appreciated outer appearance, interior color, taste, odor, aroma, texture, mouthfeel and general acceptability values were observed in the citric acid additive.

Keywords: Acrylamide, HMF, Cysteine, NaHCO3, Citric acid, Whole Flour

ÖZ

Bu çalışmada; yöresel bir ürün olan ekmek kadayıfına, tam un katkısıyla besinsel ve fonksiyonel özellik kazandırmak ve ekmek kadayıfında ısıl işlem uygulanması ile birlikte bazı reaksiyonlar sonucu oluşabilen akrilamid ve HMF içeriğini azaltmak deneysel olarak araştırılmıştır. Bu amaçla ekmek kadayıfı formülasyonuna 3 farklı oranda (%0, %1,5 ve %3) 3 farklı katkı maddesi (L-sistein, sitrik asit, $NaHCO_3$) ve 2 farklı oranda (%0 ve %30) tam un ilave edilmiştir. Üretim sonunda örnekler akrilamid ve HMF analizleri yanı sıra viskozite, pH, aw, nem, renk ve duyusal analizlere tabi tutulmuştur. Ekmek kadayıfı hamuruna eklenen 3 katkı maddesi (L-sistein, sitrik asit, $NaHCO_3$) tam un kullanılmayan örneklerde kontrole kıyasla akrilamid seviyesinde artışa sebep olmuştur. Tam un kullanılan örneklerde formülasyona eklenen 3 katkı maddesi de kontrole kıyasla akrilamid seviyelerinde azalma sağlamıştır. HMF miktarında ise formülasyona tam un eklenmeyen ve eklenen örneklerde L-sistein ve $NaHCO_3$ kontrole kıyasla azalma sağlamıştır, sitrik asit ise kontrole kıyasla HMF miktarında artışa neden olmuştur. Duyusal analiz sonuçlarını değerlendirdiğimizde tam un seviyesinin artması dış görünüş, iç renk, tat ve koku değerlerinde azalmaya neden olmuştur. En çok beğenilen; dış görünüş, iç renk, tat, koku, aroma, tekstür, ağızda bıraktığı his ve genel kabul edilebilirlik değerleri sitrik asit katkıgörülmüştür.

Anahtar Kelimeler: Akrilamid, HMF, Sistein, $NaHCO_3$, Sitrik Asit, Tam Un

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Introduction

Bakery products are widely consumed in our country. Kadayif, which is among the bakery products that are consumed fondly in Turkish cuisine, is a traditional product and has a wide use (Anonymous 2012). Known as "stone kadayif" or "flat kadayif" in different regions of our country, in Erzurum, known as bread kadayif and prepared in the traditional way, the bread kadayif is mixed with flour and water in certain proportions, then turned into a dough and after resting for a while, it is cooked on cast iron hair. It is a food product obtained by frying (Pekak 2006; Boz 2013).

During foods processing, some reactions occur and some compounds are formed as a result of these reactions. Examples of these reactions are Maillard reaction, caramelization, protein denaturation, lipid oxidation, and many compounds can be formed as a result of these reactions (Gökmen 2010). While some of the compounds formed provide the desired taste, appearance and aroma, some are not desired because they threaten human health (Gölükçü and Tokgöz 2005).

The flour used in kadayif production has different properties compared to other special purpose flours (Savlak ve Köse 2013). Kadayif producers stated that the damaged starch content, water lifting capacity, ash and protein content of kadayif flour should be low. At the same time, the particle size of the flour should be low (Savlak 2011). The wheat used for kadayif flour is in the biscuit wheat class and is soft wheat with low protein content and quality. (Savlak ve Köse 2013).

The nutritional content of wheat flour varies according to the purification of the wheat. Wheat grain contains approximately 8% husk, 3% germ, 6-7% aleurone, and 82% wet endosperm layers (Elgün ve Ertugay 1995). The aim of flour milling is to achieve maximum endosperm separation and to prevent the mixing of bran and germ into flour. Because in the milling process, depending on the amount of extraction, as these parts are mixed with flour, the storage stability and cooking quality of the final product are affected. Therefore, these bran fractions, which constitute approximately 18% of the grain, are separated in milling processes (Şanlıer 2012; Demir 2015). Whole wheat flour is obtained by grinding the wheat grain as a whole without separating the germ and bran parts. Whole wheat flour contains more fiber, dietary fiber, B-complex vitamins, minerals, essential amino acids and antioxidants (glutathione, phytic acid and tocopherol) than white flour. It is also a suitable source of energy due to its protein content with a good nitrogen balance and high starch content (Demir 2015; Kalkan ve Özarık 2017; Demir 2018).

Maillard reactions have positive and negative effects on food quality. In many scientific studies, the formation of Maillard reaction products (MRU), which reduces nutritional value and is toxic, has been frequently expressed (Yıldız et al. 2010).

Acrylamide is an intermediate product that is formed as a result of the Maillard reactions of the asparagine amino acid and the carbonyl group of reducing sugars in foods that are generally heat treated (Kavuşan 2019). The increase in acrylamide formation is directly proportional to the temperature and it is generally accepted that it occurs in heat treatments applied above 120 ^{o}C (EFSA 2015; Dybing at al. 2005). 5-(hydroxymethyl)-2-furaldehyde (HMF) is formed as a furanic compound as a result of Mailllard reactions or by direct dehydration of sugars in acidic medium (Kıvanç 2013). Different amounts of HMF may occur in the content of foods, depending on their production and preservation methods. HMF is not found in fresh and raw foods. Although it is mostly formed by heat treatment of carbohydrate-rich foods, its amount increases with storage. In this case, the control of heat treatment and storage time are important parameters (Kıvanç 2013; Uzunlu and Herken 2016; Aljahdali et al. 2017).

In this study, in order to reduce the acrylamide and HMF content in bread kadayif; 1) to increase the nutritional and functional properties of kadayif with the use of whole flour, 2) to provide a competitive environment with the amino acids in the whole flour and to encourage competitive reactions with the addition of L-cysteine amino acid, 3) to reduce the pH of the medium with the addition of citric acid, to block the combination of asparagine and carbonyl compounds, and 4) methods such as providing an alkaline environment using agents such as sodium bicarbonate have been used. 5) As a result, it was aimed to reduce the formation of acrylamide and HMF in bread kadayif.

Material and Methods

For the production of bread kadayif, bread kadayif flour, whole flour, oil and hazelnut were procured from Erzurum market. The syrup used was prepared by mixing water and granulated sugar in a ratio of 2:1 and squeezing half a lemon after boiling to prevent crystallization. 3 types of additives (L-cysteine, citric acid, $NaHCO_3$) and whole flour (2 levels) were used. Bread kadayifs were produced in AKDAĞ Yufka and Kadayif Factory. In the preparation of bread kadayifs, water, flour, salt, carbonate (content: sodium bicarbonate), baking powder (content: corn starch, sodium hydrogen carbonate, disodium diphosphate); 3 different additives such as L-cysteine, citric acid, $NaHCO_3$ in %0, %1.5, %3 levels and whole flour in 2 different levels (% 0 ve %30) were used. In the production, the temperature of the water (53 °C) was adjusted first, flour was added and a homogeneous mixture was achieved, then other additives were added. Then, it was poured onto the pan and fired at 180 °C for 2 minutes on one side. Produced bread kadayifs were fried at 190 °C for 2 minutes in the Grain Products Application Laboratories of Atatürk University Faculty of Agriculture, Department of Food Engineering. Then they were taken into cold sherbet which was prepared beforehand. Sherbet was not used in the samples used in the analysis.

Analysis of Bread Kadayif

a. Acrylamide analysis

Acrylamide analysis, was analaysed besed on Robarge et al. (2003) method.

Preparation of standard solution: Calibration solutions were prepared from chromatographically pure acrylamide standard at 10, 50, 100, 200, 300, 400 and 500 ppb and then the samples were subjected to the treatment and the calibration curve was obtained.

Extraction: In the extraction step, 1 gram of sample was weighed into a 50 mL erlenmeyer as very small particles. 10 mL of demineralized water was added and mixed in a magnetic stirrer for 20 min and then centrifuged at 5500 rpm for 10 min, after centrifugation, the supernatant was passed through a nylon filter (0.45 µm). 200-300 µL of 0.1N $KBrO_3$ was added to 3 mL of the filtrate, gently mixed by hand and kept in an ice bath for at least 1 hour. After waiting, the tubes were removed from the ice bath, a drop of 1N Na_2S2O_3 (sodium thiosulfate) was added and gently mixed. Then 2 mL of ethyl acetate was added for extraction. Gently mixed and centrifuged at 5500 rpm for 10 minutes and the supernatant was transferred to vials for analysis.

GC-MS analysis: Prepared standard solutions and sample extracts were analyzed on a GC-MS instrument using selective ion imaging mode with positive electron impact (SIM), DB-225 (30 m x 0.25 mm x 0.25 µm) as GC-MS arm and helium as mobile phase. The oven temperature was set to increase by 30 degrees per minute from 40 degrees to 200 degrees and splitless mode was used in the analysis.

b. HMF analysis

HMF analysis was performed by HPLC (high performance liquid chromatography) according to the Rada-Mendoza (2002) method.

Extraction: For this step, 2 grams of sample was transferred to a 50 mL erlenmeyer. Then 4 ml each of Carrez-I and Carrez-II solutions were added and the volume was completed to 50 mL with deionized water. After stirring the contents of the Erlenmayer, the supernatant was allowed to stand for 30 min and passed through a 0.45 µm filter and then transferred to vials for HPLC. HMF analysis was performed on Agillent 1100 system. UV-VIS detector and Inertsil ODS-3 (250x4.6 mm ID) column (HICHROM, Reading Berkshire, England) were used in the system. The mobile phase was 10:90 (v/v) methanol-water at room temperature and the flow rate was set to 1 mL/min. HMF concentration was determined using a calibration curve (55690-5-HMF, Fluca Chemika) and measurements were made at 280 nm.

c. pH determination

pH determination was made by Torley et al. (2008) Method.

d. Measuring color intensity

The measurement of color density in our samples was made with Konica Minolta CR-400 Colorimetry device in three parallels, the results were CIELAB; It was calculated according to the formula of Commission Internationale de I'Eclairage (Kotancılar 2015).

e. Water activity analysis

A water activity device (Novasina, TH-500 aw Sprint) was used to determine the water activities of the bread kadayif samples.

f. Dry matter analysis

For acrylamide and HMF analyzes, 8-10 g of each sample, which was homogenized by taking it from the surface, will be taken in 4 parallels and dried in a drying cabinet at 110 °C until it reaches a constant weight (Kotancılar 2015).

g. Viscosity measurement

Viscosity values of kadayif pastes were measured with Brookfield DV II Pro+Viscometer (Brookfield DV II, Brookfield Engineering Laboratory Inc., Stoughon, USA) brand viscometer at 20 rpm in 2 repetitions.

h. Sensory analysis

Sensory analyzes of the bread kadayif samples were carried out in the Grain Processing Laboratory of the Department of Food Engineering, Faculty of Agriculture, Atatürk University. Kadayifs were fried and served to 8 panelists by adding sherbet on top. A 9-point Hedonic Type scale (1=very poor, 9=very good) was used for evaluation (Kramer and Twigg 1980)

i. Statistical analysis

For trial bread kadayif; 2 different flours (normal flour, whole flour), 3 different additives (citric acid, L-cysteine, sodium bicarbonate), 3 different levels (0, 1.5%, 3%) were used. It was carried out with 2x3x3 factorial arrangement according to a completely random design plan with 2 replications. The raw values from the experiment were analyzed in the SPSS program (SPSS 1999) and the averages of the main sources of variation were compared with the Duncan Multiple Comparison Test (Yıldız and Bircan 2003).

Results and Discussion

a. Water Activity, pH, Acrylamide and HMF Values of Bread Kadayifs

The variation analysis results of different whole flour level, additive and additive level water activity, pH, acrylamide and HMF values of bread kadayif samples are given in Table 1. Full flour level; water activity, pH and acrylamide were very important ($p<0.01$). Additive; It had a very significant ($p<0.01$) effect on water activity and pH and a significant ($p<0.05$) effect on HMF. Additive level had a significant ($p<0.05$) effect on water activity and pH value.

Based on the averages in Table 2, it was observed that the highest water activity value was observed at 30% whole flour level. The highest pH value was found at 30% full flour level. Table 2 shows that the highest acrylamide value was observed at the 30% level. As seen in the table, addition of whole flour to bread kadayifs caused an increase in acrylamide value. In a study investigating the effect of flour type on Maillard reaction and acrylamide formation, a crisp bread model system consisting of flour, water and yeast was used. Whole wheat, wheat and rye flours were used as flour types. The breads were baked at different temperatures and times. When rye flour was used, acrylamide and HMF levels were the highest at all temperatures applied, while HMF was less when whole wheat flour was used. However, it was observed that acrylamide levels were higher in whole wheat than in wheat flour (Capuano *et al.* 2009). According to the table, the

Table 1.

Variation analysis results of water activity, pH, acrylamide and HMF values of bread kadayif fried at different whole flour level, additive and additive levels

Variation Source		Water Activity (%)		pH		Acrylamide (µg/kg)		HMF (mg/kg)	
	DF	MS	F	MS	F	MS	F	MS	F
Whole flour (A)	1	0,41	63,74**	21,75	1116,81**	69426,98	22,86**	0,39	1,46
Additive (B)	2	0,18	28,68**	6,96	357,65**	509,25	0,17	1,30	4,89*
Additive level (C)	2	0,02	3,57*	0,12	6,03*	3372,71	1,11	0,31	1,15
AXB	2	0,02	3,51	0,26	13,09**	9277,74	3,06	0,85	3,18
AXC	2	0,05	7,01**	0,09	4,69*	38604,41	12,71**	0,53	1,98
BXC	4	0,08	13,11**	3,38	173,38**	186,86	0,06	0,93	3,48*
AXBXC	4	0,01	1,98	0,08	3,91*	2689,06	0,89	0,40	1,49
Error	18	0,006		0,019		3036,65		0,27	

** Significant at the P<0.01 level.

Table 2.

Duncan multiple comparison test results of water activity, pH, acrylamide and HMF values of different whole flour levels of bread kadayif samples

Whole Flour Level (%)		Water Activity (%)		pH		Acrylamide (µg/kg)		HMF (mg/kg)	
	N	Mean	St. Error	Mean	St. Error	Mean	St. Error	Mean	St. Error
0	18	$0,32^{b}$	±0,20	$7,38^{b}$	±0,85	$74,36^{b}$	±52,55	$0,74^{a}$	±0,96
30	18	$0,53^{a}$	±0,15	$8,94^{a}$	±0,98	$162,19^{a}$	±83,76	$0,53^{a}$	±0,17

* Means with the same letter are not statistically different from each other (p<0,05)

Table 3.

Duncan multiple comparison test results of the averages of water activity, pH, acrylamide and HMF values of bread kadayif samples for different additives

Additive	Water Activity (%)			pH		Acrylamide (µg/kg)		HMF (mg/kg)	
	N	Mean	St. Error	Mean	St. Error	Mean	St. Error	Mean	St. Error
L-cysteine	12	0,46^{b}	±0,20	8,58^{a}	±0,82	115,83^{a}	±87,17	0,42^{b}	±0,22
Citric Acid	12	0,53^{a}	±0,18	7,28^{b}	±1,22	113,34^{a}	±85,07	1,01^{a}	±1,09
$NaHCO_3$	12	0,29^{c}	±0,16	8,63^{a}	±1,09	125,66^{a}	±82,53	0,47^{b}	±1,17

* Means with the same letter are not statistically different from each other (p<0,05)

highest HMF value was observed at 0% whole flour level and a decrease in HMF value was achieved in kadayifs where whole flour was added.

Duncan's multiple comparison test results of the averages of water activity, pH, acrylamide and HMF values of bread kadayif samples for different additives are given in Table 3.

When evaluated according to the additives on the averages in Table 3, the highest acrylamide value was observed in $NaHCO_3$ additive and the lowest acrylamide value was observed in citric acid additive. In addition, there was no statistical difference between the additives used and they were in the same group. Again, when we examined the table, it was seen that the highest HMF value was in citric acid additive and the lowest HMF value was in L-cysteine additive. In addition, there was no statistical difference in $NaHCO_3$ and L-cysteine additives. In this study, L-cysteine and $NaHCO_3$ decreased the amount of HMF compared to the control, while citric acid increased the amount of HMF compared to the control in samples without and with whole flour added to the formulation. In a study, it was determined that HMF value increased in environments where the temperature was high and pH was 5. (Borrelli et al. 2002). HMF formation occurs especially above 50°C and at normal humidity values and pH 4-7 (Batu vd. 2014).

The interaction of the whole flour level × additive, which has an effect on the acrylamide value, is shown in Figure 1. When the figure is examined, the highest acrylamide value was seen in L-cysteine + 30% whole flour level, the lowest acrylamide value was observed in L-cysteine + 0% whole flour level. The interaction of whole flour level × additive,

Table 4.

Variance analysis results of moisture values of different whole flour level, additive and additive level of bread kadayif samples

Variation Source	Moisture values (%)		
	DF	MS	F
Whole flour (A)	1	374,94	528,37**
Additive (B)	2	19,63	24,85**
Additive level (C)	2	2,49	3,50
AXB	2	0,16	0,22
AXC	2	18,60	26,21**
BXC	4	8,98	12,65**
AXBXC	4	1,51	2,13
Error	18	0,71	

** Significant at the P<0.01 level.

Table 5.

Variance analysis results of L, a* and b* color values of different whole flour level, additive and additive level of unfried bread kadayif samples*

Variation Source		L*		a*		b*	
	DF	MO	F	MO	F	MO	F
Whole flour (A)	1	48,91	5,52*	0,39	0,19	118,45	26,90**
Additive (B)	2	1095,71	123,57**	169,59	80,11**	20,69	4,70*
Additive level (C)	2	271,46	30,61**	71,74	33,89**	55,16	12,53**
AXB	2	12,83	1,45	4,95	2,34	0,26	0,06
AXC	2	23,22	2,62	5,12	2,42	2,19	0,50
BXC	4	302,19	34,08**	46,91	22,16**	10,89	2,47
AXBXC	4	10,71	1,21	2,93	1,38	7,79	1,77
Error	18	8,87		2,12		4,40	

** Significant at the P<0.01 level.

Table 6.

Variance analysis results of L, a* and b* color values of different whole flour level, additive and additive level of fried bread kadayif samples*

Variation Source		L*		a*		b*	
	FD	MO	F	MO	F	MO	F
Whole flour (A)	1	127,46	36,09**	1,85	1,17	160,32	107,86**
Additive (B)	2	347,00	98,25**	0,18	0,12	490,28	329,85**
Additive level (C)	2	127,68	36,15**	36,86	23,30**	154,24	103,77**
AXB	2	22,79	6,45**	2,78	1,76	10,97	7,38**
AXC	2	2,40	0,68	6,90	4,36*	4,84	3,25
BXC	4	111,09	31,45**	2,01	1,27	130,48	87,78**
AXBXC	4	10,36	2,93	0,76	0,48	9,22	6,21**
Error	18	3,53		1,58		1,49	

** Significant at the P<0.01 level.

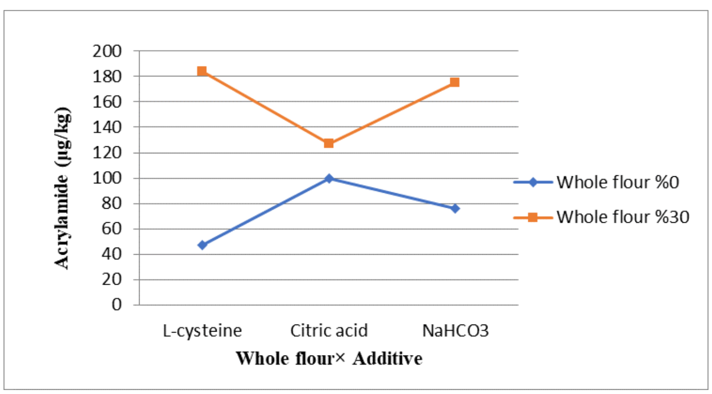

Figure 1.

The effect of different whole flour level × additive interaction on acrylamide value of bread kadayif

which has an effect on the HMF value, is shown in Figure 2. When the figure is examined, the highest HMF value was seen in citric acid + 0% whole flour level, the lowest HMF value was seen in L-cysteine + 0% whole flour level application.

b. Moisture Values of Different Whole Flour Levels, Additives and Additives Levels of Bread Kadayif Samples

The variance analysis results of the moisture values of the different whole flour level, additive and additive level of the bread kadayif samples are given in Table 4. Whole flour level and additives had a significant (p<0.01) effect on moisture value. The interaction of different whole flour level × additives that affect the moisture value of bread kadayif is shown in figure 3. When the figure was examined, it was observed that the moisture value in all additives increased as the whole flour level increased.

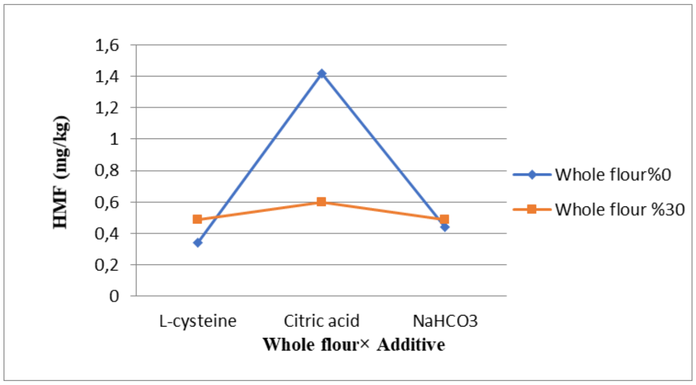

Figure 2.

The effect of different whole flour level × additive interaction on the HMF value of bread kadayif

Table 7.

The variance analysis results of the viscosity values of bread kadayif doughs of different whole flour levels, additives and additive levels

Variation Source	Viscosity (cP)		
	FD	MS	F
	1	550,68	49,18**
Whole flour (A)	2	173485,80	15492,11**
Additive (B)	2	14048,80	1254,54**
Additive level (C)	2	790,41	70,58**
AXB	2	696,31	62,18**
AXC	4	50442,72	4504,49**
BXC	4	199,06	17,78**
AXBXC	18	11,20	

*** Significant at the P<0.01 level*

which has an effect on the HMF value, is shown in Figure 2. When the figure is examined, the highest HMF value was seen in citric acid + 0% whole flour level, the lowest HMF value was seen in L-cysteine + 0% whole flour level application.

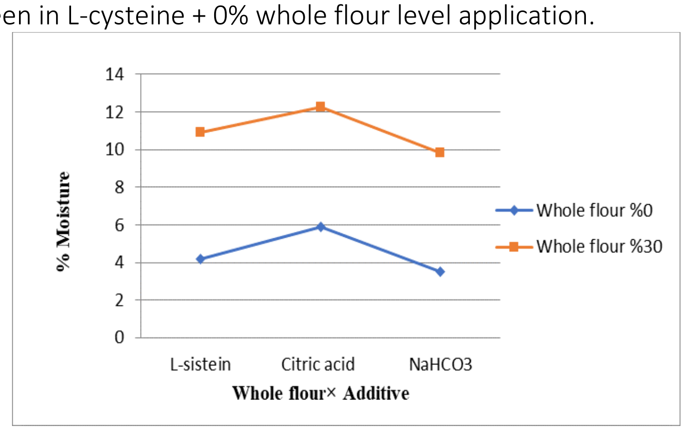

Figure 3.

The effect of different whole flour level × additive interaction on moisture value of bread kadayif

b. Moisture Values of Different Whole Flour Levels, Additives and Additives Levels of Bread Kadayif Samples

The variance analysis results of the moisture values of the different whole flour level, additive and additive level of the bread kadayif samples are given in Table 4. Whole flour level and additives had a significant ($p<0.01$) effect on moisture value. The interaction of different whole flour level × additives that affect the moisture value of bread kadayif is shown in figure 3. When the figure was examined, it was observed that the moisture value in all additives increased as the whole flour level increased.

c. L, a* and b* Color Values of Different Whole Flour Levels, Additives and Additives Levels of Unfried Bread Kadayif Samples*

The variance analysis results of different whole flour levels, additives and additive levels of bread kadayıf before frying are given in Table 5. Full flour level; It had a significant ($p<0.01$) effect on the b* value and significantly ($p<0.05$) on the L* value. Additive; It had a very significant ($p<0.01$) effect on L* and a* values, and a significant ($p<0.05$) effect on b* values. The additive level was very important ($p<0.01$) in all color values.

d. L, a* and b* Color Values of Different Whole Flour Levels, Additives and Additive Levels of Toasted Bread Kadayif Samples*

The variance analysis results of different whole flour levels, additives and additive levels of bread kadayif samples after the frying process are given in Table 6. Whole flour level and additive were very effective ($p<0.01$) on L* and b* color values. The additive level had a significant ($p<0.01$) effect on L*, a* and b* color values.

e. Viscosity Values of Different Whole Flour Levels, Additives and Additives Levels of Bread Kadayif Doughs

The variance analysis results of the viscosity values of different whole flour levels, additives and additive levels of bread kadayif dough are given in Table 7. According to the table, the full flour level, additive and additive level applications had a very significant ($p<0.01$) effect on the viscosity value.

f. Sensory Analysis Values of Bread Kadayifs

The variation analysis results of the outer appearance, inner color, taste and odor values of bread kadayif prepared and fried with different whole flour levels, additives and additive levels are given in Table 8. Full flour level, additive and additive level applications; It has a significant effect on external appearance, internal color, taste and odor values.

The variance analysis results of the aroma, texture, mouthfeel and general acceptability values of bread kadayif prepared and fried with different whole flour levels, additives and additive levels are given in Table 9. According to the table, the application of full flour level had a very significant ($p<0.01$) effect on the aroma, mouthfeel and general acceptability values. Additive and additive level applications had a very significant ($p<0.01$) effect on aroma, texture, mouthfeel and general acceptability values.

Duncan multiple comparison test results of the averages of outer appearance, internal color, taste and odor values of different whole flour levels of bread kadayif samples are given in Table 10.

As seen in Table 10, when the evaluation was made according to the whole flour level based on the averages, the addition of whole flour to the bread kadayif samples caused a decrease in the external appearance, internal color, taste and odor values, that is, it was less liked by the panelists.

Duncan multiple comparison test results of the averages of outer appearance, internal color, taste and odor values of bread kadayif samples for different additives are given in Table 11.

In Table 11, when the evaluation is made according to the additives on the averages, it is determined that citric acid additive is the most liked appearance by the panelists. The least liked appearance was found in $NaHCO_3$ supplementation. The surface color of the bread kadayifs

Table 8.

Variation analysis results of outer appearance, inner color, taste and odor values of bread kadayifs fried at different whole flour levels, additives and additive levels

Variation Source		Outer Appearance		Color		Taste		Odor	
	FD	MS	F	MS	F	MS	F	MS	F
Whole flour (A)	1	1,42	7,66*	3,19	18,82**	2,29	14,18**	1,54	9,06**
Additive (B)	2	2,63	14,21**	2,37	14,01**	1,54	9,54**	1,88	11,05**
Additive level (C)	2	6,96	37,65**	11,08	65,43**	14,73	91,19**	13,72	80,86**
AXB	2	0,78	4,24*	0,20	1,20	0,10	0,62	0,17	0,99
AXC	2	1,27	6,88**	2,33	13,74**	0,63	3,88*	0,59	3,46
BXC	4	0,87	4,71**	0,65	3,87*	0,61	3,80*	0,70	4,12*
AXBXC	4	0,65	3,54*	0,94	5,52**	0,48	2,94*	0,78	4,62*
HATA	18	0,19		0,17		0,16		0,17	

** Significant at the P<0.01 level.

Table 9.

Variation analysis results of aroma, texture, mouthfeel and general acceptability values of bread kadayif toasted at different whole flour levels, additives and additive levels

Variation Source		Aroma		Texture		Mouthfeel		GA	
	SD	KO	F	KO	F	KO	F	KO	F
Whole flour (A)	1	2,05	14,77**	0,18	1,35	4,92	19,57**	2,65	13,12**
Additive (B)	2	2,98	21,39**	2,54	18,73**	2,21	8,81**	2,19	10,81**
Additive level (C)	2	13,38	96,22**	9,17	67,73**	17,74	70,53**	12,87	63,56**
AXB	2	0,15	1,05	0,19	1,41	0,53	2,12	0,58	2,85
AXC	2	1,74	12,48**	0,60	4,43*	2,16	8,60**	0,75	3,70*
BXC	4	1,10	7,88**	0,72	5,29**	0,70	2,79	0,68	3,38*
AXBXC	4	0,90	6,49**	0,80	5,91**	1,26	5,01**	1,05	5,18**
HATA	18	0,14		0,14		0,25		0,20	

** Significant at the P<0.01 level.

Table 10.

Duncan multiple comparison test results of the averages of outer appearance, interior color, taste and odor values of different whole flour levels of bread kadayif samples

Whole Flour Level (%)		Outer Appearance		Interior Color		Taste		Odor	
	N	Mean	St. Error	Mean	St. Error	Mean	St. Error	Mean	St. Error
0	18	5,85[a]	±1,07	5,97[a]	±1,33	5,35[a]	±1,24	5,33[a]	±1,18
30	18	5,45[b]	±0,88	5,38[b]	±0,82	4,85[b]	±0,95	4,92[b]	±1,03

* Means with the same letter are not statistically different from each other ($p<0,05$)

Table 11.

Duncan multiple comparison test results of the averages of outer appearance, interior color, taste and odor values of bread kadayif samples for different additives

Additive		Outer Appearance		Interior Color		Taste		Odor	
	N	Mean	St. Error	Mean	St. Error	Mean	St. Error	Mean	St. Error
L-cysteine	12	5,64[b]	±0,95	5,68[b]	±0,98	5,08[b]	±1,07	5,01[b]	±1,15
Citric Acid	12	6,12[a]	±0,77	6,12[a]	±1,02	5,47[a]	±1,00	5,56[a]	±0,90
$NaHCO_3$	12	5,18[c]	±1,07	5,23[c]	±1,27	4,75[b]	±1,24	4,80[b]	±1,21

* Means with the same letter are not statistically different from each other ($p<0,05$)

Table 12.

Duncan multiple comparison test results of the averages of aroma, texture, mouthfeel and general acceptability values of different whole flour levels of bread kadayif samples

Whole Flour Level (%)		Aroma		Tekstür		Mouthfeel		GA	
	N	Mean	St. Error	Mean	St. Error	Mean	St. Error	Mean	St. Error
0	18	5,38[a]	±1,28	5,55[a]	±0,93	5,58[a]	±1,63	5,44[a]	±1,34
30	18	4,90[b]	±1,06	5,69[a]	±1,06	4,84[b]	±0,86	4,90[b]	±0,87

* Means with the same letter are not statistically different from each other ($p<0,05$)

Table 13.

Duncan multiple comparison test results of the averages of aroma, texture, mouthfeel and general acceptability values of bread kadayif samples for different additives

Additive		Aroma		Tekstür		Mouthfeel		GA	
	N	Mean	St. Error	Mean	St. Error	Mean	St. Error	Mean	St. Error
L-cysteine	12	4,96[b]	±1,13	5,38[b]	±0,97	5,08[b]	±1,31	5,07[b]	±1,08
Citric Acid	12	5,70[a]	±1,07	6,15[a]	±0,80	5,69[a]	±1,18	5,63[a]	±1,00
$NaHCO_3$	12	4,76[b]	±1,23	5,33[b]	±1,02	4,86[b]	±1,48	4,79[b]	±1,27

* Means with the same letter are not statistically different from each other ($p<0,05$)

with NaHCO3 additive was observed to darken too much, so they received the least appreciation by the panelistsIn his study, Cheraggi (2019) added acetic acid, CaCl2, glycine, NaCl, NaHCO3 and sucrose to tray kadayifs and subjected them to sensory evaluation. In this study, the least favorable appearance value was found in NaHCO3 supplementation.

As seen in Table 11, when evaluated according to the additives on the averages, the most liked internal color value was found in citric acid additive and the least liked internal color value was found in NaHCO3 additive. The most liked taste value was in citric acid additive and the least liked taste value was in NaHCO3 additive. In addition, there was no statistical difference in L-cysteine and NaHCO3 additives. The most liked odor value by the panelists was citric acid additive and the least liked odor value was NaHCO3 additive. In addition, there was no statistical difference in L-cysteine and NaHCO3 additives.

According to Table 12, when the averages are taken as basis and evaluated according to the whole flour level, the aroma, mouthfeel and general acceptability values most liked by the panelists were determined at 0% whole flour level. The texture value most appreciated by the panelist was found to be at the level of 30% full flour.

Duncan's multiple comparison test results of the averages of aroma, texture, mouthfeel and general acceptability values of bread kadayif samples for different additives are given in Table 13.

As seen in Table 13, when evaluated according to the additives on the averages, the aroma, texture, mouthfeel and general acceptability values most liked by the panelists were observed in citric acid additive. The least favorable aroma, texture, mouthfeel and overall acceptability values were determined for $NaHCO_3$ additive. In addition, there was no statistical difference in L-cysteine and $NaHCO_3$ additives.

Conclusion

In the study, when evaluated according to the additives used, the highest acrylamide value was observed in the $NaHCO_3$ additive, and the lowest acrylamide value was observed in the citric acid additive. While citric acid contribution gave the highest HMF value, L-cysteine contribution gave the lowest HMF value. The highest pH value was observed in the $NaHCO_3$ additive, and the lowest pH value was observed in the citric acid additive. The highest water activity value was observed in the citric acid additive, and the lowest water activity value was observed in the $NaHCO_3$ additive. With the increase of whole flour level, an increase in acrylamide, pH and water activity values, while a decrease in HMF value was observed.

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