Araştırma Makalesi

www.ziraat.selcuk.edu.tr/ojs
Selçuk Üniversitesi
Selçuk Tarım ve Gıda Bilimleri Dergisi
26 (1): (2012) 70-76
ISSN:1309-0550

Buğday Tanesine Uygulanan Bazı Stabilizasyon Uygulamalarının, Tam Buğday Ununun Kalitatif Özelliklerine ve Depolama Stabilitesine Etkisi

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(Geliş Tarihi: 22.11.2010, Kabul Tarihi: 05.10.2011)

Özet

Bu çalışmada Bezostaya-79 ve Gerek-79 buğday tanelerine, mikrodalga (MW), infrared (IR) ve ultraviyole (UV) gibi bazı fiziksel stabilizasyon metotları uygulanmıştır. Stabilize edilen materyal öğütülerek kepekli kısım ayrılarak beyaz un elde edilmiştir. Daha sonra kepekli fraksiyonlar da ince olarak öğütülmüş ve beyaz una ilave edilerek tam buğday unu elde edilmiştir. Çalışmada buğday kültürlerinin, stabilizasyon metotlarının ve depolama periyotlarının tam un kalitesi, depolama stabilitesi ve ekmekçilik kalitesi üzerine etkileri belirlenmiştir. Depolama stabilitesi ile ilgili olarak, tüm örnekte larva ve canlı böcek gelişimine rastlanmamıştır. Daha yüksek ısıl penetrasyon özelliği nedeniyle mikrodalga işlemi uygulamaları ile buğday tanesinde daha düşük maya-küf sayıları elde edilmiştir. Ayrıca, mikrodalga uygulamaları titrasyon asitliği ve tiyobarbitürik asit değerlerinin anlamlı bir şekilde (P<0.05) düşmesine neden olmuştur. Mikrodalga ve infrared uygulamaları ile su absorbsiyonunu düşerken tüm diğer stabilizasyon metotları ise alveogram değerlerinde düşüşe neden olmuştur. Pişirme çalışmalarında ise, mikrodalga ile stabilize edilen örnekler kontrol grubu dahil tüm diğer örneklere göre en düşük ekmek hacmi değerlerini vermiştir.

Anahtar kelimeler: *Tam buğday unu, stabilizasyon, mikrodalga, infrared, ultraviyole, ekmek.*

The Effects of Some Physical Stabilization Treatments of Wheat Kernel on The Storage Stability and Qualitative Properties of Whole Wheat Flour

Abstract

In this study, Bezostaya-1 and Gerek-79 wheat kernels, were treated by using some physical stabilization methods, microwave (MW), infrared (IR) and ultraviolet (UV). The stabilized material was milled and separated to obtain white flour and branny fraction. The branny fraction was fine ground and remixed with the white flour to obtain whole wheat flour. The effects of wheat cultivar, stabilization method and storage period on the whole wheat flour quality, storage stability, and bread properties were determined. In storage stability part of the study, no development was found in larva and live insect growth for all samples. The MW application on the wheat kernel was the best in terms of low mould-yeast count with higher heat penetration property. MW stabilization treatment had a significant effect to reduce the titration acidity and thiobarbituric acid values (P<0.05). MW and IR treatments lowered the water absorption, and all stabilization methods caused a sharp decrease in alveogram properties. In baking studies, MW stabilization method had the lowest volume values for the bread loaves in comparison to the other methods and control samples.

Keywords: *Whole wheat flour, stabilization, microwave, infrared, ultraviolet, bread.*

Introduction

Whole wheat kernel consists of wide range of nutrients and significant amounts of bioactive phytochemicals (Slavin 2000; Slavin et al. 2001). Consumption of whole grains have been reported to have a number of beneficial health effects including reduced risk of cancer, heart diseases, hypertension, colon cancer, diabetes and obesity (Anderson et al. 2000; Meyer et al. 2000; Slavin 2000; Hallfrisch et al. 2003).

In Turkey, large amount of calories and protein are provided from cereal and cereal products, especially from bread. Daily white bread consumption is about 330 g bread / person. Also the demand for whole wheat bread has increased in Turkey like other countries of the world because of its better nutritional image (Lai et al. 1989). In contrary to the better nutritional image of whole wheat bread, the fast development in rancidity and insect growth of the whole wheat flour, difficulties in dough processing, lower-quality bread with low volume and shorter shelf time and fast mould growth were the disadvantages (Lai et al. 1989; Marathe et al. 2002; Akhtar et al. 2008).

High biologic and enzymatic activities of outer layer of the wheat kernel influence the whole flour stability and bread properties during storage. In literature, there

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are some studies about the effects of different stabilization methods, microwave, autoclaving, steaming, roasting, toasting, infrared heating, on bran or germ fractions of wheat kernel (Rao et al. 1980; Sivri 1991; Vetrimani et al. 1992; Kermasha et al. 1993; Zwingelberg and Fretzdorff 1996; Türker et al. 2001; Pınarlı 2004). In our previous study, MW heating and autoclaving of fine branny fractions into remixed whole wheat flour samples gave satisfactory storage stability, flour and bread qualities for 90 days storage time compared with the untreated whole wheat flour (Elgün et al. 2011).

The separation and treatment of the branny fractions of wheat is a successful but time consuming process (Elgün et al. 2011). Since the stabilization application on whole grain is easier, faster and cheaper method than stabilization of branny fraction, whole grain stabilization was used in this study. Two different wheat cultivars, Bezostaya-1 and Gerek-79, in the form of whole kernel were treated by three different physical treatment methods, microwave, infrared and ultraviolet versus to control samples without any treatment were employed. These materials were examined in terms of convenient parameters for the shelf life and quality of the whole wheat flour.

Materials and Methods

Materials

The wheat materials, Bezostaya-1 (red-hard-strong) and Gerek-79 (white-soft-weak), were obtained from a commercial flour mill in dry cleaned form (Altınapa Flour mill, Konya, Turkey).

Methods

Experimental design and statistical analysis

Three physical stabilization processes (microwave heating, infrared heating and ultraviolet radiation) were applied to wheat cultivars. The control samples were prepared by the same milling procedures without any stabilization application. The storage studies were performed for three periods (1, 21 and 35 day/s). Storage stability studies were achieved at the atmospheric conditions of 34±1°C with 65 % relative humidity as "35 days accelerated storage".

In the storage stability experiments, two wheat cultivars, three stabilization methods and three storage times were used as factors. The experiments about qualitative properties were conducted with two cultivars and three stabilization methods.

TARIST (version 4.0, İzmir) software was used to perform the statistical analysis of the quality parameters according to the three and two ways ANOVA. Duncan's multiple range test was used to differentiate among the mean values.

Stabilization of wheat kernel

For stabilization of whole wheat kernel, Microwave (MW) heating, Infrared (IR) heating and Ultraviolet (UV) radiation were used on 3 mm thick layer of wheat samples. Stabilization parameters obtained from our previous study (Elgün et al. 2011) were used as MW at 70 °C for1 min, IR at 70 °C for 1 min, UV at 30 Watt-254 nm for 3 min.

Milling procedures

The treated wheat samples were milled by a lab roller mill (Chopin CD 1, Chopin Technologies., Villeneuve La Garenne, France) at 65±1 % extraction rate "white flour". After this processing, the remaining branny material (germ, coarse, fine bran and a small amount of flour) of wheat were milled into fine material on a hammer mill (FN-3100 Laboratuary Mill, Perten Instruments AB, Huddinge, Sweden) with 500-micron-sieve opening and remixed with white flour to obtain whole wheat flour.

Laboratory analyses

Kernel properties: The hectoliter and 1000 kernel weights, kernel size and hardness (vitreousness) were determined according to Elgün et al. (2001).

Flour analyses: The moisture, ash, protein, crude fat and crude fiber contents of the samples were determined using AACC standard methods (Anon. 1990). The titration acidities of the samples were calculated as sulfuric acid described by Elgün et al. (2001). The color parameters "L*", "a*" and "b*" were obtained by using Hunter Lab Color Quest II Minolta CR 400 (Konica Minolta Sensing, Inc., Osaka, Japan).Granulation of whole wheat flour was determined on a gyrating sieve with 1180, 750, 500, 250 and 140 microns.

Physical dough properties: In the measurements of the rheological properties of the remix flour samples, Alveo-consistograph was used according to AACC 54-30A and 54-50 methods (Anon. 1990).

Bread-making studies: Whole wheat bread was obtained by the modification of AACC method 10-10B. Loaf weight, volume, specific volume, crust color, crumb texture and crumb color of the samples were determined (Anon. 1990).

Storage stability

For determination of stability of whole wheat flour during "35 days accelerated storage", insect control was done, mould-yeast load were examined, titration acidity and thio-barbituric acid values were determined at 1st, 21st and, 35th days of the storage.

Dead or live insect counts of the whole wheat flour during the 35 days accelerated storage were made on the samples by using the sieve method with visual observation (Hill 1990). Mould-yeast load was determined according to Anon. (2005).

Thio-barbituric acid (TBA) test indicates the extent of oxidative rancidity of the samples. The method described by Tarladgis et al. (1960) was used for determination of TBA values of the whole wheat flour samples. The samples were blended in a commercial blender (Waring Products Division, New Hartford, CT) and then 10 g of the blended flour samples were used. The absorbance values of the distillates were read at 538 nm (UV-160 A, UV-Visible Recording Spectrophotometer, Shimadzu, Tokyo, Japan) against a blank reagent. The TBA values were expressed as milligrams malonaldehyde per kilogram samples.

Results and Discussion

Analytical Results

Kernel properties: Hectoliter weight and thousand kernel weight of the Bezostaya-1 and Gerek-79 wheat cultivars were found as 81.50 kg/hl and 80.50 kg/hl; 34.17g and 26.57g, respectively. Kernel hardness value of the Bezostaya-1 (72 %) was higher than Gerek- 79 (44 %) cultivar. Kernel size (w/w %) of the wheat samples were given over 2.2mm, 2.5mm and 2.8mm sieves. The amounts of the samples over these sieves were found as 3.94-31.38-61.40 % for Bezostaya-1 and 7.60-66.72-4.32 % for Gerek-79. In general, Bezostaya-1 showed better physical kernel properties than those of Gerek-79 except for kernel size.

Whole flour properties: Analytical properties of the whole wheat flour samples obtained from the both cultivars at the same milling conditions without any treatments are given in Table 1. Bezostaya-1 flour was found stronger with its higher protein amount, darker in color, a little coarser in granulation than those of Gerek-79 (Table 1). Bezostaya-1 flour was determined better than Gerek-79 in quality in term of alveo-consistogram parameters. As a result, Bezostaya-1 wheat was found red, hard and strong wheat with good bread-making quality. But Gerek-79 wheat was found a kind of white, soft and semi hard cultivar with medium bread-making quality.

Storage stability of the whole wheat flour

Dead or live insect loads: No larva and live insect were seen in the all samples during 35 days accelerated storage period.

Mould-Yeast load (MYL): The effects of wheat cultivar, storage period and stabilization method on MYL were found significant (*P<0.01*) according to ANOVA results. The statistically significant (*P<0.01*) "wheat cultivar x storage period x stabilization method" interaction in MYL, was shown that the microorganism load is rising with increasing storage time for the both cultivar, being more effective on soft cultivar Gerek-79 with originally high microorganisms load (Figure 1a). When compared to the control, all of the stabilization methods became effective on MYL. MW application was shown as the most effective stabilization method for both cultivars. Probably, MW application with higher heat penetration property (Vetrimani et al. 1992) was more effective than the other applications on MYL in both forms, generative and vegetative. The IR and UV applications probably killed only vegetative forms mostly due to their radiation effect on the grain surface with slow penetration into the mass of material, and after 21 days, the spores in generative forms germinated and caused more increase in growth count. As result, the MW heating may be the most suitable method for long time keeping of ground whole grain products.

Table 1. The results of analytic analysis of whole wheat flour of B*ezostaya-1 and Gerek-79*

Parameters	***Bezostaya-1***	***Gerek-79***
Moisture (%)	10.47	10.19
Crude ash (%)[1]	1.70	1.48
Crude protein (%)[1,2]	13.01	11.18
Crude fat (%)[1]	2.30	2.37
Crude fiber (%)[1]	2.90	2.85
Color		
L*	86.24	90.32
a*	0.14	-0.17
b*	12.01	11.42
Granulation		
> 500 micron	1.59	1.61
>250 micron	21.71	20.54
>140 micron	69.53	65.42
<140 micron	7.17	12.43
Alveoconsistogram properties[3]		
WA (%)	55.9	56.5
T (mm H_20)	129	57
A (mm)	18	21
Ex (mm)	9.4	10.2
Fb (10 E- 4J)	106	48
T/A	7.17	2.71

[1] *Based on dry matter*
[2] *N x 5.70*
[3]*WA: Water absorption (based on 15 % moisture), T:Tenacity A: lengthening, Ex: Expandability, Fb: baking force (energy) T/A: Configuration ratio*

Titration acidity (TA): As seen in Table 2 wheat cultivar did not change the TA values of the whole wheat flour samples statistically. Storage period and stabilization method variance sources were found significant (*P<0.05*) on the TA values. The TA increased with the increasing storage time, up to 35 days storage at the accelerated storage conditions. The highest mean value (0.04 %) of TA obtained in experiment did not pass the critical amount that the maximum permissible level of 0.07 % given by Turkish Food Codex (Anon. 1999). MW treatment was found as the most effective method with the lowest titration acidity value (0.026 %).

Table 2. Effect of wheat cultivar, stabilization method and storage period on mould-yeast load (MYL), titration acidity (TA) thio-barbituric acid (TBA) values[1]

Factors	N	MYL (10^3 cfu/g)	TA (%)	TBA (mg malonaldehyde/kg)
Wheat cultivar				
Bezostaya-1	24	35.88^b	0.029^a	1.20^b
Gerek-79	24	53.25^a	0.031^a	1.74^a
Storage period (days)[2]				
1	16	25.19^c	0.021^c	1.37^c
21	16	39.88^b	0.030^b	1.49^b
35	16	68.63^a	0.038^a	1.56^a
Stabilization method				
Control	12	71.08^a	0.033^a	1.49^a
Microwave	12	29.25^c	0.026^b	1.41^b
Infrared	12	38.92^b	0.029^{ab}	1.49^a
Ultraviolet	12	39.00^b	0.031^a	1.49^a

[1]*The means with the same letter in column are not significantly different (P < 0.05). (Three way ANOVA)*
[2]*Storage conditions; at 34±1 ºC and 65% humidity*

Thio-barbituric acid (TBA) value: All of the variance sources were found significant (*P<0.05*) on the TBA values of the whole wheat flour samples (Table 2). The mean TBA value of Gerek-79 was higher than that of Bezostaya-1. By the increase of the storage time, the TBA values of the samples were increased significantly (*P<0.05*). According to "wheat cultivar x storage period x stabilization method" interaction (Figure 1b), the effect of stabilization methods on TBA value became more remarkable for hard wheat Bezostaya-1 than those of Gerek-79. In inhibition of rancid development of whole wheat flour of Bezostaya-1, MW treatment was the most effective method. No difference was observed on soft Gerek-79 flour samples with high TBA, originally for the control at the experimental conditions during the 35 days accelerated storage period (Figure 1b).

Qualitative properties of whole wheat flour

Color values and alveo-consistogram properties of the whole wheat flour samples were given in Table 3 as a summary of the two ways ANOVA and Duncan's multiple range tests.

Flour color: Wheat cultivar and storage period variance sources significantly (*P<0.05*) affected the "L*", "a*" and "b*" color values of whole wheat flour samples according to results of two ways ANOVA. As seen, in Table 3, Gerek-79 gave whiter "L*" values in flour color than Bezostaya-1. All stabilization application increased "a*" and "b*" color intensity, and decreased "L*" values of the flour samples (Table 3). MW treatment showed the highest darkness and decreased the brightness of whole wheat flour for both cultivars while increasing "a*" and "b*" values (Table 3). The possible causes of the flour color darkness may be due to more penetration ability and toasting effect of the MW heating (Vetrimani et al. 1992). The darkening effect of IR was the secondary due to the restriction of IR heating on the surfaces of kernels. In Figure 2, the increasing effect of MW heating on "a*" values of the whole wheat flour is seen clearly. Also, Bezostaya-1 with high natural reddish pigmentation had a significantly (*P<0.05*) higher "a*" values than the other cultivar.

Alveo-Consistograph studies: Alveo-consistogram properties of two wheat cultivars' flour obtained in the research are shown in Table 3. Gerek-79 gave the higher water absorption (WA) value than Bezostaya-1 due to low kernel hardness of the Gerek-79. MW and IR stabilization applications decreased WA a bit but at statistically significant level (*P<0.05*). In the dough rheological properties, IR treatment had the highest T and Fb values compared to the other stabilization methods. As seen in Table 3, the lowered WA and enhanced stiffness in dough structure as a result of stabilization applications caused a decrease in extensibility of the dough and resulted in low energy value of the dough being the most for MW (Table 3). Probably, the excessive MW application is in force in thermal inactivation of the enzymes potential as given by Dıraman and Boyacıoğlu (1996) and Bayrakçı (2008). Here the proteolytic enzymes which are more sensitive to heat applications (Pomeranz 1988) were primarily inactivated by the heat treatments. In contrast to this finding, in the previous study (Elgün et al. 2011), the stabilization applications on the branny fraction of whole wheat, gave positive effect on consistogram properties of the whole wheat flour samples, possibly due to some limitation of MW and IR heating on the material than those on whole kernel. These results lead to more research on the production of whole wheat flour on the application norms of MW and IR heating in the case of whole kernel.

Bread-making studies: The effects of wheat cultivar and stabilization method on bread properties are summarized in Table 4. According to Duncan's multiple range test results, wheat cultivars did not change the weight, volume and specific volume of the whole wheat bread. This result indicated higher quality loss of strong Bezostaya-1 wheat during the stabilization procedures. All of the stabilization applications decreased bread weight, and MW treatment lowered the loaf volume of whole wheat bread compared to the control (Table 4). In this loaf volume loss, changes in qualitative properties of the flour and rheology of its dough by means of stabilization methods became effective

There was no difference between the crumb texture of the wheat cultivars, soft-weak wheat Gerek-79 and hard-strong Bezostaya-1 (Table 4). The lowest texture value was obtained from MW heating together with the volume loss.

Table 3. Effect of wheat cultivar and stabilization method on color and alveoconsistograf values of the whole wheat flour[1]

Factors	N	Color L*	Color a*	Color b*	WA (%)	T (mmH_2O)	A (mm)	Ex (mm)	Fb(10E-4J)
Wheat cultivar									
Bezostaya-1	8	86.18^b	0.45^a	12.70^a	55.31^b	163.00^a	19.25^b	9.65^b	139.13^a
Gerek-79	8	90.23^a	0.23^b	11.92^b	56.06^a	64.63^b	25.50^a	11.24^a	61.38^b
Stabilization method									
Control	4	88.77^a	0.11^d	12.01^d	56.08^a	113.50^c	26.00^a	11.23^a	114.00^a
Microwave	4	87.79^c	0.61^a	12.61^a	55.38^b	116.50^b	21.00^{bc}	10.05^c	89.25^c
Infrared	4	88.09^b	0.43^b	12.44^b	55.30^b	118.75^a	22.00^b	10.40^b	108.00^b
Ultraviolet	4	88.16^b	0.20^c	12.17^c	56.00^a	106.50^d	20.50^c	10.10^c	89.75^c

Alveo-consistograph properties[2]

[1]*The means with the same letter in column are not significantly different (P < 0.05). (Two way ANOVA)*
[2]*WA: Water absorption (based on 15 % moisture), T:Tenacity, A: Lengthening, Ex: Expandability, Fb: Baking force*

Table 4. Effect of wheat cultivar and stabilization method on bread properties[1]

Factors	N	Weight (g)	Volume (cc)	Spesific volume (cc/g)	Texture (0-5)	Crust color L*	Crust color a*	Crust color b*	Crumb color L*	Crumb color a*	Crumb color b*
Wheat cultivar											
Bezostaya-1	8	148.65^a	372.50^a	2.51^a	4.75^a	60.60^b	4.54^a	18.39^b	52.18^a	5.38^a	13.29^b
Gerek-79	8	148.58^a	367.50^a	2.47^a	4.56^a	61.21^a	4.08^b	19.65^a	55.95^a	3.58^b	15.40^a
Stabilization method											
Control	4	149.18^a	373.75^a	2.51^{ab}	4.88^a	60.83^b	4.08^c	18.27^d	52.92^a	4.69^a	14.49^a
Microwave	4	148.26^c	365.00^b	2.46^b	4.75^{ab}	60.55^c	4.76^a	19.17^b	54.10^a	4.10^c	14.53^a
Infrared	4	148.783^b	373.75^a	2.51^a	4.50^b	61.20^a	4.30^b	19.95^a	56.08^a	4.73^a	13.96^b
Ultraviolet	4	148.24^c	367.50^{ab}	2.48^{ab}	4.50^b	61.03^{ab}	4.13^c	18.67^c	53.17^a	4.39^b	14.59^a

[1]*The means with the same letter in column are not significantly different (P < 0.05). (Two way ANOVA)*

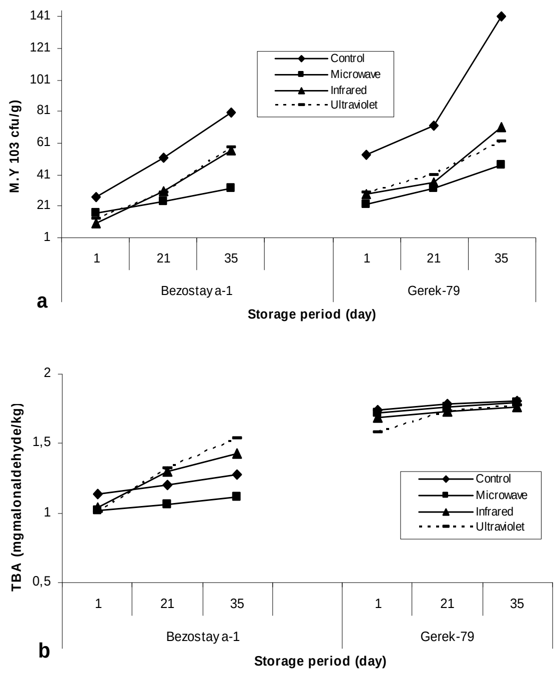

Figure 1. Effects of stabilization method, storage period and wheat cultivar on the M.Y (mould-yeast) load (a) and TBA (thio-barbituric acid) value (b) of whole wheat flour

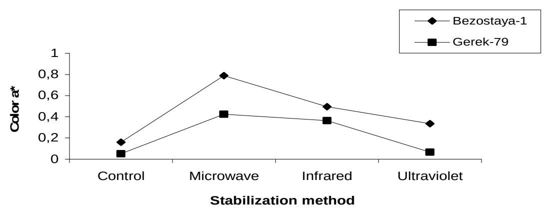

Figure 2. Effects of stabilization method and wheat cultivar on color *a** values of whole wheat flour.

Whole wheat flour samples of Gerek-79 gave more bright and yellow crust color, and increased crumb yellowness compared to Bezostaya-1. Bezostaya-1 increased the crumb and crust redness together. All stabilization applications except for MW improved crust lightness. MW and IR caused an increase in crust "a*" and "b*" values. Crumb lightness was not affected by the stabilization methods. MW and UV applications decreased crumb redness compared to the control.

Gerek-79 gave higher "L*" and "b*" values, but less "a*" value in crumb color in company with the texture values, than the hard-strong Bezostaya-1 wheat cultivar (Table 4).

Conclusion

As conclusion, the MW treatment of wheat kernel may be the most suitable method for long time keeping of ground whole wheat products, but not for the qualitative properties, possibly due to lowered enzymatic activity by MW treatment.

These results leads further researches for the production of whole wheat flour on the application norms of MW stabilization in the case of whole grain. Also, the effect of enzymatic supplementation may be tried for the recovering the dough physical properties and bread quality of whole wheat flour.

Acknowledgement

The study was supported by The Scientific & Technological Research Council of Turkey (*TUBITAK*) (Project number, TOVAG–106 O 187)

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