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EFFECT OF IRRADIATION ON RHEOLOGICAL AND BAKING PROPERTES OF FLOUR WHEAT GRAIN .

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ABSTRACT

Physicochemical studies on flours milled from irradiated samples of Sakha 94 wheat indicated that, besides its protective role from insects and microorganisms, gamma irradiation also has important effects on various quality criteria of wheat flour. Experiments have been performed to study the effects of gamma irradiation on various aspects of wheat flour quality such as dough properties, and baking quality. It was reported in the previous study that falling number, wet gluten and dry gluten values of the flour decreased significantly as radiation levels increased. Apparently the detrimental effect of γ-irradiation was largely on the gluten protein. In this study water absorption and degree of weakening values increased with increasing radiation doses higher than 0.5kGy compared to control sample, while dough stability decreased. The results showed that the overall bread quality of wheat flour was greatly reduced at doses of radiation (1.5-3.5kGy). At 3.5KGy, the mixing requirement was reduced and loaf volume and crumb grain were impaired.

Keywords: Irradiation,Wheat flour,Physicochemical,Technological properties.

INTRODUCTION

Wheat is the world's most important food grain. In general, wheat is mainly consumed in bakery products manufactured from endosperm flour, which forms 83% of the kernel, and has unique technological properties for creating superior, consumer appealing product quality in terms of flavor and texture (Jacobs *et al*., 1998, Liu *et al.,* 2000, Pereira *et al*., 2002). In addition to high-energy content, wheat is also a good source of protein and contains considerably more protein on average than other cereals. The proteins of wheat are complex; they can be divided into two broad categories based on biological function to non-gluten proteins (albumins and globulins) and storage gluten proteins (gliadins and glutenins). The gliadins and glutenins are referred collectively as the gluten proteins, and are mainly located within the mealy endosperm of the grain (Lookhart and Bean, 2000).

Many investigators studied the effect of different gamma ray on improvement of the quality levels in wheat such as extension of shelf-life of whole-wheat flour (Marathe *et al.*, 2002) and increasing the activity of wheat grain endogenous amylases (Gralik and Warchalewski, 2006). In addition to a number of studies which focused on the effect of gamma irradiation treatment on gluten protein (KÖksel *et al*., 1998) and gluten fraction (Nayeem *et al*., 1999). Reports are conflicting on the baking qualities of wheat irradiation at low-dose levels, using lean straight-dough formulas increased loaf volume at dose levels below 200Krad (Milner, 1957, Nicholas, 1957,Lee, 1959, Lai *et al*., 1959, and). However, other workers reported that using a rich formula, have no difference in the baking performance of wheat irradiated at those dose levels (Webb *et al*., 1961, 1955 and Fifield *et al*. 1967).

Lai *et al*., (1959) found that loaf volume for wheat irradiated at low dose levels, increased when using a lean baking formula and decreased when using a rich formula. At doses above 500Krad, irrespective of baking formula used, loaf volume and baking quality deteriorated (Nicholas, 1957and Lai *et. al*., 1959)

Rao *et al*., (1975) reported that, as the irradiation dose increased, height of amylogram peak and peak dough stability decreased.

The FAO/ WHO/ IAEA Joint Expert Committee on Food Irradiation have unconditionally cleared food irradiation up to 10KGy (KGy = 100Krad) as safe for human consumption (Diehl, 1995).

Besides its protective role from insects and microorganisms, gamma irradiation also has important effects on various quality criteria of cereal grains. Experiments have been performed to study the effects of gamma irradiation on various aspects of wheat quality such as milling characteristics, dough properties, and baking quality (Lai *et al* 1959, Lee 1959, Fifield *et al* 1967, Rao *et al*., 1975, Paredes-Lopez and 1983,Covarrubias-Alvarez, 1984, MacArthur and D'Appolonia and Ng *et al*., 1989). It was reported that amylograph peak viscosity and falling number values of the flour decreased significantly as radiation levels increased (MacArthur and D'Appolonia 1983, Ng *et al*., 1989). At 10 kGy, loaf volume and crumb grain were impaired. Paredes-Lopez and Covarrubias-Alvarez (1984) found that the overall bread quality of wheat was greatly reduced at medium doses of radiation (1-10kGy). At doses >5kGy, irrespective of the baking formula used, loaf volume and baking quality deteriorated (Lai *et al* 1959). Irradiation of grain has also caused problems in noodle quality. Japanese noodles (udon) show increased cooking losses and inferior scores in sensory analysis when the bread wheat have been irradiated in the range of 0.2-1.0kGy (Shibata *et al* 1974 and Urbain 1986).

A Joint Expert Committee on the Wholesomeness of Irradiated Food convened by FAO, IAEA, and WHO stated that irradiation of any food commodity up to 10kGy presents no toxicological hazard .

The aim of work the purpose of the present study was to determine the effect of irradiation on rheological and baking properties of wheat grain.

MATERIALS AND METHODS

Materials:

Wheat *(Triticum aestivum L.)* variety Sakha 94 was obtained from Wheat Research Department, Field Crops Research Institute, ARC. Giza. Egypt.

Gamma rays:

Dry grains of wheat were exposed to different gamma doses (0, 0.5, 1.5, 2.5 and 3.5 KGy). Irradiation treatment was carried out in Indian Co60 (NCRRT) gamma cell. The dose rate was 0.9 KGy/ hr at the time of experiment was carried out in the National Center for Radiation Research and Technology, Cairo, Egypt.

Methods :

Wheat samples milling: wheat samples were mill in a standard Brabender Duisburg laboratory mill, Type 279002, Germany, Break and reduction flours were collected and sieved into (flour 72% ext. rate, fine bran, coarse bran, brown shorts and white bran). Wheat flours (72% extraction rate) samples were used in technological studies.

1. Rheological properties:

Farinograph test:

The farinograph (877563 Brabender farinograph Germany HZ 50) was used to study the hydration and mixing characteristics of the dough under investigation according to (A.A.C.C. 2012).

Extensograph test:

Extensograph test was carried out according to the method described in the (A.A.C.C. 2012) using an Extensograph type: 4821384 (Brabender Extensograph Germany HZ 50).

Leavening ability of dough test:

The leavening ability of yeast in dough made from wheat flour (72% extraction rate), which obtained from mill of gamma irradiated wheat samples were determined by measuring the gas volume evolved from standard dough at 30°c for 2hr. as described by Oda and Tonomura (1993). The composition of standard dough was; 10g flour, 5.5ml distilled water (containing 0.5 sugar +0.1 salt) and 0.1g instant active dry yeast (*S. cerevisiae*). The aforementioned ingredients were mixed quickly for min, then placed in a graduated measuring cylinder and kept at 30°c for 2hr.; dough volume was measured every 15min accord to Food Technology Institute, Agriculture Research Center, Giza, Egypt

2- Pan bread preparation:

The straight dough method for pan bread production was carried out according to the method described by (A.A.C.C. 2012).

Physical analysis of pan bread:

- Weight:

The average weight (g) of pan bread was determined individually within one hour after baking.

- Volume:

The volume (cm^3) of produced pan bread was determined by rapeseed.

- Specific volume:

Specific volume was calculated according to the method of (AACC, 2012) using the following equation:

$$\text{Specific volume} = \text{Volume } (cm^3) / \text{Weight } (g)$$

Sensory evaluation of pan bread:

The sensory evaluation of pan bread produced (control and different blends) was done as described by Kralmer and Twigg (1962) and A.A.C.C (2012) using ten panelists from the Bread and Pastry Research Department Staff in Food Technology Institute, Agriculture Research Center. The quality score of pan bread included color (20), texture (20), taste (20), flavor (20), general appearance (20) and overall acceptability was calculated (100).

Statistical analysis :

All the abtained data were subjected to statistical analysis and compared according to the least significant difference (L.S.D.) as mentioned by (Snedecor and Cochroun,1989).

RESULTS AND DISCUSSION

1- Effect of irradiation on the rheological properties of flour .

The rheological characteristics of dough are important, as they affect both the machinability of the dough and the quality of the product. The data in Table(1) and Figures (1 and 2) shows the rheological properties obtained from farinograms and extensograms of dough made from flour (72% extraction rate), which obtained from mill wheat grains after applying different irradiation doses (0.0, 0.5, 1.5, 2.5 and 3.5kGy). Water absorption of wheat flour irradiated at 0.5kGy dose was not changed, with obtained value to that of control (56.5%). However, water absorption increased with increasing radiation doses higher than 0.5kGy. Rate of increase in water absorption values of irradiated samples ranged from 0.0 to 5.13% compared to control sample. This could be due to increase damaged starch with increasing irradiation dose, which is accompanied with production of higher levels of reducing sugars, a factor that would raise the water absorption (Azzeh and Amr, 2009).

Dough stability exhibited a steady decrease with increased irradiation doses up of 0.5kGy. Sample irradiated at 0.5kGy gave the same stability value (5.5 min.) as the control sample, while other doses showed lower stability values (5.0, 4.5 and 4.0 for samples with irradiation doses 1.5, 2.5 and 3.5kGy, respectively.

Degree of weakening values of wheat flour irradiated with 0.5, 1.5, 2.5 and 3.5kGy doses were (110, 110, 120 and 150 BU (Brabender Units), respectively, which were higher than that of the control sample (100 BU). Flour absorption is an important factor in the production of all types of baked goods. The variation in water absorption level could be related to several factors. First and most important is the protein content, damaged starch and particle size were also involved in determining the water holding capacity of dough. Flour strength is usually associated with wheat or flour protein and encompasses both quantity and quality measurements (Pratt, 1978). Irradiated wheat flour has lower maximum amylograph viscosity, and its mixing behavior indicates higher water absorption, longer development time, increased dough stability and greater dough consistency for doses up to 2kGy (Rao *et al,.* 1978).

From the previous results in Table (1) and figure (1) of extensograms for dough made from flour (72% extraction rate), which obtained from mill wheat grains after applying different irradiation doses (0.0, 0.5, 1.5, 2.5 and 3.5kGy), it could be observed that resistance to extension, extensibility, proportional number (R/E) and energy for irradiated wheat flours were varied between 210 to 340 B.U.; 105 to 140mm, 1.5 to 3.24 and 48 to 60cm², respectively.

Table (1):Rheological properties from farinograms and extensogram of flour (72% extraction rate), which obtained from mill of gamma irradiated wheat grains.

Farinograms parameters		**Irradiation dose (kGy)**				
		0.0	**0.5**	**1.5**	**2.5**	**3.5**
Water absorption	(%)	56.5	56.5	57.0	58.1	59.4
	Rate of increase %	--	0.0	0.88	2.83	5.13
Arrival time (min)		0.5	0.5	1.0	1.0	1.0
Dough development (min)		1.0	1.0	1.5	1.5	2.0
Dough stability (min)		5.5	5.5	5.0	4.5	4.0
Degree of weakening		100	110	110	120	150
Extensograms parameters		Irradiation dose (kGy)				
		0.0	0.5	1.5	2.5	3.5
Resistance to extension (B.U.)		340	280	230	210	220
Extensibility (min)		105	120	135	140	115
Proportional number		3.24	2.3	1.75	1.5	1.92
Energy (Cm^3)		60	57	58	58	48

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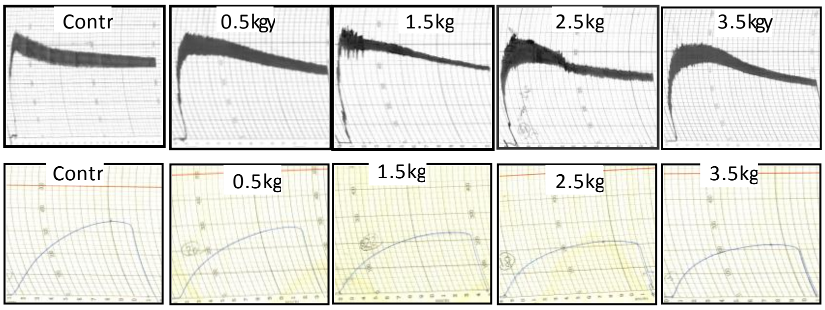
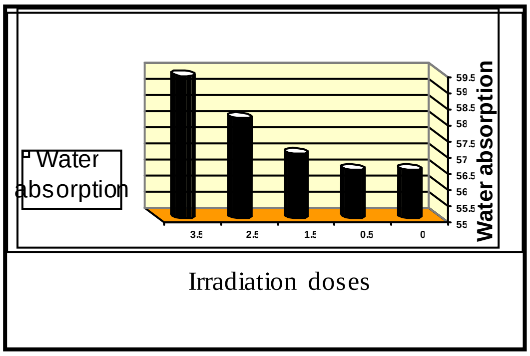


Fig (1) : Farinograms and extensogram of flour (72% ext.), which obtained from mill of gamma irradiated wheat grains

From the same results it could be observed that resistance to extension, proportional number and energy for flour samples decreased as the irradiation doses increased. Wherever, these parameters were higher for the control wheat flour than for irradiated wheat flours. Extensibility values for flour samples increased as the irradiation doses increased. However, this parameter was higher for irradiated wheat flours than for control wheat flours. The resistance to extension measures the ability of gluten to retain gas and the extensibility measures the extent to which a properly developed gluten can be extended or sheeted. The observed variation in these parameters could be related to the differences in protein-quality criteria which is related to the gluten of the flour protein. Both protein quantity and quality are considered to its end-use Pratt (1978) and Walker and Hazelton (1996). The reduction of viscosity in irradiated flour could be explained by free radicals created by gamma irradiation that are responsible for molecular changes such as uncoiling of starch chains and fragmentation by the breaking of hydrogen bonds in starch molecules (Sokhey and Hanna, 1993). Protein content in the flour sample also influences flour gelatinization. Consequently, de-polymerization and/or disaggregation of some globular proteins of wheat flour, which occur under influence of gamma irradiation, participates in the total change in viscosity taking place during irradiation (Köksel, *et al*., 1998 and Ciesla, *et al*., 2000). These changes may affect the physical and rheological properties of flour, thus decrease the viscosity.



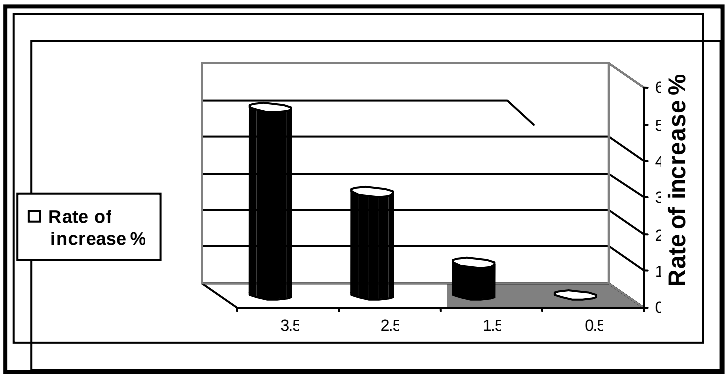


Figure (2): Water absorption ratio (A) and rate of increase in water absorption ratio (B) as affected by irradiation doses (0.5, 1.5, 2.5 and 3.5kGy).

2- Leavening ability of dough made from flour (72% extraction rate), which obtained from mill of gamma irradiated wheat grains.

Leavening ability of yeast for dough made from flour (72% extraction rate) was determined every 15min of fermentation period and expressed as dough volume (cm³) as presented in Table (2) and illustrated in Figure (3), from the obtained data it could be noticed that the production of gas (expressed as dough volume) Showed a gradual increase with the increasing of the fermentation period for all treatment. These results are in agreement with those obtained by Abou El-Azm (2005) and Yousif (2011) mentioned that the amount of gas production clearly increased with increase of fermentation times.

Table (2): Leavening ability of dough made from flour (72% extraction rate), which obtained from mill of_gamma irradiated wheat grains.

Irradiation dose (kGy)	Fermentation time (min.)								
	0	**15**	**30**	**45**	**60**	**75**	**90**	**105**	**120**
0.0	13	20	28	33	45	58	64	68	73
0.5	13	21	33	48	49	63	68	68	70
1.5	13	23	35	49	52	65	69	71	73
2.5	13	26	37	49	57	67	71	73	75
3.5	13	27	38	49	58	69	71	73	75

Remarkably, the ability of yeast to produce CO_2 gas was enhanced for dough made from flour (72% extraction rate), which obtained from mill of gamma irradiated wheat grains. The increasing in the production of CO_2 gas may be due to the increasing the activity of wheat grain endogenous amylases by gamma irradiation (Gralik and Warchalewski, 2006), In γ-irradiation, the rates of α-amylosis of starch was shown to increase degradation of starch with irradiation (Nene *et al*, 1975). It could be explained by free radicals created in irradiated flour that are responsible for molecular changes such as uncoiling of starch chains and fragmentation by the breaking of hydrogen bonds in starch molecules (Sokhey and Hanna, 1993). These results verified that irradiation treatments played an important role for improving the leavening ability of yeast.

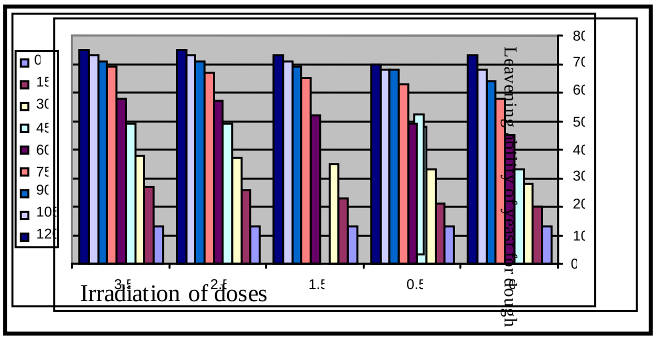
Amer *et al*.(2007) reported that the improvement in properties of bread, baked from flour irradiated, could be explained on the basis of a simulation in gas production during dough fermentation due to increase in starch degradation products.

3- Effect of irradiation doses (0.5, 1.5, 2.5 and 3.5kGy) on the sensory characteristics of pan bread:

Table (3 and 4) and Figures (4 and 5) show the sensory characteristics and physical properties of pan bread produced from flour (72% extraction rate), which obtained from mill of gamma irradiated wheat grains.

The data in Table (3) shows the sensory evaluation of pan bread. The symmetry and taste of pan bread produced from all irradiated flour were not significantly different from the control sample. The crust appearance, crust color and odor of pan bread produced from irradiated flour with 0.5, 1.5 and 2.5kgy were not significantly different from the control sample, while the same properties were significantly different by irradiation treatment up to 3.5kGy.

There were no significant differences between control sample and pan bread produced from irradiated flour with 0.5 in all properties except crumb grain. The increment of wheat flour radiation treatment levels led to reduced sensory properties of pan bread, the change that caused sharply decrease in overall acceptability.



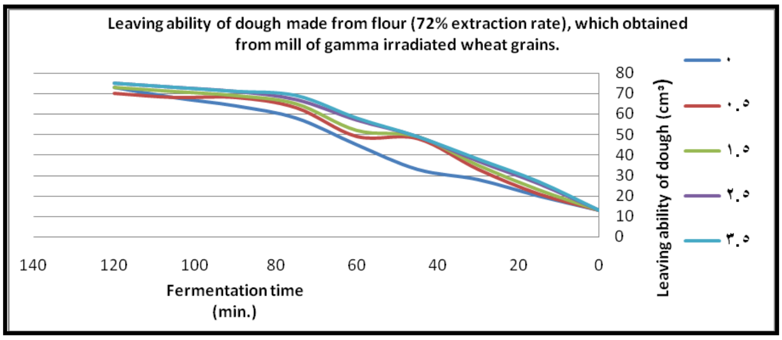


Figure (3): Leavening ability of yeast for dough made from flour (72% extraction rate), which obtained from mill of gamma irradiated wheat grains with doses (0.0, 0.5, 1.5, 2.5 and 3.5kgy at fermentation time from 0.0 to 120min.

The overall acceptability of the control sample pan bread was the highest (98.5), while overall acceptability values of irradiated wheat flour with 0.5, 1.5, 2.5 and 3.5kgy were gradually decreased as the radiation treatment levels increased. Bread quality seems satisfactory for all flour irradiated with doses.

Good sensory properties still remain a key priority as a consumer choice criterion. Processing could have negative or positive effects on bioavailability of some nutrients, processing must, first, provide products that have suitable form and good sensory properties (Slavin, *et al*. 2000). The potential impact of irradiation on starch/gluten separation, it would appear that the doses sufficient to treat insect infestation may not have significant effects on the gluten, but starch yield and properties may be affected. Bread quality seems satisfactory for flour irradiated with doses of up to 10kGy (Milner, 1961). Physicochemical changes in both starch and gluten, however, bread, prepared from wheat samples irradiated above 7.5KGy, exhibited significantly lower values of acceptance (Amer *et.al.* 2007).

Table (3): Sensory characteristics of pan bread produced from flour (72% extraction rate), which obtained from mill of gamma irradiated wheat grains.

Irradiation dose (KGy)	External characteristics				Internal characteristics					Overall acceptability (100)
	Symmetry (5)	Crust appearance (5)	Crust color (10)	Volume (10)	Crumb color (10)	Crumb grain (20)	Texture (15)	Taste (15)	Odor (10)	
0.0	5.0^{a}	5.0^{a}	10.0^{a}	10.0^{a}	9.5^{ab}	20.0^{a}	15.0 ^{a}	14.0^{a}	10.0^{a}	98.5^{a}
0.5	5.0^{a}	5.0^{a}	10.0^{a}	10.0^{a}	10.0^{a}	19.0^{b}	15.0 ^{a}	14.0^{a}	9.5^{a}	97.5^{a}
1.5	5.0^{a}	4.5^{ab}	10.0^{a}	9.5^{b}	9.0^{bc}	18.0^{c}	14.0^{b}	13.5^{a}	9.5^{a}	93.0^{b}
2.5	4.5^{a}	4.5^{ab}	9.5^{ab}	9.5^{b}	9.0^{bc}	18.0^{c}	13.5^{b}	14.0^{a}	9.5^{a}	92.0^{b}
3.5	4.5^{a}	4.0^{b}	9.0^{b}	9.0^{c}	8.5^{c}	17.5^{c}	13.0^{c}	13.5^{a}	8.5^{b}	87.5^{c}
L.S.D.	---	0.55	0.7	0.49	0.9	0.9	0.6	-----	0.7	2.4

Contr 0.5k 1.5kg 2.5kg 3.5kg

Figure (4): Pan bread samples produced from flour (72% extraction rate), which obtained from mill of gamma irradiated wheat grains.

Table (4) shows the physical properties of pan bread made from irradiated wheat flour with 0.0, 0.5, 1.5, 2.5 and 3.5kgy. Control sample (0.0kgy) showed the highest values of specific volume (4.36), while pan bread made from irradiated wheat flour with 0.5,1.5,2.5 and 3.5 kgy the specific volume were ,4.33,3.99,3.38 and 2.86 respectively. Percentage of decrease in specific volume (%) of pan bread samples produced from irradiated wheat flour with 0.5, 1.5, 2.5 and 3.5kgy varied from 0.7 to 34.4% compared with specific volume of control sample.

Table (4): Physical properties of pan bread produced from flour (72% extraction rate), which obtained from mill of gamma irradiated wheat grains.

Irradiation dose (kGy)	Physical properties			Percentage of decrease in specific volume %
	Loaf weight (g)	Loaf volume (Cm3)	Specific volume (Cm3/g)	
0.0	152.5	665	4.36	---
0.5	150.0	650	4.33	-0.70
1.5	153.0	610	3.99	-8.50
2.5	152.5	515	3.38	-22.5
3.5	154.0	440	2.86	-34.4

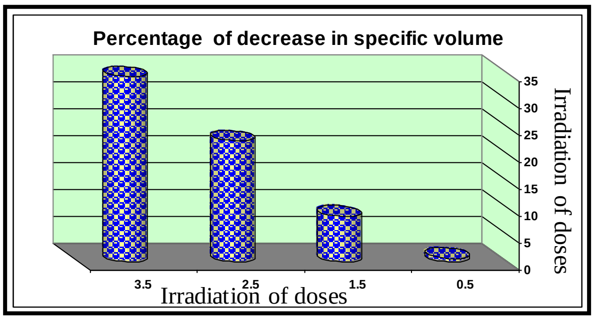


Figure (5): Rate of decrease in specific volume as affected by irradiation doses (0.5, 1.5, 2.5 and 3.5kGy).

4- Effect of gamma irradiation doses (0.5, 1.5, 2.5 and 3.5KGy) on the alkaline water retention capacity (AWRC %) of stored pan bread:

Effects of gamma irradiation doses of wheat flour on alkaline water retention capacity (AWRC %) of stored pan at 25±2°C are shown in Table (5) and Figure (6). It could be noticed that Rate decrease(RD%)of control pan bread increased with increasing storage period. While gamma irradiation treatment decrease the RD% by increasing dose levels, so that the freshness increased to these levels and improved the staling rate comparing with control sample.

This improvement may be due to increased damaged starch with increasing irradiation dose, which is accompanied with production of higher levels of reducing sugars, a factor that would raise the water absorption (Azzeh and Amr, 2009) and increase bread shelf-life.

Table (5): Effect of gamma irradiation doses (0.5, 1.5, 2.5 and 3.5KGy) on the alkaline water retention capacity (AWRC% and rate of decrease (RD%) of stored pan bread stored at 25ºC for 3 days (on dry weight basis).

Storage time		Treatments gamma decreased (KGY)				
		Control (0.0)	0.5	1.5	2.5	3.5
Zero time		269.4	268.5	274	276.8	280
24 h	AWRC	262.1	263	269	272.1	274.5
	RD %	2.71	2.05	1.82	1.70	1.96
48 h	AWRC	250.6	251.3	256.9	261.9	262.6
	RD %	6.98	6.41	6.24	5.38	6.21
72 h	AWRC	235.7	237.7	249.2	252.3	255.2
	RD %	12.51	11.47	9.05	8.85	8.86

$$\text{Rate of decrease (RD) \%} = \frac{\text{AWRC (zero time)} - \text{AWRC (n time)}}{\text{AWRC (zero time)}}$$

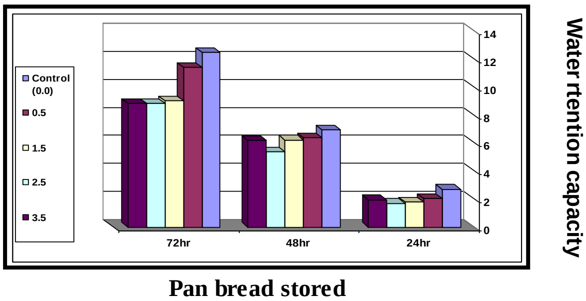


Figure (6): Rate of decrease (RD) % in alkaline water retention capacity of stored pan bread stored at 25ºC for 3 days as affected by irradiation doses (0.5, 1.5, 2.5 and 3.5kGy).

5. Effect of storage period on texture measurement (mechanical properties)of pan bread made from gamma irradiated wheat flour with different doses .

Firmness (hardness) of pan bread produced by using irradiated wheat flour with different doses of (0.5, 1.5, 2.5 and 3.5KGy) was determined at zero, 24, 48 and 72hrs and the obtained results are shown in Table (6) and Figure (7).

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The obtained results indicated that firmness, gumminess and chewiness degrees of all pan bread samples increased as storage period increased for all irradiation treatment levels, while cohesiveness, stringiness, adhesiveness and resilience degrees decreased mainly for most samples as storage time increased. According to apparatus texture analysis application overview in Food Technology Research institute by texture analysis in the Giza, Egypt.

The results also indicated that at zero time of storage, samples prepared using wheat flour irradiated with different levels of gamma rays showed lower degrees of firmness, gumminess and chewiness compared to control samples. However, using irradiation treatment showed low firmness degree after 24, 48, and 72hrs at all levels of gamma radiation. The same trend was also observed for gumminess and chewiness at levels of gamma radiation treatment. Control sample had the highest firmness degree compared to the other samples at 24, 48 and 72hrs. The same results also indicated that firmness degree of most samples decreased as the level of gamma radiation treatment increased.

Figure (7): Effect of gamma irradiation of wheat flour with different doses on texture measurement (mechanical properties) of pan bread at storage period zero time (A), 24hrs (B), 48hrs (C) and 72hrs (D).

CONCLUSION

Beside this protective role, gamma irradiation also has important effects on various quality criteria of cereal grain flours such as rheological properties, dough properties and baking quality due to starch polymerization, protein degradation and the creation of small molecular products resulting in decreased viscosity or cross-linking that are taking place under influence of gamma irradiation. Therefore, the proper use of this technique can improve the quality and prolong the shelf-life of wheat flour products, since the functionality of an individual biopolymer in foods may be affected by its interaction with other food components. Increased irradiation dose levels resulted in increasing water absorption meaningfully, and dough stability was decreased. The overall acceptability of the pan bread samples produced from irradiated wheat flour were different from those produced from un-irradiated wheat flour (control). This study provides that 2.5-3.5kGy irradiation treatment is the maximum dose that can be applied to maintain desirable quality of wheat flour and pan bread product.

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تـأثير الإشـعاع (أشـعة جامـا) علـى الخـواص الريولوجيـة وخصـائص منتجـات المخابز النـاتج من حبوب دقيق القمح

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أظهرت الدراسات الفيزو- كيميائية علي الدقيق الناتج من طحن حبوب القمح(صنف سخا ٩٤) والمعاملة بجرعات منخفضة من أشعة جاما (٠,٥ ، ١,٥، ٢,٥ ، ٣,٥ كيلوجراي) انه بجانب الدور الوقائي لهذه الأشعة وقدرتها علي الإصابات الميكروبية والحشرية فإن لها تأثير مهم من عدة جوانب علي جودة دقيق القمح. حيث أظهرت النتائج تأثير جرعات الأشعة علي جودة الدقيق من حيث خصائص العجين أو من حيث صفات الجودة للخبز الناتج. وقد أظهرت النتائج في هذا البحث تأثير الأشعة في خفض قيم رقم السقوط ونسبة كلاً من الجلوتين الرطب والجلوتين الجاف ويزيد الخفض بزيادة الجرعة المستخدمة من الإشعاع، وبناءاً عليه فإن التأثير القوي للأشعة يعود لتأثيرها علي الجلوتين أكثر من غيره من المكونات مما كان له تأثير اكبر علي جودة الخبز الناتج. وقد أظهرت هذه الدراسة زيادة نسبة امتصاص الدقيق للماء ودرجة ضعف العجين مع انخفاض درجة ثبات العجينة علي خط ٥٠٠ برابندر بزيادة جرعات الإشعاع عن ٠,٥كيلوجراي مقارنة بعينة الكنترول. كذلك أظهرت النتائج وجود انخفاض تدريجي في قيم الجودة الكلية للخبز الناتج بزيادة جرعات الإشعاع من ١,٥ إلي ٣,٥كيلوجراي كما قلت الفترة اللازمة للعجن، وقل حجم الرغيف الناتج وانخفضت جودة لبابة الرغيف.

وتخلص الدراسة إلى عدم تعرض القمح أو الدقيق إلى جرعات من الاشعاع أكبر من ٣.٥ كيلو جراي حتى لا يؤثر على جودة المنتجات المختلفه وكذلك صحة الانسان .

Table (6): Effect of gamma irradiation doses (0.5, 1.5, 2.5 and 3.5KGy) and storage period on texture measurement (mechanical properties) of pan bread.

Sample (No.)		Firmness	Springiness	Cohesiveness	Gumminess	Chewiness	Stringiness	Adhesiveness	Resilience
Control (0.0)	Zero time	94.00	0.87	0.85	82.34	71.60	1.01	1.71	0.48
0.5		93.00	0.87	0.87	83.79	73.23	0.36	0.71	0.53
1.5		85.00	0.91	0.89	77.41	70.34	0.35	0.37	0.53
2.5		79.00	0.86	0.85	68.94	59.56	0.37	0.38	0.50
3.5		79.00	0.88	0.87	71.50	62.84	0.61	1.14	0.53
Average of zero time		86.0	0.88	0.87	76.80	67.51	0.54	0.86	0.51
Control (0.0)	24hrs	215	0.92	0.80	185.12	169.82	0.06	0.08	0.43
0.5		188	0.89	0.77	156.75	139.55	0.06	0.06	0.39
1.5		173	0.90	0.83	151.48	135.69	0.05	0.05	0.49
2.5		158	0.91	0.81	137.46	125.67	0.36	0.41	0.48
3.5		129	0.84	0.81	111.29	93.4	0.05	0.05	0.49
Average of 24hrs.		172.6	0.89	0.80	148.42	132.83	0.12	0.13	0.46
Control (0.0)	48hrs	305	0.86	0.77	256.15	220.76	0.11	0.14	0.41
0.5		285	0.87	0.76	235.7	206.01	0.06	0.06	0.41
1.5		285	0.90	0.73	229.27	205.74	0.81	0.88	0.37
2.5		242	0.85	0.80	208.79	176.73	0.05	0.05	0.45
3.5		168	0.84	0.84	148.13	124.89	0.07	0.07	0.49
Average of 48hrs		257.0	0.86	0.78	215.61	186.83	0.22	0.24	0.43
Control (0.0)	72hrs	404	0.88	0.74	325.9	286.5	0.06	0.06	0.41
0.5		376	0.91	0.74	305.55	276.74	0.12	0.12	0.39
1.5		291	0.87	0.75	237.35	206.17	0.19	0.20	0.39
2.5		281	0.86	0.75	229.51	198.36	0.06	0.06	0.40
3.5		267	0.86	0.77	225.5	194.15	0.28	0.32	0.44
Average of 72hrs		323.8	0.88	0.75	264.76	232.38	0.14	0.15	0.41
Total average		209.85	0.88	0.80	176.4	154.89	026	0.35	0.45