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The effect of Gamma ray on baking properties of the bread wheat Roshan

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ABSTRACT: Wheat is known as a staple crop around the world. Roshan wheat cultivar is an elite variety with high cultivation in Iran, on which radiation has been done in order to access higher qualitative feature. After data collection of the tests Farinograph and Extensograph were implemented using physical and chemical features of wild type wheat and mutant line. The results suggest that line mutant in many traits related to the quality of baking is significantly improved. Comparing the qualitative figure of Farinograph shows a significant increase in the mutant line compared to the wild type due to the higher stability and less the dough softening in the mutant line. Extensograph result display that if the time for the rest of dough is extended from 45 to 135, maximum resistance to dough elasticity will also increase in mutant sample.

Key words: Roshan wheat, morphological, agricultural, mutant, Farinograph test, Extensograph test, chemical experiments

INTRODUCTION

Wheat is a strategic product among cereal around the world (Khodabandeh, 2005). There are different species of wheat and the most important type, *Triticum aestivum* is known as baking wheat. Wheat provides one fifth of calorie needed for maintenance of our body, besides it is the most essential food resources for one third of the population all around the world (Akbarnia and Azar-Abad, 2011). In Iran, approximately 6.5 million hectare of fields are under wheat cultivation (Jalal-Kamali and Duveiller, 2008). This explains the particular research focus on the wheat production in more than seven decades. Highlighting the importance of the quality of wheat in determining the final product characteristics, evaluation of physiochemical features of wheat is inevitable. Mangova and Rachovska (2004) found significant differences in quality and dough softening between fifteen hybrid radiation mutant lines and two chemically mutated lines. Quality index, softening of dough and energy for dough deformation in line MX77/14 is more than of control. In addition, crude protein, softening of dough and energy for dough deformation in MX84/37 were considerably significantly different when compared with wild type. Corpuz *et al.* (1983) investigated four wheat genotypes after chemical mutagenesis. They observed increasing in the amount of protein (0/7 to 2% over control) accompanied with decreasing the grain yield in mutational generations M8 to M10 in 3 years. However, some of the mutated lines with high protein levels were functionally similar to the control genotype. Height changes resulting from ethyl methanesulfonate (EMS) were generally favorable; most of the mutant lines were shorter than the control group, but flowering date was generally postponed. By irradiation of F1 dry wheat seeds with the dose of 200 Gray, Kozub *et al.* (2013) observed that the irradiation induced mutations at gliadin loci with a frequency of 7.4% (against 0.5% in the control). The results suggest that irradiation leads to gene silencing in the gliadin gene and this increases the ratio of glutenin to gliadin and consequently an increase in the baking quality of the wheat. Varieties of wheat are different regarding protein content and nutritional value but also the quality of neither one is the same (Kozub *et al.* 2013). Thus, the flour is considerably different in terms of morphology, quality, and quantity of chemical compounds and function (Muris, 2003).

On the other hand, each of the cereal products needs a specific kind of flour and this demands different characteristics suitable for a special product. Therefore, determining the properties of wheat is important for using it in industrial (Bordes *et al.*, 2008). Measuring the amount of protein, hardness and performing tests including Farinograph, mixograph, alveograph, and reflective spectroscopy of infrared are indirect ways to determine the quality wheat flour (Sissons *et al.*, 2006). Hardness of seed is the most crucial factor in the quality of product and volume of the bread. In addition to the quality of gluten and starch, a high correlation between the index of hardness and rheological features of the dough has been observed (Hoseney, 1986).

The baking value of wheat is dependent on the amount of glutenin of the seed. Generally, 80% of wheat flour is composed of proteins of gluten including gliadin and glutenin. The amount of protein in the seed depends on type and climate (Iran-Nejad and shahbaziyan, 2005). Having examined the spring and winter wheat, it was observed that the time required for expansion of the dough is much in strong flour than in weak flour (Maghirang, 2006). Studying rheological features of the dough is one of the fastest and more reliable ways to measure the indexes of quality and texture of food stuff like wheat flour (Hoseney 1986). By applying farinograph and extensograph tests, here, we report physiochemical features of the dough including water absorption, stability of the dough against blending, the degree of dough softening, maximum resistance, and energy of the dough in a radio mutant wheat line. Write a brief report of results.

MATERIALS AND METHODS

A. Plant material

Roshan cultivar is one of the most cultivated cultivars in Iran (Jalal-Kamali 2008) which was subjected for Gamma ray with the dose of 200 Gray in order to access improve physicochemical properties of wheat flour. This work was carried out by an international alliance between Iran Atomic Energy Organization and International Atomic Energy Agency.

B. Field experiment

After cultivation of Roshan wheat, morphological and agricultural features including height, peduncle length, panicle number, leaf area index, chlorophyll amount and yield were measured to investigate its morphological characteristics. Roshan wheat and mutant line were cultivated in a field located on Zaferanieh, Alborz province, Iran, to examine morphological and functional features During the growth, leaf area index and chlorophyll meter (with SPAD number) which is related to the amount of chlorophyll was firstly measured at the end of the length growth of the leaf at 3 point of leaf in 3 repeat. After reaping, we also measured the height, peduncle length, panicle length, number of panicle, and biomass. Agricultural operations including preparing the field, fertilizer, irrigation and control of weed were carried out according to common cultural condition both for mutant and wild type plants.

Qualitative experiments of flour and wheat seed. Seeds were harvested twice repeat at year (because amount of flour need for this test is very much) during the growth and stored for three months and then grinded. Measurements were as follows: (i) chemical features of wet gluten using glutamic and centrifuge according to standard 137 of International Association for Cereal Chemistry (ICC); (ii) hardness of seed using inframatic (8100); (iii) percent of protein with ICC standard (105); (iv) water absorption value of flour based on protocol number 110.1; (v) ICC using Farinograph; (vi) volume of the bread; and finally, (vii) the volume of sediments based on standard 116 of ICC. Relevant features of Farinograph test including the development of dough, stability of the dough, the time of softening after 10 or 20 minutes, Valorimeter number of the dough and Farinograph qualitative number were conducted in the chemistry laboratory in Karaj in 2012. The following parameters were evaluated to investigate extentographical features: (i) maximum resistance to drought (RM); (ii) resistance against drought after 5 minutes (RS); (iii) drought ability (EX); (iv) relative resistance (RX/EX); (v) the graph that modifies the amount of energy required for stretching the dough (E) with the fermentation times of 45, 90 and 135 minutes using AACC; and, (vi) numbers 54-10 by extensograph machine (Brabender, Germany). Finally, the results were analyzed using statistical software MSTAT-C (Michigan State University 1991).

RESULTS

A. Agricultural features

In the final stages of well-grown grains lower leaves will generally wither up and there is hardly any nutritional reserve in the stem. Since the greatest part of dry material in the grains is made after fecundity, the potential yield of plant depends on size, period and photosynthesis of the organs that remains after the growth of the green ear of the crop.

The organs include peduncle, leaf and ear of the crop. Different studies show that because the leaf area index and ear of the crop are in proximity to the grain and are exposed to sun, they are the most essential resources of producing carbon hydrats (Gardner, 1984; Lupton, 1974). The length of the peduncle also is correlated to function of the grain (Bessonova, 1989; Mohiuddin, 1980). Table 1 illustrates the data on agricultural features of the wheat.

Analyzing the data from table 1 revealed that there is a significant difference between two types. The mutant type is favorable regarding agricultural features (length of peduncle, height of panicles, the number of panicles, leaf area index and yield).

Table 1: Agricultural data about Roshan wheat flour (control) and the mutant.

Plants	Traits						
	Height	**Peduncle length**	**Height of panicles**	**Number of panicles**	**Leaf area index**	**Yield**	**SPAD**
Roshan	116.5	18.55	10.6	11.25	28.06	70.93	17.1
Mutant	129.75*	25.08**	12.25*	21*	28.15**	150.63*	21.3*
Coefficient of Variation	5.98	10.31	7.03	24.38	14.5	29.13	12.87

** And * significantly different at 1 and 5 % level of probability respectively

The amount of chlorophyll in control sample was lower than mutant sample. This is due to an increase in pigment that leads to an increase in photosynthesis. Therefore, the control sample is weaker in the absorption of food stuff than the mutant.

B. Measuring the chemical features of flour

The best way for determining the quality of wheat, its usage in industry, cooking quality and the quality of the final product is evaluation of its technological features. That's the reason why determining protein content, sediment volume, loaf volume, hardness, wet gluten, gluten index and understanding of its rheological features are important (Ahmadi-Gavligi, 2004).

The results of evaluation of chemical features can be seen in Table 2. The results revealed that there is a significant difference between the control sample and the mutant. The amount of protein in control was 10.95 and the amount of wet gluten was 22.

The control sample has an average quality while the amount of protein (12.55) and wet gluten (32.50) are indicants of good quality and nutritional value. Increasing the amount of protein and wet gluten is due to breaking the links in protein components specially the link between gluten components and other wheat synthesis like starch and fiber. In determining the quality of protein the amount of gluten and its quality both are effectual factors. In this research the quality of gluten was assayed using Zeleny test. Zeleny number is a function of the quality of gluten which is 38.50 in mutant and it is more than control (30). This increase could be due to sulfhydryl oxidation to disulfide bonds that can, in turn, strengthen the gluten and increase its elasticity. Considering the volume of loaf we can conclude that the mutant flour is strong. The links of gluten are firm in strong flours because gas storage capacity is quite trivial in these flours. Thus, the volume of loaf decreased in mutant sample than the control one.

Hardness is a genetic trait that can be a good criterion for identifying the wheat with high quality for consumption, along with quality and quantity of protein. Hardness in mutant wheat is more than the control one and this reveals the fact that the flour from mutant wheat is rough and grainy. Hard wheat is suitable for making bread owing to more flour yield and high protein content. The starch granules of wheat suffer more damage while the it is milled and absorbs more water.

Table 2: The chemical features of Roshan wheat flour (control) and mutant.

Plants	Traits				
	Protein content (%)	**Zeleny sedimentation value (cm^3)**	**Loaf volume**	**Seed hardness**	**Wet gluten**
Roshan	10.95	30	625.5	45	22
Mutant	12.55*	38.5*	542	54*	32.5*
Coefficient of Variation	2.48	3.26	6.98	2.86	4.1

* Significantly different at 5 % level of probability

C. Rheological features

Farinograph. The results of Farinograph curves are shown in Table 3. The test investigates the indexes of water absorption in flour (percent), qualitative number of Farinograph (without unit), the time of stability of the dough, the degree of softening after 10 or 20 minutes and Valorimeter number. Analyzing the rheological features shows that there is a significant difference between the water absorption of flour in the mutant wheat flour than the control one; in addition, water absorption in the mutant wheat flour (58.9) is more than the control (55.850). This shows that water storage capacity in mutant sample is more than the control one. The time of stability in mutant wheat flour was more than the control wheat flour.

Stability gives some information about the blending ability of the flour. Comparing Farinograph curves revealed the fact that the stability of dough (the time when curve remains on the line of 500) and width of Farinograph curve diminished in the control that implies the low stability of the sample against blending.

Table 3: The results from Farinograph test of Roshan wheat flour and the mutant.

Plants	Traits					
	Water absorption (%)	FQN	Dough stability	Degree of softening at 10 minute	Degree of softening at 20 minute	Valorimeter number
Roshan	55.85	37.5	2.75	115	130	39
Mutant	58.9*	58.75	4.88	60*	90	48.5*
Coefficient of Variation	0.63	18.91	23.87	12.78	9.09	3.43

* Significantly different at 5 % level of probability

The mutant line showed a significant difference between the degree of softening after 10 or 20 minutes in wheat flour and the control. Studying the data in the control sample shows a reduction in the resistance of the dough against blending.

The Farinograph qualitative number (FQN) is a conventional criterion that was introduced by Brabender Company. This rheological parameter is the outcome of all the indexes in the Farinograph curve that can be used to assess the quality of wheat and flour (Appolonia, 1997). This number can describe the general quality of flour; in fact, instead of calculating different indexes in Farinograph curve we can use a single number to report the quality power of flour. Weak flours show low and strong ones show high FQN (Ghamari, 2009). Comparing qualitative number revealed that there are two significant differences so that this number was more in mutant sample than the control one. The reason for this matter is related to increase of stability and decrease of softening of the dough in the mutant.

Ghamari (2009) reported the effect of qualitative number of the dough on qualitative features of baking and its relation with other rheological parameters. It was manifested that there is a positive correlation between qualitative number of Farinograph and the stability of the dough against extension which corresponds to the results of the research. Valorimeter number that states the elasticity features of the dough depends on factors such as softening degree. The results showed that the mutant sample has a better elasticity than the control one.

Extensograph. The rheological tests with high variation scope (Payan, 2005), like one way extension test provide some information concerning viscoelastic dough and gluten web. Extensograph is used to obtain information about elasticity of the dough (extension ability of the dough as a result of exerting power and keeping on until it is apart), resistance against extension and the relation of them to each other (Federica, 2009). A balanced combination of good resistance and elasticity are characteristics of proper dough.

The details of the data from Extensograph curve in three times 45, 90 and 135 minutes are illustrated in Table 4. The data display that if the time for the rest of dough is extended from 45 to 135, maximum resistance to dough elasticity will also increase in mutant sample. However, the process of extension will occur in 90 minute in the control sample and after that maximum resistance to extension dwindles. The dough rests in the case of Extensograph machine. The elasticity of the dough in mutant sample was higher than the control one. Measuring the area under the Extensograph curve that stands for mechanical work or the energy needed for the extension of the dough, clarifies the rheological behavior of the dough in Extensograph test. The energy of the dough or the area under the curve shows the energy required for the extension of the dough until it is apart or mechanical work on the dough that is a good index to determine nourishment of the flour.

The data display that resistance to extension and stability of the dough is better in mutant sample than the control one. It also shows that the mutant dough has a suitable rheological feature. Comparing the area under the curve in 45 minute took about three times in mutant sample than in control one, in 90 minute about five and half and in 135 minute about 8/8 times. There is a relationship between maximum height of the curve and strength of the dough. Strong dough has higher and even longer Extensograph curve than the weak one. Generally the more the height of the curve the higher its resistance to extension will get. The data show that the strength of dough is more in mutant than in the control sample.

Table 4: Results of Extensograph test on Roshan wheat flour (control) and mutant.

Time	Plants	RM	RS	EX	RS/EX	E
45	Roshan	92.5	80	148.5	0.54	16
	Mutant	217.5*	152*	176.5	0.86*	49.5*
	CV	14.61	10.75	4.29	9.04	17.87
90	Roshan	0.95	70	100.5	0.71	10.5
	Mutant	270*	195*	170.5	1.14*	59*
	CV	18.38	13.61	16.64	10.81	22.52
135	Roshan	76	35	65.5	0.33	6.5
	Mutant	285**	205*	159	1.26	57.5*
	CV	11.37	31.73	36.09	42.19	16.09

** And * significantly different at 1 and 5 % level of probability respectively; CV: Coefficient of Variation

Investigating the resistance to extension, the relationship between resistance and ability to extension and the power spent for extension show that the flour from mutant wheat is very strong and resists against fermentation. In addition, considering the data from resistance we get to know that the glutenin of the flour in the mutant sample is more than the control one. This will increase disulfide links in molecules resulting in a decrease in elasticity and an increase in resistance of the dough. However, in the control sample the resistance of the dough will decrease and elasticity will increase due to the rise in gliadin content.

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