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EFFECT OF ENVIRONMENTAL TEMPERATURES ON PRODUCTION AND BREAD CHARACTERISTICS OF FOUR BREAD WHEAT CULTIVARS

II. BREAD QUALITY ATTRIBUTES AS A FUNCTION OF ENVIRONMENTAL TEMPERATURES PRODUCTIVITY

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ABSTRACT

The effect of environmental temperatures on the production of wheat and the resulted bread quality of four cultivars was vestigated. The tested samples of (Misr 1, Gemmeiza 9, Sakha 93, and Sids 12) were grown under heat environment stress (HES) and compared with other samples of the same cultivars which were grown in the normal environment stress (NES). All wheat samples were milled in a Hummer mill to obtain 100% extraction rate whole meal flour. Rheological properties of all HES cultivars samples or NES were studied. The results appeared that heat stress increased water absorption, mixing time, arrival time and stability values of dough, while it decreased the dough weakening value. The same HES cultivars parameters showed an adverse tend. The extensograph results revealed that the HES cultivars recorded the highest elasticity compared with the NES cultivars. Extensibility of HES wheat bread cultivars recorded the lowest results compared with the NES wheat bread cultivars. The proportional umber of dough was increased in case of the HES cultivars compared with the NES cultivars. Energy value (cm^2) was increased in the HES cultivars, while it was decreased in the NES cultivars. Chemical analysis of whole wheat bread varieties appeared that the fat content was lower in the HES whole meal cultivars, whereas protein, ash and crude fiber of the HES cultivars recorded the highest percentage compared with the NES cultivars. Total carbohydrates of the NES cultivars recorded the highest percentage compared with the HES cultivar. Sensory evaluation attributes of balady bread which made from whole meal of all varieties were studied. The balady bread of HES cultivars recorded the highest acceptable degree compared with NES balady bread varieties. In general, balady bread made from whole meal flour of Misr 1 cultivar recorded the highest preference degree followed by balady bread of whole meal of Gemmeiza 9 cultivar and Sakha 93, respectively, while balady bread made from Sids 12 of HES cultivar showed the lowest acceptable degree.

Keywords: Bread wheat, rheological (farinograph and extensograph tests), chemical and sensory properties

INTRODUCTION

The understanding of the environment and complex interaction of genetic and environmental (GXE) factors is a highly essential issue to help breeders to set proper adjectives and strategies to develop wheat varieties to achieve the high yield potential as well as with specific and consistent quality attributes to meet market needs (Wiliams *et al.*, 2008). The importance of the effects of genotype, environment and GXE is increasing for breeders, growers, grain traders and end-use processors. In wheat, environmental temperature affects grain yield, protein content and the size and number of starch granules (Sofield *et al.*, 1977; Bhuller and Jenner 1985, Tester *et al.*, 1995). Shi *et al.*, (1994) reported that increasing the environmental temperature during grain filling led to increase the amylase content and, also, the starch gelatinization temperature was increased. Starches from most wheat grown at 40^{o}c had increased portions of unit chains with DP 10-16 and reduced proportions of unit chains with DF 17-21. Two of the key enzymes in starch biosyenthesis, the starch synthase and branching enzyme, have been proposed to play a significant role in linking starch deposition when the temperature was exceeded than 25^{o}c (Keeling *et al.*, 1994). Variations in dough rheological properties are largely determined by the genotype (G) but the environment (E) and its interaction with (G), also, play an important role in the expression of the end use product quality of a genotype (Peterson *et al.*, 1998). Similary, Don *et al.*, (2005) reported that the HMW-GS/LMW-GS ratio of glutenin macropolymer (GMP) decreased, but larger glutenin particles occurred under heat stress. Heat shock affects protein contents, SDS sedimentation volume and rheological properties (Corbellini *et al.*, 1997 and Tahir *et al.*, 2006). Bread wheat differs from durum wheat in kernel texture. In particular, common wheat cultivars can be divided into three endosperm texture classes based on their average SKCS (Single Kernel Characterization System) value. i.e. soft (SKCS index = 15-40), medium hard (55-70) and hard (71-95). By contrast, all durum wheat cultivars are characterized by an external kernel texture with SKCS>80, mainly due to the absence of two proteins named puroindolines A (Pin-A) and B (Pin-B). Tryptophan-and cysteine rich polypeptides were, also, encoded by two closely linked genes named Pina-D1 and Pinb-D1, which are located in the distal end of the short arm of chromosome 5D (Gauteir *et al.*, 1994 and Mattern *et al.*, 1973). Soft textured common wheat cultivars possess wild-type allelers Pina-D1a and Pinb-D1a and accumulate large amounts of both Pin-A and Pin-B on the surface of their starch granules (Corona *et al.*, 2001). The ratio between soluble and insoluble proteins, which affects bread-making quality is a function of the protein composition that is genetically controlled. Environmental factors, such as temperature, water and nitrogen also influence this ratio (Jia *et al.*, 1996 and Stone and Nicolas, 1996). Bakery products are increasingly popular due to their ready-to-eat convenience, cost competitiveness, availability of various products with different taste and textural profiles, beneficial nutritional profile and longer shelf-life (Azziz *et al.*, 2003). Among functional food additives, surfactants have been increased and used to improve bread quality. The beneficial effects of surfactants are due to the improvement in dough properties and quality of bread (Kamel and Ponte, 1993 and Potgieter, 1992).

MATERIALS AND METHODS

HES bread wheat varieties, Misr1, Gemmeiza 9, Sakha 93, and Sids 12 as applied by Abo El-Naga and El-Gharbawy (2013), samples and other samples of the NES same varieties. All samples were milled in a Hummer mill to obtain whole meal flour (100% extraction rate).

Preparartion of balady bread:

Balady bread formula was prepared by using 1000 g of whole meal flour (100% extraction rate) as a base. The other ingredients were: 5 g active dry yeast, 10 g sodium chloride and 800-850 ml water. The ingredients were mixed in a mixer for 25 min. The resulted dough was left to ferment for one hour at 30^{o}c and 85% relative humidity. After that, the dough was divided into 160 g pieces. The pieces were then arranged at a wooden board, previously sprinkled with a fine layer of bran, and left to ferment for about 45 min at 30^{o}c and 85% relative humidity. The fermented dough pieces were flattened to form loaves and then baked at 450-500^{o}c for 1.5 min. The baked bread loaves were allowed to cool on wooden racks for 30 min at room temperature before evaluation and then packaged into polyethylene bags.

Rheological properties:

Farinigraph tests:

The farinograph tests were carried out by an OGH brabender farinograph instrument, Duisburg, Germany, to study the water hydration and mixing characteristsics of dough under investigation. The Water absorption (%), arrival time (min), dough development time (min), dough stability (min) and dough weakening (B.U) parameters as described in the AACC (2002).

Extensograph test:

Extensograph tests were carried out according to the method described in AACC (2002), using a 4821384 extensograph brabender Extensograph instrument, West Germany, to measure the dough elasticity(B.U), dough extensibility (mm), dough prportional number (P.N., elasticity/ extensibility) and dough energy (cm^2).

Chemical composition of balady bread:

Chemical compositions (moisture, ether extract (fat), protein, crude fiber and ash contents) of balady bread were determined using the method outlined in AOAC (1990) and the carbohydrates were calculated by differences.

Sensory evaluation of balady bread:

Fresh samples of balady bread were sensory evaluated by 15 panelists from Food Technology Research Institute staff, Agricultural Research Center, Giza, Egypt. All the loave samples were characterized for external color, internal color, taste, odor and separation of layers. The characteristics were scored by 15, 10, 20, 20 and 10 degrees, respectively, as recommended by Mousa *et al.*, (1979).

Statistically analyzed:

Values of each sensory evaluated character were statistically analyzed. Such analysis was carried out by SPSS10 program (SPSS 2000) and Duncan's tests to specify the variation level at 0.05.

RESULTS AND DISCUSSION

Numerous researches were done to estimate the impact of different environmentl conditions on yield and its components. To achieve the objectives of such studies, it should evaluate the effect of such factors on the quality attributes of the produced bread. Therefore, the rheological, chemical and sensory properties of the bread manufactured by the tested varieties under the specified conditions, as applied by Abo El-Naga and El-Gharbawy (2013), were put under investigation in the present study.

Rheological properties:

The rheological (farinograph and extensograph measurements) properties of wheat bread varieties were recorded in Tables (1 and 2). These results appeared that, the HES (high temperature environment) recorded the highest values in relative to NES (agronomy under the normal weather) for each parameter, as discussed below:

Water absorption values showed that the HES varieties recorded the highest percentage of water absorption. While the NES varieties recorded the lowest percentage of water absorption (%). It was, also, found that Misr 1 variety recorded the highest percentage (90.5%) and followed by Gemmeiza 9 (84%), while the values of the corresponding NES varieties recorded 82.5% and 82%, respectively. These results may be due to the variation in protein percentage of the HES varieties as detected by Abo El-Naga and El-Gharbawy (2013). These results are in agreement with those observed by Sofield *et al.*, (1977) who reported that, environmental temperature variations affects grain yield, protein content and the size and number of wheat grains.

Table (1): Farinograph measurement values of bread wheat varieties cultivated under heat stress and normal conditions

Conditions	Variety	Water Absorption (%)	Arrival Time (min)	Dough Development (min)	Stability Time (min)	Degree of softening
Heat stress	Misr 1	90.5	2.5	3.5	14.0	20
	Gemmeiza 9	84.0	1.0	1.5	11.0	50
	Sakha 93	75.8	1.5	2.5	8.0	70
	Sids 12	82.8	1.0	2.0	12.5	30
Normal	Misr 1	82.5	1.0	2.0	6.5	70
	Gemmeiza 9	82.0	0.5	1.0	9.5	60
	Sakha 93	72.5	1.0	2.0	3.5	90
	Sids 12	73.1	0.5	1.5	10.5	40

HES Varieties rewarded the highest arrival time values compared the corresponding NES varieties. The values were ranged between 2.5 to 1.0 min, while the NES varieties were ranged between 1.0 and 0.5 min.

Dough development (min) values were higher in HES varieties than the corresponding NES varieties. The NES varieties recorder 1.0, 1.5,2 and 2.0 min for Gemmeiza 9, Sids 12, Sakha 93 and Misr 1, respectively, while the corresponding values in the HES varieties were 1.5, 2.0, 2.5 and 3.5 min, respectively. These results agreed with those found by Blumenthal *et al.*, (1991) who reported that the environment (climate, soil, agronomic practices, etc.) exerts a softening influence on the expression of the technological quality of different cultivars. On the other hand Ciaffi *et al.*, (1995) reported that, agronomy conditions, particularly marked in southern Europe where the Mediterranean climate characterized by increasing water deficit and thermal stress during grain filling may cause large fluctuations, not only on grain yield but also on grain protein content and composition, with higher effects on the rheological properties of dough.

The stability time (min) of HES varieties dough recorded the highest stability compared with the corresponding NES varieties. Misr 1 recorded the highest stability (14.00 min) followed by Sids 12 (12.5 min), while Sakha 93 recorded the lowest stability (8.0 min) value. On the other hand, NES varieties recorded the lowest stability (Sids 12 recorded 10.5 min, followed by Gemmeiza 9 recorded 9.5 and Sakha 93 recorded the lowest stability which , 3.5 min). These results are in agreement with those found by Daniel-Vazquez *et al.*, (2012), who reported that, environment, that produced grain with higher protein content were not necessarily those of better rheological quality. Environments 14, 18 and 20 had the highest protein content, while environments 3,14 and 18 had the highest wet gluten percentage, both related with protein content. Environments with higher Alveograph and sedimentation volume were both 2007 Chilian C12 and 13), whilethose with higher farinograph stability were 4,7,16 and 17. On the other hand, Moldestad *et al.*, (2011) found that, the temperature in different periods during grain filling had an impact on gluten resistance. In general, higher mean temperature from heading to approximately midway in the grain filling periods was positively related to gluten resistance. This was seen both for maximum and mean temperature. On the other hand, Uhlen *et al.*, (2004) reported that the stronger gluten and higher SDS sedimentation volume in wheat were detected in the warmer seasons.

Degree of softening of wheat bread varieties increased with decreasing the stability of wheat bread dough (Table 1). All HES varieties recorded a lower (20-70) degree of softening than all other NES varieties (40-90). Those results were concurrent with those found by Randall and Moss (1990) who reported an increment in dough strength with increasing mean temperature up to 30^{o}c. On the other hand, Johansson and Svensson (1998) analyzed field trials from southern parts of Sweden in the period of 1975 - 1996, and reported that weaker doughs was noticed in cooler seasons.

Table (2): Extensograph measurement values of bread wheat varieties cultivated under heat stress and normal conditions

Conditions	Variety	Elasticity (B.U)	Extensibility (mm)	PN	Energy (cm^2)
Heat stress	**Misr 1**	530	45	11.8	16
	Gemmeiza 9	360	52	6.9	20
	Sakha 93	340	35	9.7	17
	Sids 12	340	42	8.1	19
Normal	**Misr 1**	230	58	3.9	22
	Gemmeiza 9	260	90	2.9	27
	Sakha 93	225	69	3.3	29
	Sids 12	220	107	2.1	37

Extensograph measurement results shown in Table (2) appeared that, all parameters (Elasticity (B.U), extensibility (min), PN and Energy (cm^2) of all HES varieties recorded rheological measurement values better than all corresponding NES varieties. Elasticity (B.U) in HES varieties under recorded the highest elasticity compared with all NES varieties. Misr 1 recorded the highest elasticity (530 BU) followed by Gemmeiza 9 (360 BU), Sakha 93 and Sids 12 (both of them recorded 340 BU).

Extensibility of all HES varieties recorded the lowest values compared with the corresponding NES varieties. Extensibility of Gemmeiza 9 recorded the highest extensibility (52 mm) followed by Misr 1 (45 mm) and Sakha 93 which recorded the lowest extensibility (35 mm). The NES varieties recorded the highest extensibility (ranged from 58-107mm) and Sids 12 recorded the highest extensibility (107 mm) followed by Gemmeiza 9 (90 mm) and the lowest results was found in Misr 1 (58 mm). These results agreed with those reported by Johansson and Svensson (1998) and Uhlen *et al.*, (2004) as previously discussed.

The proportional number (elasticity/extensibility) of dough was higher in HES varieties compared with values of NES varieties. Misr1 recorded the highest values (11.8) followed by Sakha 93 (9.7) and the lowest value was in Gemmeiza 9 (6.9). The NES varieties recorded the lowest results of proportional number values, where, Misr 1 recorded 3.9 followed by Sakha 93 (3.3), while Sids 12 recorded the lowest value (2.1).

Energy value (cm^2) of the tested dough of HES varieties recorded the lowest values compared with the dough of the NES varieties. The Misr 1 variety under heat stress recorded the lowest energy value (16), followed by Sakha 93 (17) while Gemmeiza 9 recorded the highest energy (20) value. On contrary, the Sids 12 NES variety recorded the highest energy (37) value, followed by Sakha 93 (29), Gemmeiz 9 (27) and Misr 1 which recorded the lowest energy value (22 cm^2).

Chemical compositions of whole-meal flour:

Moisture content of the HES tested varieties recorded lowest values than the corresponding NES varieties (Table 3). Protein and fat contents showed the same trend of moisture, where the HES varieties recorded the lowest fat content compared with the corresponding NES varieties. These results are in agreement with those found by Panozzo and Eagles (1999) who reported that, chronic moderate HT(25-35^{o}c) and short periods of vary than HT (>35^{o}c) during the filling phase and are frequently associated with an increase in grain protein concentration and a decrease in final grain dry mass and hence grain yield. Sofield *et al.*, (1977); Bhuller and Jenner (1985); Tester *et al.*, (1995), also, reported that environmental temperature affect the amylose content, structural features and gelatinization properties of starches in several cereal species. In wheat, environmental temperature affects grain yield, protein content, and the size and number of starch granules. The ash and crude fiber contents of the HES varieties recorded the highest percentage of ash compared with the corresponding NES varieties. On contrary, total carbohydrates of HES varieties recorded the lowest values compared with corresponding NES varieties. These observations are concurrent with those found by Jenner *et al.*, (1991) who reported that, the effects are mostly simply explained by the effects of temperature on the rate and duration of grain filling and by the reduction of starch.

Table (3): Chemical compositions (%) of bread wheat varieties cultivated under heat stress and normal conditions

Conditions	Variety	Moisture	Fat*	Protein*	Ash*	Crude fiber*	Carbohydrates*
Heat stress	Misr 1	7.62	0.65	11.55	1.59	1.72	84.49
	Gemmeiza 9	5.75	0.88	10.82	1.34	1.89	85.07
	Sakha 93	8.50	0.177	12.45	1.56	1.80	84.01
	Sids 12	7.08	0.74	13.54	1.63	1.91	82.18
Normal	Misr 1	9.50	0.80	10.14	1.01	1.34	86.71
	Gemmeiza 9	9.98	1.15	10.78	1.30	1.61	85.16
	Sakha 93	9.10	1.5	8.45	1.53	1.70	86.82
	Sids 12	8.60	1.05	7.95	1.60	1.87	87.53

*** On dry weight basis**

Sensory Evaluation:

Sensory evaluation of balady bread made from HES whole meal wheat (Misr 1, Sids 12, Gemmeiza 9 and Sakha 3) and the same NES varieties after baking and cooling at room temperature was found in Table (4). The panelists evaluated the external color, internal color, taste, odor, and separation of the two layers of bread.

Table (4): Sensory attribute values of bread prepared by wheat varieties cultivated under heat stress and normal conditions

Conditions	Variety	External color	Internal color	Taste	Odor	Separation of layers
Heat stress	Misr 1	14.80 a ±0.4216 ±0.1333	9.10 a ±0.7378 ±0.2333	18.50 ^{a} ±0.5270 ±0.1666	18.50 ^{a} ±0.5270 ±0.1666	8.90 ^{a} ±0.3162 ±0.1000
	Gemmeiza 9	14.10 ^{b} ±0.3162 ±0.1000	8.40 ^{b} ±0.6992 ±0.2212	17.70 ^{b} ±0.4880 ±0.1522	17.70 ^{ab} ±0.6719 ±0.2134	7.90 ^{b} ±0.3162 ±0.1000
	Sakha 93	13.60 ^{c} ±0.5164 ±0.1633	7.80 ^{cd} ±0.6124 ±0.2000	17.10 ^{c} ±0.3152 ±0.1000	16.80 ^{abc} ±0.7388 ±0.2494	7.50 ^{b} ±0.5220 ±0.1657
	Sids 12	12.80 ^{d} ±0.7888 ±0.2494	7.50 ^{ed} ±0.5270 ±0.±0.1667	16.00 ^{ed} ±0.6714 ±0.1491	16.00 ^{bcd} ±0.6619 ±0.2108	6.96 ^{dc} ±0.5676 ±0.1795
Normal	Misr 1	13.50 ^{c} ±0.5270 ±0.1667	8.10 ^{cb} ±0.3162 ±0.1000	17.20 ^{c} ±0.4216 ±0.1333	16.30 ^{bcd} ±2.9458 ±0.9315	±7.80 ^{b} ±0.4216
	Gemmeiza 9	12.80 ^{c} ±0.6325 ±0.2000	7.80 ^{cd} ±0.6325 ±0.2000	16.30 ^{d} ±0.4830 ±0.1528	15.40 ^{edc} ±2.9889 ±0.9452	7.00 ^{c} ±0.4714 ±0.1491
	Sakha 93	12.20 ^{e} ±0.6325 ±0.2000	7.20 ^{e} ±0.6325 ±0.2000	15.70 ^{e} ±0.6209 ±0.2134	14.70 ^{ed} ±2.6967 ±0.8825	6.50 ^{d} ±0.5766 ±0.1667
	Sids 12	11.40 ^{f} ±0.5164 ±0.1633	6.60 ^{f} ±0.5164 ±0.1633	14.60 ^{f} ±0.6902 ±0.2211	13.90 ^{e} ±2.0461 ±0.9000	5.80 ^{e} ±0.7166 ±0.1333

- Each mean within the same column followed by the same letter is not significant different at 0.05 level.

- Each mean is followed by ± standard deviation and ± standard error, respectively.

Concerning the external color of balady bread, a significant differences were noticed among the samples. Balady bread made from whole wheat bread Misr 1 recorded the highest values followed by Gemmeiza 9 , Sakha 93 and Sids 12, respectively. While the bread made from whole wheat flour of NES varieties recorded the lowest degree compared with the corresponding bread which were made from whole wheat flour of HES varieties. The preferred degree was sorted as Misr 1, Gemmeiza 9, Sakha 93 and Sids 12, respectively.

The internal color of balady bread made from whole wheat flour of HES varieties recorded the highest degree compared with the bread made from whole wheat flour of the corresponding NES varieties. In both, Misr 1 varieties group (normal or heat) recorded the highest degree compared with the bread made by the other varieties. The other varieties, in both of HES or NES, Gemmeiza 9, Sakha 93 and Sids 12 were gradually reversed in the preferred degree of taste, color and separation of layers attributes. These results agreed with Shewry *et al.* (2002) and Don *et al.* (2006) who reported that, the end-use quality of a wheat cultivar depends on the combination and interaction of several compositional traits; however, the unique viscoelasticity of wheat gluten is the main compositional factor determining if wheat dough is suitable to manufacture breads, noodles, biscuits, or cakes. High molecular weight glutenin subunits (HMW-GS) play a critical role in determining dough elasticity. On the other hand Caffe-Terenl *et al.*, (2011) found that, yeast type represented the main source of variations of several protein quality characteristics.

Consequently, it could be concluded that environment may be the main source of variations in protein, ash contents and some dough strength related properties (e.g. bread volume, absorption and dough extensibility values). On the other hand, Misr 1 could be considered the proper variety, due to its stability toward either SHE or NHE conditions and its ability to produce a highly nutritional and preferred bread.

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تأثير إجهاد البيئة الحرارية على انتاجية وخصائص جودة الخبز لبعض اصناف قمح الخبز

II - صفات جودة الخبز لبعض اصناف قمح الخبز المنزرعة تحت تأثير إجهاد البيئة الحرارية

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يهدف هذا البحث الى دراسة التأثير البيئى و المناخى على إنتاجية أصناف قمح الخبز (مصر 1 و جميزة 9 و سخا 93 – سدس 12) وجودة الخبز الناتج منها. حيث تمت زراعة تلك الأصناف فى منطقتين أحدهما حارة والاخرى معتدلة. وقد تم طحن الحبة كاملة لكل الأصناف ودراسة الصفات الريولوجية للدقيق الناتج. وأظهرت النتائج أن ارتفاع الحرارة عند زراعة أصناف قمح الخبز يؤدى الى زيادة إمتصاص الماء و زمن الوصول ووقت العجين و ثبات العجينة لكل الأصناف التى نمت تحت الظروف الحاره بينما ادى الى التقليل من درجة ضعف العجينة مقارنة بالأصناف تحت الظروف العادية. وقد ادت زيادة درجة الحرارة الى زيادة مرونة العجينة الناتجة وزيادة الرقم النسبى وخفض المطاطية عن عجائن الأصناف التى تنمو فى الظروف المعتدلة ، كما ان المساحة تحت المنحنى (الطاقة) تقل فى دقيق الحبة الكاملة للأصناف التى تزرع تحت ظروف حرارية عالية وتزيد فى الأصناف التى تنمو فى ظروف معتدلة لكل الأصناف تحت الدراسة. كذلك أظهرت نتائج التحليل الكيماوى زيادة % للدهن للأصناف التى تنمو فى ظروف معتدلة عن الأصناف التى تنمو فى الظروف الحرارية بينما أظهرت كمية البروتين نتائج عكسية الإتجاه، حيث زادت النسبة المئوية للبروتين بالنسبة للأصناف التى تنمو فى الظروف الحارة عن الأصناف التى تنمو فى الظروف المعتدلة بينما سلك كل من الرماد و كذلك الألياف الخام نفس الإتجاه، أما بالنسبة لنتائج الكربوهيدرات الكلية فقد كانت مرتفعة فى الخبز الناتج من الأصناف التى تمت زراعتها فى ظروف حرارية معتدلة بدرجة أكبر من الخبز الناتج من الأصناف التى تمت زراعتها تحت ظروف حارة. وكانت صفات التقييم الحسى للخبز الناتج من دقيق الحبة الكاملة لكل من الأصناف التى تمت زراعتها تحت ظروف حارة أعلى مقارنة بعينات الخبز التى نمت تحت الظروف المعتدلة. كذلك فقد وجد أن الخبز الناتج من صنف مصر1 قد أعطى أعلى درجات قبول حسية يليه الخبز الناتج من جميزة 9 ثم سخا 93. بينما الخبز الناتج من صنف سدس 12 المنزرع تحت الظروف المعتدلة قد أعطى أدنى درجات فى الصفات التى تمت دراستها.

قام بتحكيم البحث

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