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Influence of Plantation in a Saline-Stressed Location on the Agronomical Characteristics and Technological Quality of Flour and Baladi Bread for Two Egyptian Wheat Varieties

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ABSTRACT

This study investigates the influence of plantation in a saline-stressed location on the agronomical characteristics and technological quality of flour and Baladi bread for Sids-14 and Misr-2 wheat varieties. The wheat varieties were planted in normal conditions of Sids Station and in West-West Al-Minya as a saline-stressed location during the 2018-2019 and 2019-2020 seasons. The study found that salinity in West-West Al-Minya significantly influenced the agronomical characteristics and yield attributes of the wheat varieties, which in turn influenced the proximate composition and rheological behavior of the flour and the sensory and physicochemical properties of Baladi bread. Sids-14 and Misr-2 grown at West-West Al-Minya showed earlier heading and maturation, shorter height, reduced kernel/spikes, thousand kernel weight, and lower grain yield compared to normal conditions. Sids-14 flour had higher crude protein and wet gluten content but exhibited lower water absorption, prolonged development time, stability time, significant protein weakening, hot gel stability, and starch retrogradation. Misr-2 flour showed fewer influences and better performance in most characteristics, with increased crude protein, wet and dry gluten contents, higher water absorption, and postponed Baladi bread staling. Baladi loaves from the West-West Al-Minya location had higher sensory scores, more dietary protein, lower specific volume, lower ash contents, and an excess increase in Na and lower Zn and Fe contents. The study recommended Misr-2 was better than Sids-14 under salinity stress, despite the stress conditions in West-West Al-Minya location, it is a promising location for wheat plantations with good yield attributes and reasonable flour and bread technological qualities.

Keywords: Local wheat varieties, Salt stress, Rheological behavior, Physicochemical characteristics, Staling , Sensory scores

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INTRODUCTION

Bread wheat *Triticum aestivum* L. is one of the most commonly farmed crops in the world, covering 220 million hectares and producing 729 million tons annually. About 20% of the world's dietary energy and protein consumption comes from wheat as a staple food consumed by one-third of the world's population **(Ramadas, *et al.*, 2019; Paux, *et al.*, 2022; Kettlewell, *et al.*, 2023 and Singh, *et al.*, 2023)**. In Egypt, wheat has the most harvested area (1,392 thousand hectares), the highest production (9,070 thousand tons), and the highest yield (6.5 metric tons per hectare) based on the last five year average. It provides one-third of daily caloric consumption for Egyptians and 45% of daily protein intake, mostly in the form of subsidized baladi bread **(Wally, 2023)**. The amount of wheat consumed annually by Egyptians is 18.5 million tons, or approximately 196 kilograms per person, more than the world average by almost 100 kilograms **(Abdalla, *et al.*, 2023)**. Without a doubt, wheat is the most important crop for ensuring global food security; by 2050, more than 224–359 million tons will be required to meet the increased demand due to many factors, including changing dietary habits, population growth, and rising costs for fertilizers **(Paux, *et al.*, 2022 and Kettlewell, *et al.*, 2023)**. Concerning the food security of wheat in Egypt, Egypt is the biggest importer of wheat in the world; it has been seriously impacted economically, particularly in the wake of the Corona crisis, the Ukrainian-Russian War, and the inflated rise in grain prices **(Darwish, *et al.*, 2023)**. So, Egypt's agricultural sector has to confront unprecedented food security challenges. Narrowing the gap between wheat consumption and production in Egypt will inevitably require increasing land reclamation, particularly in the Western Desert, to increase wheat production **(Abdalla, *et al.*, 2023; Darwish, *et al.*, 2023; Khawaga, 2021; Omran, & Negm, 2022; Shehata, *et al.*, 2023)**. The location of West Al-Minya is regarded as the most desert area focused on for soil reclaiming in Egypt. The Egyptian government reclaimed about 250.000 hectares in the “West Minya Land Opening Project” between 2013 and 2022 **(Elbeih, 2021 and Gabr, 2023)**. The location of West Al-Minya is dependent mostly on the extraction of groundwater through drilled wells. Additionally, it represents a stressful environment caused by the partly saline water used for irrigation and the unfavorable conditions of environment **(Rashed, 2020)**. The electrical conductivity (EC, dS m^{-1}) of the soil and irrigation water of the West-West Al-Minya location ranges from 2.0 to 4 dS m^{-1}, which is defined as “slightly saline,” and sensitive crops are affected. In addition, loss of yield for more sensitive crops is taking place **(Fadl, *et al.*, 2023)**. It is thought that wheat is a crop that is moderately sensitive to salinity stress., and the quality characteristics of varieties of wheat mainly depend on extrinsic factors such as stress conditions; besides the intrinsic factors such as the physical and chemical characteristics of the varieties, both of them have a significant impact on the characteristics of flour and bread, particularly the protein content, baking attributes, and their ability to produce quality dough **(Amir, *et al.*, 2020; Nagy-Réder, *et al.*, 2021 and Moroșan, *et al.*, 2022)**. Although there are many studies discussing the productivity and yield of bread wheat cultivars cultivated in the Western Desert Region under normal and salinity conditions **(Abdalla, *et al.*, 2023; Darwish, *et al.*, 2023; Moghazy & Kaluarachchi 2020; Ibrahim & Said, 2020;**

Sayed, *et al.*, 2021 and El-Hashash, *et al.*, 2022), however there is a need for additional studies that widely correlate between the extrinsic and intrinsic factors and the wheat flour and bread characteristics. Consequently, with the foregoing in mind, the purposes of the present study were: (a) to assesse the yield and quality performance of two bread wheat varieties, that include Sids-14 and Misr-2, at two locations representing the normal one in Sids Agricultural Station, Beni sweif Governorate, and the newly reclaimed lands in Experimental Farm of West-West Al-Minya, Al-Minya Governorate, during the two growing seasons of 2018-2019 and 2019-2020; (b) to evaluate the quality of the milled flour in terms of chemical and rheological characteristics; and (c) to evaluate the Baladi bread quality in terms to physical characteristics, staling rates, the nutritional and sensory characteristics.

MATERIALS AND METHODS

Materials

During the growing seasons of 2018–2019 and 2019–2020, two local bread wheat varieties were evaluated at two locations that represented normal and newly reclaimed lands. The first location was Sids Agricultural Station, Beni sweif Governorate (latitudes 29° 3' North, longitudes 31° 6' East), representing a normal environment. The second location was the experimental farm of West-West Al-Minya, Al-Minya Governorate, which lies between latitudes of 28° 7′ and 28° 25′ N and longitudes of 29° 35′ and 30° 1′ E, representing a stressful environment caused by the partly saline water used for irrigation and the unfavorable soil salinity conditions. The location of West Al-Minya is thought to be the desert region that has been the focus of soil reclamation efforts during the last ten years, mostly reliant on drilling wells to extract groundwater. Table 1 represents the physicochemical properties of the soil and the irrigation water of the Sids and West-West Al-Minya locations.

Pancreatic α-amylase (1: 2000 activity) was obtained from Oxford Lab. Chem, India. Amyloglucosidase (amylo 300) was obtained from Biocon. India Pvt. Ltd., India. The *D*-glucose standard was obtained from Sigma Aldrich, St. Louis, MO, USA. Granulated sugar, instant dry yeast, and table salt were obtained from the local market in Al Gizah, Egypt. The instant dry yeast ingredients mentioned on the label were Saccharomyces cerevisiae and the emulsifier (E491): sorbitan monostearate. All chemicals used in the present investigation were analytical reagent grade.

Methods

Field Experiment

The experiment was laid out in a complete block randomized design (CBRD), each planting date having three replications. Each plot consisted of six rows, three meter long and twenty centimeter apart. All other agricultural practices were applied in accordance with the recommendations. The studied characteristics were the earliness characteristics: days to heading (DH), days to maturity (DM), and agronomic characters: plant height (PH); number of spikes per meter square (S/M2); number of kernels per spike (NK/S); Normalized Difference Vegetation Index (NDVI) ; Total Chlorophyll Content (TCC); grain yield (GY, Kg/plot 3.6m2); hectoliter (HL, Kg/L); and thousand kernel weight (T-KWT). The Chlorophyll Meter was used to determine the TCC. Model: OPTI-SCIENCES, INC., CCM 200 Plus, of the blade flag leaf at a complete flowering stage from 11 a.m. to 2 p.m. during a sunny day. For each plot, three replicates were measured.

Table 1. The physicochemical properties of the soil and the irrigation water of the Sids and West-West Al-Minya locations

Properties	Sids location		West-West Al-Minyalocation		
	Soil	Irrigation Water	Soil	Irrigation Water	
		Normal		Normal	Groundwater
Clay (%)	51.20	–	7.0	–	–
Silt (%)	34.60	–	6.7	–	–
Sand (%)	14.2	–	87.0	–	–
Texture grade	Clayey	–	Sandy	–	–
pH	8.10	7.5	7.9	7.84	7.91
Electrical Conductivity (EC dS m^{1})	1.39	0.58	2.5	3.41	3.38
Organic matter (%)	1.25	–	0.19	–	–
$CaCO_3$(%)	1.7	–	–	–	–
Anions (meq/kg soil)					
HCO_3^-	1.58	2.94	2.5	3.5	2.99
SO_4^{-2}	5.2	2.33	12.3	7.5	4.63
Cl^-	4.96	1.17	100.2	22.0	27.15
Cations (meq/kg soil)					
Mg^{+2}	3.99	0.99	25.9	8.0	7.9
Na^+	2.08	1.24	61.0	15.0	8.71
K^+	2.0	0.24	0.9	1.5	0.40
Ca^{+2}	3.99	4.15	30.2	8.5	7.21
Available Macroelements (mg/kg soil)					
Available Nitrogen	17.90	–	181.0	–	–
Available Phosphorous	8.65	–	0.41	–	–
Available Potassium	275.33	–	102.3	–	–

Wheat milling and Extraction

The wheat grains were tempered overnight at 37–40 °C to 14% moisture content and milled into a flour extraction rate of 72% with a Quadrumat Junior Mill (Brabender, Duisburg, 191 Model QU-J, Germany). Coarse bran, fine bran, and shorts were sieved to pass through 297 µm sieve openings and then mixed with a flour extraction rate of 72 % to obtain a flour extraction rate of 82 % following equation 1:

$$\textbf{Extraction rate}\ (\%) = \frac{\textbf{flour (g)}}{\textbf{crude wheat (g)}} \times \mathbf{100}$$

After the extraction of flour from the studied wheat varieties (Sids 14 and Misr 2), the extracted flour of the seasons (2018–2019 and 2019–2020), they were combined for further rheological and breadmaking evaluations.

Mixolab analysis

Dough mixing properties, quality of starch, and protein of wheat flour extraction rate of 82% were determined using a Mixolab 2 (Chopin Technologies, France). Standard Chopin+ analysis protocol according to **AACC International (2000)** Approved Method 54-60 in compliance with ISO ICC173/1. A mixing bowl of 50 g was used with a mixing speed of 80 RPM. Water absorption (WA) of wheat flour was 54% on the basis of 14% moisture (recombined with the initial moisture content of the samples). The Mixolab curves showed WA, or the percentage of water required for the dough to produce a torque of 1.1 ± 0.05 Nm. Development time (DT) is the time (min) to reach the maximum torque at 30 °C. Stability (ST) is the time (min) until the torque at point C1 decreases by 11%. C1 determines the maximum dough torque for water absorption (Nm). C2 measures protein weakening as a function of mechanical work and temperature (Nm). C3 measures starch gelatinization (Nm). C4 measures hot gel stability (Nm). C5 measures starch retrogradation (Nm). The C5-C4 corresponds to the anti-staling effects and represents the shelf life of the end products. The α-slope indicates protein weakening speed, the β-slope indicates starching speed, and the γ-slope indicates α-amylase degradation speed.

Baladi bread making

The bread baking formula of 1000 g from the obtained flour extraction rate of 82% (14% moisturecontent basis), 10 g of dry yeast, and 10 g of table salt. All components were mixed together using the straight dough method, with the time and amount of water estimated from Mixolab 2. The formed soft dough was left to rest for un hour at 35–37° C and 80 % relative humidity, then transferred to a wooden bowl and fermented at 35–37° C and 80 % relative humidity for an additional 30 minutes. The dough is manually portioned into 120–130 g portions on wooden racks that are covered in a layer of fine bran and dusted with flour. After proofing and fermentation for an additional 15 min., the dough pieces were once more dusted with fine bran, flattened, degassed with a light hand pressing, and then baked in a hot steel belt oven at 450±50°C for 1-2 min. Baladi bread loaves were allowed to cool down for about 1 hr before a different assessment.

Sensory evaluation of Baladi bread loaves

The panelists, consisting of 15 subjects from the staff of the Food Technology Research Institute, Agricultural Research Center, Al Gizah, Egypt, evaluated the sensory properties of Baladi bread loaves according to **Hegazy and Faheid (1990)**. The staff of panelists gives scores for general appearance, separation of layers, roundness, distribution of crumb, crust color, taste, odor, and overall acceptability on a hedonic scale from (one) dislike extremely to (nine) like extremely.

Baladi bread specific volume (cm^3/g)

The specific volume (cm^3/g) of Baladi bread loaves was determined according to the **AACC International (2000)** Approved Method 10–05.01, using the rapeseed displacement procedure. The specific volume has been calculated as loaf volume (cm^3) divided by Baladi bread weight (g).

Chemical analyses

Total starch in wheat flour was hydrolyzed by heat-stable α-amylase, then followed by amyloglucosidase, according to the **AACC International (2000)** Approved Methods 76–13.01. The released glucose from digested starch maltodextrin was measured against the standard curve of *D*-glucose. A molar mass of 0.9 was used to convert glucose to the starch monomer unit. Moisture, crude protein, crude fat, ash, and crude fiber contents were determined according to the **AACC International (2000)** Approved Methods 44-16, 46-30, 30-10, 08-01, and 32-10.01, respectively. Total carbohydrates was calculated by subtracting the sum of moisture, crude protein, crude fat, ash, and crude fiber percentages from 100. The content of crude protein was calculated as N × 5.7. The energy of Baladi bread loaves was calculated by the formula of **James (2013)**, following equation 2:

$$\mathbf{Energy}\ (\mathbf{kcal\ /\ 100g}) = \mathbf{Crude\ protein} \times \mathbf{4}\ + \mathbf{Crude\ fat}\ \times \mathbf{9} +\ \mathbf{Total\ carbohydrates} \times\ \mathbf{4}$$

Sodium (Na), potassium (K), calcium (Ca), phosphorous (P), magnesium (Mg), zinc (Zn), and iron (Fe) contents were determined according to the AACC International (2000) Approved Method 40-75.01, using the Agilent Technologies Microwave Plasma Atomic Emission Spectrometers (Model 4210 MPAES, USA). The wet gluten, dry gluten, and gluten index were determined using the method described by **AACC International (2000)** Approved Method 38-12.02. The wet gluten was dried in the instrument Glutomatic 2200 (Perten Instruments) to determine the dry gluten content. Flour yield (%) was calculated as the percent total flour weight (break flour plus mids) of the sample grain weight following equation 3:

$$\mathbf{Flour\ yield}\ (\%\ ) = \frac{\mathbf{Total\ Flour}}{\mathbf{grain\ weight}} \times \mathbf{100}$$

Staling Rate Percentages (%SR)

Staling rate percentages SR (%) were calculated using the alkaline water retention capacity method according to **Yamazaki (1953)** as modified method by **Kitterman and Rubenthaler (1971)** following equation 4:

$$\mathbf{SR}(\%) = \frac{\mathbf{AWRC_0} - \mathbf{AWRC_n}}{\mathbf{AWRC_0}} \times \mathbf{100}$$

Where SR (%): Staling rates Percentage; $AWRC_0$: Alkaline water retention capacity at zero time; $AWRC_n$: Alkaline water retention capacity after 24, 48 and 72 hours. Briefly, one gram of each dried and grounded Baladi bread sample was put in a 15-ml tube (W_1), then 5 ml of 0.1 N $NaHCO_3$ were added, and mixed for 30 seconds and left at room temperature for 20 minutes. The slurry was centrifuged for 15 minutes at 3000 rpm, the supernatant was discarded, and tubes were let to drip upside down for 10 minutes. Then, dried tubes were weighed (W_2). The percentage of AWRC was calculated following equation 5:

$$\mathbf{AWRC}\ (\%) = \frac{\mathbf{W_2} - \mathbf{W_1}}{\mathbf{W_1}} \times \mathbf{100}$$

Where **AWRC**: Alkaline water retention capacity, W1: weight of tube containing the dry sample; W2: weight of tube containing the dripped sample. Analyses were conducted in triplicate at zero time and after 24, 48 and 72 hours.

Statistical Analysis

The data of the agronomical trial, physicochemical, rheological, and sensory characteristics were analyzed using computer software CoStat 6.303, CoHort, USA, 1998–2004 for Windows; an analysis of variance (ANOVA) was followed by Duncan's multiple range tests at $P \leq 0.05$ to compare between means.

RESULTS AND DISCUSSION

Agronomical characteristics and yield attributes

Table 2. demonstrates the mean values of all studied characteristics under Sids and West-West Al-Minya locations during seasons (2018–2019) and (2019–2020). The results showed the presence of significant ($P \leq 0.05$) differences between the two studied locations in terms of all attributes except plant height (PH) and the normalized difference vegetation index (NDVI). This finding indicates the existence of substantial differences between the two locations about salinity stress that influenced the productivity and characteristics of the studied wheat plants. The findings demonstrated that compared to wheat plants grown under Sids conditions, those planted at the West-West Al-Minya location had earlier heading (DH) and maturity (DM). The wheat plant tends to mature early under stressful conditions as a form of adaptation. The plant height (PH) in West-West Al-Minya location was shorter than the Sids location. Regarding yield productivity and its traits, it can be observed that the grain yield (GY) and the number of kernels per spike (NK/S) obtained from the West-West Al-Minya location decreased in comparison to those from the Sids location. With regard to T-KWT (g), it can be observed that the T-KWT produced from the West-West Al-Minya location had a significant decrease in Sids-14 by 10.0, and 22.14%, and Misr-2 by 9.4 and 5.0% for the two seasons, respectively, in comparison with the ones produced from the Sids location. It indicates that the wheat variety Misr-2 caused lessened T-KWT in the West-West Al-Minya location. These findings are in accordance with the results of **Darwish *et al.* (2023), Ibrahim, & Said (2020), and Sayed *et al.* (2021)**, who showed that the wheat plants are greatly impacted by the surrounding stressful locations. A decrease in T-KWT was caused by reduced filling of grain that was impacted by different environmental stresses, such as drought, salinity, or heat, as it can lead to losses in kernel weight and density **(Salehi, and Arzani, 2013; Hassan, 2016)**. One important physical quality criterion that indicates the flour yield is the hectoliter weight (HL, Kg/L). Hectoliter depends on the size, shape, and soundness of the grain. The hectoliter weight displayed a reduction in the West-West Al-Minya location with a wide range of variations during the two seasons, between a minimum of 204.57 kg/l and a maximum of 211.63 kg/l. The variation in the HL can probably be attributed to the variance in T-KWT, the salinity stress, and the genetic structure of the varieties of wheat Sids-14 and Misr-2 **(Dhaka, *et al.*, 2012)**. The present findings confirmed that the West-West Al-Minya location is promising for future cultivation of wheat owing to its good yield productivity in spite of its stress conditions. **Al-Naggar *et al.*, (2020)** stated that the stress-tolerant genotypes are characterized by short plant height, early maturity, and a high grain yield. These current findings are in agreement with the results obtained by **Darwish *et al.* (2023), Ibrahim & Said (2020), and Abdelkhalik *et al.* (2021)**, who demonstrated that the wheat plant is significantly influenced by its surrounding environmental conditions.

Table 2. Mean values for earliness and physiological traits, yield and its attributes of two wheat varieties as affected by Sids and West-West Al-Minya locations at seasons 2018- 2019 and 2019-2020

Season	First season 2018- 2019				
Location	Sids location (normal conditions)		West-West Al- Minya location (Salt-stress conditions)		
Wheat variety	Sids-14	Misr-2	Sids-14	Misr-2	LSD $P \leq 0.05$
DH (days)	103.33 ± 0.57^{a}	101.33 ± 0.57^{a}	87.33 ± 3.05^{c}	91.67 ± 1.52^{b}	3.31
DM (days)	165.67 ± 1.154^{a}	156.00 ± 1.00^{b}	131.00 ± 1.00^{d}	140.00 ± 1.00^{c}	1.95
PH (cm)	118.33 ± 2.88^{a}	113.33 ± 2.88^{a}	110.00 ± 5.00^{a}	111.67 ± 5.77^{a}	8.15
S/M^2	386.00 ± 18.52^{ab}	374.001 ± 1.53^{b}	400.00 ± 34.64^{b}	428.33 ± 25.65^{a}	45.48
NK/S	63.97 ± 2.00^{c}	67.00 ± 1.00^{b}	70.00 ± 1.00^{a}	$66.33\pm0.577b^{c}$	2.37
NDVI	0.73 ± 0.01^{a}	0.72 ± 0.03^{a}	0.67 ± 0.04^{a}	0.68 ± 0.01^{a}	0.06
TCC (mg/m^{-2})	56.53 ± 2.03^{a}	50.90 ± 3.68^{ab}	48.80 ± 1.15^{b}	52.17 ± 4.70^{ab}	6.04
GY ($Kg/3.6m^2$)	3.38 ± 0.15^{a}	3.16 ± 0.27^{ab}	2.77 ± 0.14^{b}	3.07 ± 0.33^{ab}	0.45
HL (Kg/L)	211.63 ± 1.8^{a}	205.43 ± 1.2^{bc}	207.13 ± 0.4^{b}	204.57 ± 0.12^{c}	2.37
T-KWT (g)	58.12 ± 2.89^{a}	58.62 ± 4.49^{a}	53.19 ± 8.45^{ab}	45.64 ± 0.37^{b}	9.42
Season	Second season 2019- 2020				
Location	Sids location (normal conditions)		West-West Al-Minya location (Salt-stress conditions)		
wheat variety	Sids-14	Misr-2	Sids-14	Misr-2	LSD $P \leq 0.05$
DH (days)	108.33 ± 0.57^{a}	109.00 ± 0.00^{a}	95.33 ± 1.52^{b}	96.00 ± 1.73^{b}	2.24
DM (days)	157.33 ± 1.52^{a}	155.67 ± 1.15^{a}	135.00 ± 1.00^{b}	132.33 ± 2.51^{b}	3.12
PH (cm)	106.67 ± 5.77^{a}	106.67 ± 7.63^{a}	81.70 ± 2.88^{b}	98.30 ± 2.88^{a}	9.79
S/M^2	318.67 ± 34.94^{b}	375.00 ± 30.00^{a}	316.70 ± 10.40^{b}	323.30 ± 17.55^{b}	47.43
NK/S	83.27 ± 6.00^{a}	72.17 ± 2.75^{b}	64.00 ± 7.00^{b}	65.70 ± 4.16^{b}	9.87
NDVI	0.69 ± 0.01^{a}	0.62 ± 0.02^{a}	0.80 ± 0.07^{a}	0.61 ± 0.15^{a}	0.17
TCC (mg/m^{-2})	50.37 ± 1.91^{a}	40.27 ± 0.40^{c}	47.33 ± 0.96^{b}	44.93 ± 1.70^{b}	2.60
GY($Kg/3.6m^2$)	3.01 ± 0.25^{a}	2.43 ± 0.36^{ab}	2.30 ± 0.13^{b}	2.70 ± 0.42^{ab}	0.59
HL (Kg/L)	206.17 ± 0.58^{ab}	207.25 ± 0.25^{a}	205.89 ± 0.54^{b}	205.67 ± 0.76^{b}	1.25
T-KWT (g)	54.11 ± 3.05^{a}	49.70 ± 2.01^{ab}	49.03 ± 1.65^{ab}	47.17 ± 4.68^{b}	5.81

DH: days to heading, DM: days to maturity, PH: plant height, (S/M^2): no. spikes m^{-2}, NK/S: no. kernels spike, NDVI: normalized difference vegetation index, TCC: total chlorophyll content, GY: grain yield (Kg/plot $3.6m^2$), -1,HL: Hectoliter, T- KWT: 1000 kernels weight,. Data are presented as means ± SDM (n=5) & Means within a row with different letters are significantly different at $P \leq 0.05$.

Wheat flour quality

Table 3. shows the quality attributes of wheat flour from Sids and West-West Al-Minya locations during seasons 2018–2019 and 2019–2020. Data in Table 3 displayed a significant reduction in total starch contents in the West-West Al-Minya location by 2.2 & 0.4 and 3.2 & 1.35 % in the studied bread wheat varieties Sids-14 and Misr-2 during the two seasons, respectively. The decrease in the content of total starch was high ($P \leq 0.05$) in the bread wheat variety Misr-2. The decrease in the content of total starch may be attributed to two reasons: The first is that the salinity stress in the West-West Al-Minya location inactivates starch syntheses, the key enzyme of starch biosynthesis, which results in a lower accumulation of starch in the endosperm pathway reaction. The second reason is the reduction in the quantity and area (less than 9.9 μm2) of the β-granules in the wheat kernel that store starch **(Hassan, *et al.*, 2016 and Balla, *et al.*, 2011).**The protein content of grains is known to be affected by environmental conditions and variety **(Rozbicki, *et al.*, 2015)**. In contrast to the normal conditions in the Sids location, the protein content in wheat flour was influenced ($P \leq 0.05$) by the salinity stress in the West-West Al-Minya location. The contents of

protein increased in the West-West Al-Minya location from 2.3% to 7.8% and 8.8% to 11.63% in the bread wheat varieties Sids-14 and Misr-2 during the two seasons, respectively. The wheat variety Misr-2 showed more ($P \leq 0.05$) increase in protein content. likewise, **Salehi & Arzani (2013) and Nadeem *et al.* (2020)** noticed a higher content of protein in wheat flour in salinity-stressed conditions, which may be outlined in the loss of yield and decreased T-KWT owing to a reduction in the production of starch **(De Santis, *et al.*, 2021; Karimzadeh, *et al.*, 2023)**. It is noteworthy that wheat varieties Sids-14 and Misr-2 have protein contents that comply with **Egyptian Standard ES: No. 1251-1 (2005)**, which states wheat flour, at various extraction rates, should have a protein content of around 9% on a wet basis. The gluten index is a measurement to determine gluten quantity and quality **(AACC International 2000).** The gluten contents (wet and dry) and their components are the key factors that affect the quality of the bread made from wheat flour. Nonetheless, they are affected by environmental conditions and the genetic history of wheat cultivars **(Salehi, and Arzani, 2013; EL Sabagh, *et al.*, 2021)**. Salinity stress in the West-West Al-Minya location caused a ($P \leq 0.05$) increase in wet gluten (5.30–5.68%), dry gluten (9.67–17.85%), and a ($P \leq 0.05$) decrease in gluten index (2.38% for the first season only) in the flour of the wheat variety Misr-2 for the two seasons, in comparison with the normal conditions in the Sids location. On the contrary, salinity stress in the West-West Al-Minya location caused a ($P \leq 0.05$) reduction of wet gluten (33.34–1.48%), dry gluten (22.45–4.9%), and a ($P \leq 0.05$) increase in gluten index (4.73 for the second season only) in the flour of the wheat variety Sids-14. The same observation was obtained by **El Sabagh *et al.* (2021),** who noticed that salinity tends to boost wet and dry gluten contents in salt-tolerant wheat varieties, while the contrary has been observed for salt-sensitive varieties. Nonetheless, they are affected by environmental conditions and the genetic history of the wheat varieties. That means Misr-2 could possibly be classified as a salt-tolerant wheat variety, while Sids-14 could be salt-sensitive. It indicates that the genotypic history could be the reason for the different gluten contents under the same condition **(Mahdavi, *et al.*, 2022)**. The decrease in the ratio of glutenin (which is responsible for dough elasticity) to gliadin (which is responsible for dough extensibility) and ultimately reducing the gluten index in Misr-2 may be one possible explanation, as the gluten index values have a significant influence in controlling the genetic inheritance of wheat varieties **(Nagy-Réder, *et al.*, 2021; Salehi, & Arzani, 2013; Popa, *et al.*, 2019).**While the Egyptian Standard ES 1251-1(2005) revealed that wheat flour with an extraction rate of

82% should have a percentage of wet gluten ~ 25% at a moisture basis of 14%, the current findings showed that wet gluten is at an optimal value for making Baladi bread. Moreover, the gluten index values higher than 80 **(Popa, *et al.*, 2019)** emphasize the strong gluten present in both the Misr-2 and Sids-14 varieties. According to the data in Table 3. The wheat varieties Sids-14 and Misr-2 showed a ($P \leq 0.05$) decrease in flour yield (%) at the West-West Al-Minya location by 17.67 and 5.75% and 10.4 and 3.56% for both seasons, respectively. The reduction in flour yield was ($P \leq 0.05$) higher in the wheat variety Sids-14 than that of Misr-2. This reduction is due to the reduced T-KWT, hectoliter weight (Table 2), and contents of total starch (Table 3.). The same results were observed by **Dhaka *et al.* (2012), McDonald & Kheir (2020), Wang *et al.* (2021), and Gebreil, & Mohamed (2023)** who noted that wheat varieties having better test weight, thousand kernel weight, and starch content have great potential for better milling yield; however, increasing groundwater salinity results in a decrease in grain weight, total starch content, and, therefore, flour yield. Interestingly, **Ragab & Kheir (2021) and Mitura *et al.* (2023)** demonstrated that bread wheat should be cultivated in a way that ensures a high yield of perfected quality characteristics to comply with standers and miller requirements.

Table 3. Quality characteristics of wheat flour from Sids and West-West Al-Minya locations at seasons 2018-2019 and 2019-2020

Season	First season 2018-2019					
Location	Sids location (normal conditions)		West-West Al-Minya location (Salt-stress conditions)			
Variety	Sids-14	Misr-2	Sids-14	Decrease/ Increase (%)	Misr-2	Decrease/ Increase (%)
Moisture (g/100gm)	8.31±0.40[a]	8.02±0.42[a]	8.34±0.34[a]		8.57±0.46[a]	
Total starch (g/100gm)	72.57±0.52[b]	74.44±0.68[a]	71.0±0.18[d]	2.2 D	72.06±0.39[c]	3.2 D
Crude protein (g/100gm)	13.00±0.21[b]	11.61±0.02[c]	14.01±0.47[a]	7.8 I	12.96±0.05[b]	11.63 I
Flour yield (%)	69.4±0.12[a]	69.61±0.11[d]	57.14±0.13[b]	17.67D	62.37±0.12[a]	10.4 D
Wet gluten (%)	37.07±0.74[a]	23.0±0.46[d]	36.52±0.73[b]	1.48 D	24.22±0.48[c]	5.30I
Dry gluten (%)	13.26±0.26[a]	8.17±0.16[c]	12.61±0.25[b]	4.9 D	8.96±0.17[d]	9.67 I
Gluten Index	92.06±0.12[c]	99.17±0.34[a]	91.78±0.56[c]	0.3D	96.86±0.72[b]	2.32 D
Season	Second season 2019-2020					
Moisture (g/100gm)	8.32±0.46[a]	8.86±1.2[a]	8.47±0.45[a]		8.47±0.94[a]	
Total starch (g/100gm)	73.03±0.12[b]	74.17±1.6[a]	72.74±0.2[c]	0.4 D	73.17±0.23[b]	1.35 D
Crude protein (g/100gm)	12.91±0.4[a]	11.56±0.3[b]	13.21±0.07[a]	2.3 I	12.58±0.02[a]	8.8 I
Flour yield (%)	64.4±0.22[a]	60.35±0.82[ab]	60.7±0.46[ab]	5.75 D	58.2±0.9[b]	3.56 D
Wet gluten (%)	34.4±0.68[a]	24.3±0.48[c]	22.93±0.45[d]	33.34D	25.68±0.51[b]	5.68 I
Dry gluten (%)	13.05±0.1[a]	9.41±0.82[d]	10.12±0.24[c]	22.45D	11.09±0.22[b]	17.85 I
Gluten Index	93.75±7.5[c]	99.09±0.18[a]	98.19±0.38[b]	4.73 I	99.05±0.1[a]	0.04 D

Data are presented as means ± SDM (n=5) & Means within a row with different letters are significantly different at $P \leq 0.05$.

Dough rheology of Baladi bread

Table 4. represents the dough rheological properties of Baladi bread obtained from Mixolab analysis at the two locations. The data indicated that the water absorption (%WA) in West-West Al-Minya was lower ($P \leq 0.05$) compared to the Sids location, and the flour of the Sids-14 variety absorbed a lesser, insignificant amount of water than the Misr-2 variety. The decrease in WA may attributed to that salt stress may change the net charges on the surface of proteins, accelerate the hydrophobic interaction between proteins, and decrease gluten hydration, thereby strengthening the gluten network. Moreover, osmosis postpones the hydration of gluten **(Ortolan *et al.*, 2017; Avramenko *et al.*, 2018)**.

The dough development time (DT, min) is very significant for Baladi bread baking, as the development of the gluten protein network should be adjusted to guarantee a high loaf volume

(Schmiele *et al.*, 2017). The dough of the West-West Al-Minya location required longer ($P \leq 0.05$) time (min) than the Sids location to reach the C1 torque, and the dough of the Sids-14 variety took longer ($P \leq 0.05$) time to develop than the Misr-2 variety. That may attributed to that salt stress decreased the free (-SH) interactions and increased the non-covalent interactions of the gluten, which formed a fibrous structure or β-sheet structure and less soluble protein network **(Carcea *et al.*, 2020),** which in turn increased the dough mixing tolerance, extended the dough mixing time, and postponed the DT to reach the C1 torque. Part of this behavior for dough resistance is due to the significant decrease in WA of the flour in the salt-stressed wheat variety, as mentioned before **(McCann, and Day, 2013; Kim *et al.*, 2023).**

The dough stability (ST, min) exhibited a similar behavior to the development time (DT, min), in which the dough of the West-West Al-Minya location displayed significant ($P \leq 0.05$) resistance against mixing and showed greater significant ST. It usually occurs with the C2 values related to the strengthened gluten network, where higher C2 values (0.44 Nm) with the stronger proteins have developed (5:42 min) and enhanced their stability (8:77 min) lately.

The C2 determines the protein weakening under both mechanical and thermal Mixolab constraints. The dough of the West-West Al-Minya location exhibited a significant ($P \leq 0.05$) increase in the protein weakening values (C2, Nm) compared to the dough of the Sids location. Sids-14 variety showed the highest ($P \leq 0.05$) C2 value, which means higher ($P \leq 0.05$) stability of Sids-14 dough, as both higher mechanical and thermal energy are required to break the protein-protein interactions and to resist the gluten network than the energy consumed for Misr-2 dough to have rich C2 torque. In addition, C2 torque speed (a, Nm/min) under the heating constraints of Mixolab also decreased. The same behavior was observed by **Kim *et al.* (2023) and Singh *et al.* (2019)**.

The C3 (Nm) determines the ability of the starch to gelatinize. The dough of the West-West Al-Minya location showed a non-significant increase in the gelatinization values (C3, Nm) compared to the values of the Sids location.

Table 4. Mixolab parameters of Chopin+ protocol for flour of wheat varieties Sids-14 and Misr-2 planted in Sids and West-West Al-Minya locations

Flour	WA (%)	DT (min)	ST (min)	C1 (Nm)	C2 (Nm)	α (Nm/min)	C3 (Nm)	β (Nm/min)	C4 (Nm)	γ (Nm/min)	C5 (Nm)	C5-C4 (Nm)
Location	Sids location (normal conditions)											
Sids14	56.5±0.39[a]	3:92±0.05[c]	6:25±0.64[c]	1.16±0.11[a]	0.44±0.31[c]	-0.096±0.02 [a]	1.81±0.2 [a]	0.480±0.4[b]	1.41±0.23[d]	-0.008±0.0[d]	3.17±0.00[c]	1.76±0.22[a]
Misr -2	52.5±0.12[b]	4:.05±0.02[c]	5:.98±0.66[c]	1.10±0.05[b]	0.41±0.20c	-0.070±0.05 [b]	1.94±0.22[a]	0.214±0.5[d]	1.82±0.11[c]	-0.032±0.03[c]	2.81±0.25[d]	0.99±0.12[d]
Location	West-West Al-Minya location (Salt-stress conditions)											
Sids 14	46.2±0.34[cd]	5:42±0.02[a]	8:77±0.72[a]	1.15±0.31[a]	0.54±0.21[a]	-0.062±0.01[c]	2.0±0.30[a]	0.558±0.23[a]	2.17± 0.05[a]	0.030±0.31[a]	3.83±0.04[a]	1.66±0.05[b]
Misr-2	46.5±0.24[c]	4:17±0.03[b]	6:48±0.53[b]	1.10±0.25[b]	0.47±0.25[b]	-0.056±0.03[d]	1.94±0.35[a]	0.302±0.5[c]	2.12±0.11[b]	0.028±0.11[b]	3.32±0.44[b]	1.2±0.33[c]

WA- water absorption (14% moisture basis), DT- development time, ST- stability time, C1- maximum dough torque to determine water absorption, C2- protein weakening as a function of mechanical work and temperature, α slope- protein weakening speed, C3- starch gelatinization, *β* slope- starching speed, C4 hot gel stability, γ slope-enzymatic degradation speed, C5- starch retrogradation in the cooling phase, C5-C4-calculated value corresponds to the anti-staling effects represents the shelf life of the end products.

Data are presented as means ± SDM (n=3) & Means within a column with different letters are significantly different at $P \leq 0.05$.

However, the speed of the gelatinization process (*β,* Nm/min) exhibited a ($P \leq 0.05$) increase. In salinity stress, the short-branched chain of amylopectin decreased; however, the protein accumulation increased, and the starch content decreased; in consequence, the stability of the starch and the gelatinization temperature increased, and the further *β* slope torque and C3 values increased (**Li *et al* ., 2023**). Another concerning issue is that the decrease in starch contents is accompanied by a reduction in the number and surface area of the β-granules that retain starch in the wheat grain and an increase in the A-type granules **(Zhang *et al* ., 2010; Balla *et al* ., 2011; Hassan *et al* ., 2016).**

C4 determines the hot gel stability of starch under the heat constraints of Mixolab as influenced by the wheat flour enzyme (α-amylase). The C4 (Nm) of the West-West Al-Minya location exhibited a significant ($P \leq 0.05$) increase compared to the Sids location, and the hot gel of the Sids-14 variety showed the highest ($P \leq 0.05$) stability and superior speed ($P \leq 0.05$) values of γ-slope for amylosis.

The starch retrogradation in the cooling phase (C5) responded with the same behavior as the hot gel stability (C4) **(Kim *et al.,* 2023),** wherein, in comparison to those values of the Sids location, the starch of the West-West Al-Minya location showed a ($P \leq 0.05$) increase in the retrogradation degree during the C5, due to the higher gelatinization in the C4. The starch of Misr-2 showed a slight ($P \leq 0.05$) anti-retrogradation than Sids-14, which may extend the staling in Baladi bread loaves of Misr-2 **(Schmiele *et al., 2017).***

The sensory scores of Baladi bread loaves

Table 5. shows the sensory acceptability scores of Baladi bread loaves. The sensory acceptability scores of Baladi bread loaves showed ($P \leq 0.05$) changes in general appearance, distribution of crumb, crust color, taste, and odor, as influenced by the salinity stress in the West-West Al-Minya location, in comparison to the normal conditions in the Sids location. Nonetheless, no ($P \leq 0.05$) changes were observed for the scores of separation of layers, roundness and overall acceptance. The panelists gave lower ($P \leq 0.05$) scores from ("like extremely") to ("like very much") for the general appearance and crumb distribution of the loaves of the West-West Al-Minya location. That could be due to the lower water absorption (Table 4), as the salinity stress ($P \leq 0.05$) affects the water absorption and dough development (DT), potentially influencing the volume, final form, and general appearance of the Baladi bread loaves **(Karimzadeh, *et al.,* 2023; Schmiele, *et al.,* 2017; Caffe-Treml, *et al.,* 2017 and Okuda, *et al.,* 2016)** . Additionally, in one study, it was found that the general appearance of bread samples varied depending on the content of water in the dough, with intermediate water content being preferred by panelists **(Singh, *et al.,* 2020).** Moreover, salinity stress ($P \leq 0.05$) influences the gluten behavior (C2, Table 4) and contents (Table 3), which impact the elasticity and the dough structure.

Table 5. Sensory acceptability scores of Baladi bread loaves

Baladi bread	General Appearance (9)	Separation of Layers (9)	Roundness (9)	Distribution of Crumb (9)	Crust Color (9)	Taste (9)	Odor (9)	Overall Acceptability (9)
Location	Sids location (normal conditions)							
Sids-14	9.0±0[a]	8.8±0.35[a]	8.9±0.35[a]	8.8±0.46[a]	8.1±0.62[bc]	8.2±0.50[b]	8.4±0.37[b]	8.4±0.73[a]
Misr-2	8.7±0.42[b]	8.8±0.46[a]	8.6±0.7[a]	8.9±0.50[a]	8.4±0.37[b]	8.2±0.37[b]	8.4±1.0[b]	8.6±0.50[a]
Location	West-West Al-Minya location (Salt-stress conditions)							
Sids-14	8.3±0.37[c]	8.8±0.37[a]	8.8±0.37[a]	8.0±0.37[b]	8.9±0.44[a]	8.8±0.73[a]	8.8±0.37[a]	8.7±0.37[a]
Misr-2	8.4±0.46[c]	8.9±0.35[a]	8.8±0.46[a]	8.3±0.52[b]	9.0±0.37[a]	9.0±0.35[a]	9.0±0.0[a]	8.9±0.37[a]

Data are presented as means ± SDM (n = 15, a 9-point hedonic scale: 1 (9= like extremely, 8= like very much, 7= like moderately, 6= like slightly, 5= neither like nor dislike, 4= dislike slightly, 3= dislike moderately, 2= dislike very much, 1= dislike extremely) & Means within a column with different letters are significantly different at $P \leq 0.05$.

That may result in differences in the size and distribution of air pockets within the Baladi bread, potentially making it harder or influencing its crumb texture or distribution **(Okuda, *et al.*, 2016; Džafić, *et al.*, 2022 and Schopf, *et al.*, 2021).** On the other hand, the panelists gave higher ($P \leq 0.05$) scores from ("like very much") to ("like extremely") for the crust color, taste, and odor of the Baladi bread loaves of the West-West Al-Minya location. Salinity stress significantly influenced the wheat grain metabolism, which may influence the aromatic profile of the bread flour **(Lahue, *et al.*, 2020)**. It can, in turn, produce a more intense toasting aroma and flavor **(Raffo *et al.*, 2018)**, leading to ($P \leq 0.05$) differences in the taste and odor of the baked loaves of West-West Al-Minya location in comparison with those loaves made from the best conditions in Sids location. In addition, various salt levels have been observed to impact the sensory profile of bread, with higher levels promoting the formation of Millard reaction products and caramelization at baking **(Taş, *et al.*, 2023)**, resulting in ($P \leq 0.05$) differences in the crust color of Baladi bread loaves. It should be noted that the ($P \leq 0.05$) differences in the sensory evaluations can depend on the level of salinity stress and also on the wheat variety. The electrical conductivity (EC dS m^{-1}) of the soil and irrigation water of the West-West Al-Minya location ranges from 2.5 to 3.41 dS m^{-1} (Table 1), which is considered slightly saline, according to the guidelines of **Scianna (2002).** That explains the reason there were ($P \leq 0.05$) variations in some of the sensory scores of the Baladi bread, while the change on the hedonic scale was slightly from 9 (like extremely) to 8 (like very much).

The specific volume (cm^3/g) and the staling rates (%) of Baladi bread loaves

The specific volume (cm^3/g) of Baladi bread loaves is presented in Fig. 1 . The specific volume of Baladi bread in the West-West Al-Minya location showed a significant decrease in comparison with those values of Sids location, and the specific volume of Misr-2 (■) showed a ($P \leq 0.05$) reduction (7.28%) compared to that specific volume of Sids-14 (□) showed a reduction of 3.69% (Fig. 1). Other reports obtained by **Caffe-Treml *et al.* (2010) and Karimzadeh *et al.* (2023)** showed a similar reduction in bread volume under salinity stress conditions. This pattern of behavior is attributed to the lower (%) of water absorption, extended dough stability, and dough development times in the West-West Al-Minya location, as shown in Mixolabe curves (Table 4). **Caffe-Treml *et al.* (2010) and Schmiele *et al.* (2017)** found significant correlations between the volume of loaf, dough development time, dough stability, and WA. Also, **Okuda *et al.* (2016)** recorded a reduced bread volume when the water hydration of flour was <45%. The lower water hydration of the flour below the optimal amount maintains protein-protein hydrogen bonding and inhibits gliadin protein from being embedded in the network structure. Additionally, a weak viscoelastic protein network is formed, which is unable to retain the CO_2 produced during dough fermentation, which results in lower bread-specific volume **(Schopf, and Scherf, 2021).**

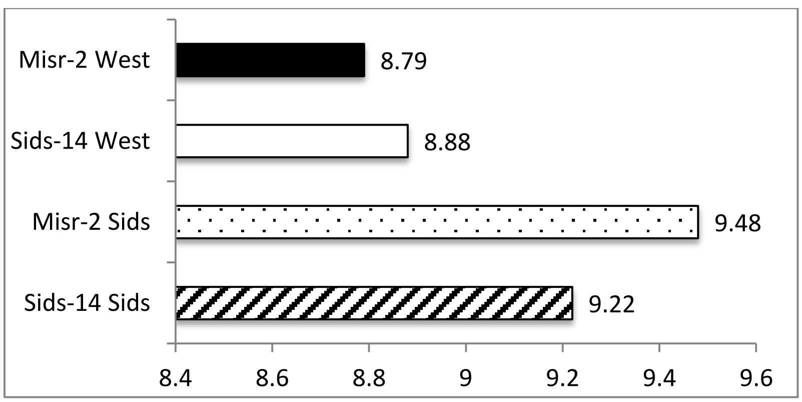

Fig. 1 Specific volume (cm^3/g) of Baladi bread loaves

(◪):Loaves of wheat variety Sids-14 in Sids location;(⊡): loaves of wheat variety Misr-2 in Sids location; (□):loaves of wheat variety Sids-14 in West-West Al-Minya location; (■):loaves of wheat variety Misr-2 in West-West Al-Minya location.

In the West-West Al-Minya location, wheat variety Sids14 had a higher crude protein content and more wet gluten ($P < 0.05$) than wheat variety Misr-2 (Table 3). The higher the gluten content, the more favorable the rheological properties, and the higher the bread volume **(Džafić, *et al.*, 2022)**. In addition, the wheat variety Sids-14 dough showed a higher ($P \leq 0.05$) C2 value and a lower ($P \leq 0.05$) protein weakening speed (α) than that of wheat variety Misr-2 dough in the West-West Al-Minya location (Table 4); Flour with stronger gluten networks, characterized by higher resistance to thermal and mechanical constraints, has a higher capacity of the network to enclose carbon dioxide through fermentation and produces bread with a higher specific loaf volume **(Barak, *et al.*, 2013 and Frauenlob *et al.*, 2017).**

The percentages of crumb moisture loss and staling rates of Baladi bread loaves at zero time, 24, 48, and 72 hours at 25°C are shown in Fig. 2 (a and b). The staling rates (%) (Fig. 2b) of

Baladi bread loaves showed a significant ($P \leq 0.05$) increase in the West-West Al-Minya location during 0, 24, 48, and 72 hrs when compared to those rates (%) in the Sids location. The loaves of Sids-14 wheat variety (...■....) showed higher ($P \leq 0.05$) staling rates (%) than loaves of Misr-2 wheat variety (- .-●.-.-) after 48 and 72 hrs. It means that Baladi bread loaves of Misr-2 may have an extended shelf life than loaves of Sids-14, as they turned staled later. Owing to the lower ($P \leq 0.05$) loss in crumb moisture (Fig. 2a) of Baladi bread loaf of Misr-2 (36%, - .-●.-.-), than that loss of crumb moisture in Baladi bread loaf of Sids-14 (37.92%, ...■....) where the percentage of staling rates tends to slow down with loss in crumb moisture loss **(Besbes, *et al.*, 2014)**. Furthermore, owing to the reduced ($P \leq 0.05$) C5 of the flour of Misr-2 (Table 4), the flour with a lower retrogradation capacity ensures a longer shelf life of Baladi bread **(Dubat, and Boinot, (2012)**.

a) **b**)

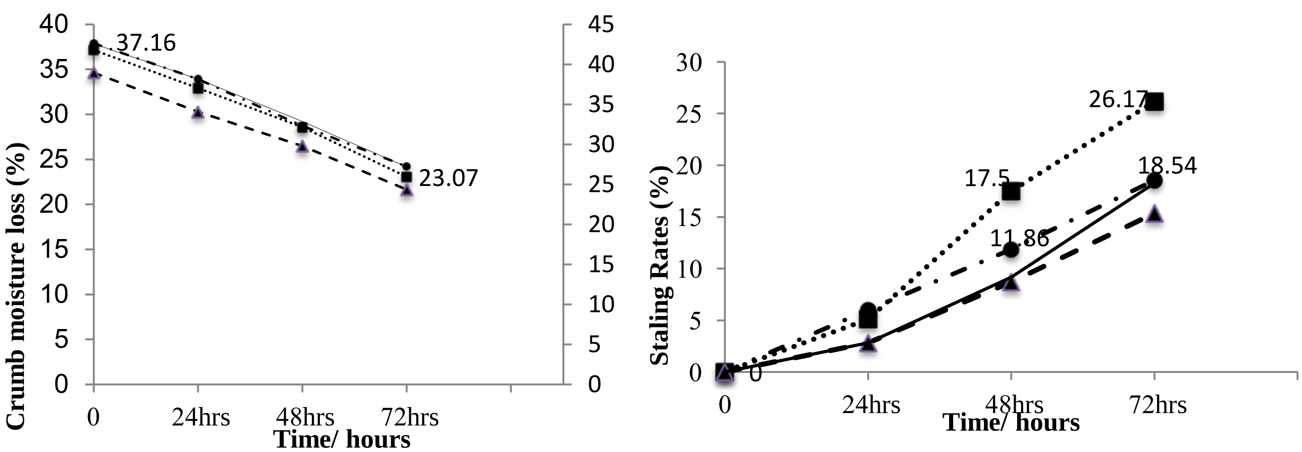

Fig. 2 Percentages of the Crumb moisture loss (**a**) and Staling rates (**b**) of Baladi bread loaves at zero time, 24, 48, and 72 hours at 25°C.

Loaves of wheat variety Sids-14 in Sids location: (─); loaves of wheat variety Misr-2 in Sids location: (---▲---) ; loaves of wheat variety Sids-14 in West-West Al-Minya location: (¨¨■¨¨) ; loaves of wheat variety Misr-2 in West-West Al-Minya location: (-·-·-●-·-·-)

In addition, the starch of Misr-2 showed a decreased C5-C4 value, meaning improved shelf-life of Baladi bread. It is thought that the retrogradated amylopectin in the starch molecule absorbs the water in the gluten protein, causing the moisture to transfer from the bread crumb to the crust. Consequently, the bread loses its freshness, crispness, and palatability and becomes more firm **(Sehn, and Steel, 2020).**

The nutritional quality of Baladi bread

Table 6. exhibits the nutritional composition of Baladi bread on dry weight. The crude protein contents of the Baladi bread followed a similar pattern to those of its flour (Table 3), with the Baladi bread from the West-West Al-Minya location having higher ($P \leq 0.05$) crude protein contents than those from the Sids location, and the Baladi bread produced from wheat variety

Sids-14 being superior ($P \leq 0.05$). Notably, numerous researchers have observed that the amino acid proline is one of the most common amino acids that are produced and stored in wheat and its products under salinity-stress **(Aycan, *et al.*, 2022)**, indicating that there might be more content of proline in the Baladi bread at the West-West Al-Minya location. That is significant from a nutrition point of view, where proline helps in wound healing, antioxidant reactions, and immune responses. Moreover, it plays a role in the biosynthesis of polyamines, arginine, and glutamate.

For crude fat in Baladi bread, when comparing the two wheat varieties in the two locations, there were no ($P \leq 0.05$) differences in the contents of crude fat. That may be because wheat flour is not known for being high in crude fat. As a result, any changes in the Baladi bread crude fat content under salinity stress were probably minor and may not have ($P < 0.05$) influence in the bread overall composition, where the major constituents of the bread were mostly of crude protein and total carbohydrates.

Regarding the ash content of Baladi bread, the wheat variety Misr-2 had higher ($P \leq 0.05$) ash content than Sids-14. Salinity stress in the West-West Al-Minya location significantly lowered the ash contents of Baladi bread compared to the normal conditions for cultivation in the Sids location. That is due to improved absorption of minerals from the irrigation water and soil in the Sids location, as mentioned in Table 1; nonetheless, salinity stress in the West-West Al-Minya location relates to mineral absorption, translocation, and accumulation systems, which lead to a severe decline in the ash content of Baladi bread **(Salehi, and Arzani, 2013; Nadeem, *et al.*, 2020; EL Sabagh, *et al.*, 2021).**

For crude fiber, no significant changes were found in the crude fiber contents of Baladi bread samples, the same in the West-West Al-Minya or Sids locations. While Baladi bread is produced from 82% extraction rate of wheat flour, it retains significant amounts of the wheat kernel, which includes the bran rich in fiber. This offers many nutritional benefits, such as promoting digestive health, managing satisfaction and weight, and controlling blood sugar. Additionally, it has important elements like antioxidants, minerals, and vitamins **(Abdel-Haleem, 2019).**

Table 6. Nutritional composition of Baladi bread on dry weight

Baladi bread	Moisture (g/100gm)	Crude protein (g/100gm)	Crude fat (g/100gm)	Ash (g/100gm)	Crude fiber (g/100gm)	TC (g/100gm)	Energy KCal./100gm
Location	Sids location (normal conditions)						
Sids-14	11.36±0.01[b]	15.56±0.05[b]	0.83±0.04[a]	1.53±0.01[b]	0.84±0.01[c]	81.24±0.1[b]	394.67±0.21[a]
Misr-2	11.12±0.01[c]	14.19±0.03[c]	1.04±0.3[a]	1.79±0.01[a]	0.92±0.02[b]	82.06±0.31[a]	394.36±1.4[a]
Location	West-West Al-Minya location (Salt-stress conditions)						
Sids-14	10.78±0.03[d]	16.21±0·03[a]	0.95±0.04[a]	1.48±0.01[c]	0.88±0.01[bc]	80.48±0.04[c]	395.31±0.15[a]
Misr-2	11.81±0.1[a]	15.37±0.04[b]	0.85±0.01[a]	1.77±0.02[a]	0.96±0.01[a]	81.05±0.01[b]	393.33±0.18[a]

Data are presented as means ± SDM (n=3) & Means within a column with different letters are significantly different at $P \leq 0.05$.

The total carbohydrates content of Baladi bread was in a similar trend to the values of the flour starch, as mentioned in Table 3, whereby the Baladi bread sample from the West-West Al-Minya location had lower significant total carbohydrates than those from the Sids location, and the Baladi bread sample of wheat variety Sids-14 was significantly the lowest. Wheat grains and their products can have changes in their carbohydrate composition due to salinity stress. Particularly, it could contribute to changes in the proportions of sugars, starch, and other carbohydrates, with a significant correlation between dietary carbohydrates, glycemic index, and blood glucose in the human body **(Sadak, 2019; Bonsembiante *et al.*, 2021).** There were no **(**$P \leq 0.05$) differences in Baladi bread's energy found between the Sids or West-West Al-Minya locations. That may be due to the increase in the content of crude protein compensating for a decrease in total carbohydrates, as the energy of the Baladi bread comes mainly from the total carbohydrate contents, crude proteins, and crude fats.

The mineral contents of Baladi bread

Table 7. represents the mineral contents of Baladi bread loaves. The mineral composition is reflected by the amount of ash in Baladi bread. Significantly, the ash content and mineral compositions (with the exception of Zn and Fe) of Baladi bread produced from wheat variety Misr-2 were higher ($P \leq 0.05$) than those of Baladi bread produced from wheat variety Sids-14. Another significant change is the increase in Na levels and lower Zn and Fe levels in the West-West Al-Minya location, particularly in Baladi bread produced from the wheat variety Misr-2. High soil salinity increased Na levels and impacted the balance of essential minerals in wheat grain and its products, according to research by **Nadeem *et al.* (2020).** Therefore, since an excessive Na intake is generally not desirable for human health, special considerations should be taken if this Baladi bread is subject to a bread subsidy system for Egyptians. Furthermore, an imbalance in essential minerals may have an impact on the bioavailability of iron and zinc.

Table 7. Mineral contents of Baladi bread

Baladi bread	Na (mg/100g)	K (mg/100g)	P (mg/100g)	Ca (mg/100g)	Mg (mg/100g)	Zn (mg/100g)	Fe mg/100g)
Location	Sids location (normal conditions)						
Sids-14	147.37^{bc}	294.74±0.58^{c}	58.36±0.21^{c}	65.47±0.11^{b}	89.71±0.17^{c}	0.74±0.09^{a}	4.70±0.34^{a}
Misr-2	165.685^{b}	331.37±0.15^{a}	74.45±0.16^{a}	88.30±0.32^{a}	118.17±0.07^{a}	0.65±0.47^{b}	3.26±0.22^{b}
Location	West-West Al-Minya location (Salt-stress conditions)						
Sids-14	577.00^{a}	288.50±0.33^{d}	39.79±0.26^{d}	63.76±0.19^{c}	89.40±0.13^{cd}	0.53±0.05^{c}	3.39±0.22^{b}
Misr-2	656.67^{a}	330.29±0.05^{b}	73.33±0.08^{b}	57.57±0.05^{d}	97.35±0.13^{b}	0.64±0.11^{b}	2.92±0.17^{c}

Data are presented as means ± SDM (n=3) & Means within a column with different letters are significantly different at $P \leq 0.05$.

CONCLUSION

Soil and water salinity in the Western Desert Region of Egypt negatively influence the agronomical development and yield attributes of wheat grains, which may diminish flour rheological behavior and bread quality. Accordingly, there is a need to correlate these adverse soil and water conditions with flour and breadmaking qualities. This study evaluates the quality of flour and Baladi bread produced by two wheat varieties, Sids-14 and Misr-2, in favorable and stressed locations. Salinity stress significantly altered the agronomic traits and yield performance of wheat plants, reduced the flour composition, rheological properties, sensory, physical, and nutritional qualities of Baladi bread. However, the West-West Al-Minya location with the Misr-2 variety showed promise for future expanded cultivation due to its productivity and satisfactory qualities. Further research is needed to analyze the amino acid proline, zinc, and iron bioavailability of Baladi bread.

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