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Quality of Flour and Balady Bread Made of Two Bread Wheat Varieties Planted in a Favorable and Saline-Stressed Location in Egypt

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Abstract: This study aims to assess the quality of the flour and Balady Bread of two bread wheat varieties, namely Sids-14 and Misr-2, planted in Sids Station as a favorable location and in West-West El-Minya as a saline-stressed location, in the seasons 2018–2019 and 2019–2020. Salinity stress in West-West El-Minya had ($P \leq 0.05$) changes in the agronomic characteristics and yield performance of the wheat plants, which ($P \leq 0.05$) diminished the flour composition and rheological behavior, and the sensory, physical, and nutritional properties of the Balady Bread. The wheat plants grown at the West-West El-Minya location were earlier in heading and maturity, shorter in height, had a reduced number of kernels per spike, thousand kernel weight, and grain yield than those cultivated under Sids conditions. The flour of the wheat variety Sids-14 might, however, have more ($P \leq 0.05$) crude protein and wet gluten, but its dough showed lower water hydration, extended development time, and stability time, with significant protein weakening (C2), hot gel stability (C4), and starch retrogradation in the cooling phase (C5). The flour of the wheat variety Misr-2 exhibited lesser ($P \leq 0.05$) changes and better performance in most of the studied characteristics, with an increase in crude protein, wet and dry gluten contents, higher water hydration, and an anti-staling effect (C5-C4) for its bread. Balady Bread loaves from the West-West El-Minya location had ($P \leq 0.05$) acceptability scores in the crust color, taste, and odor; more dietary protein with reduced specific volume; lower ash contents; and an extreme increase in Na and lower Zn and Fe contents. This study recommended that the West-West El-Minya location is promising for future wheat cultivation due to its good yield productivity and acceptable flour and bread qualities, despite its stress conditions, and the wheat variety Misr-2 was better than Sids-14 under these conditions.

Keywords: Sids-14 and Misr-2. Salinity stressed-locations. Rheological and physicochemical properties. Staling rates. Nutritional and sensory characteristics.

1 Introduction

Bread wheat (*Triticum aestivum* L.) is one of the most widely grown crops worldwide, covering 220 million hectares with an annual production of 729 million tons. It is a staple food for one-third of the human population, which represents about 20% of global dietary energy and protein intake [1-4]. In Egypt, wheat stands first in terms of harvested area of 1,392 thousand hectares, production of 9,070 thousand tons, and yield of 6.5 metric tons per hectare as the last 5-year average [5] and provides one-third of Egyptian daily caloric intake and 45% of protein intake, mainly in the form of subsidized Balady Bread. Egyptians consume 18.5 million tons of wheat annually, while it reaches 196 kilograms per capita, which surpass the world average by about 100 kilograms [6].
There is no doubt that wheat is the most essential crop contributing to global food security; an additional 224–359 million tons will be needed to meet the increased global demand by 2050, especially with the array of changing diets and growing world populations, rising prices for fertilizers, and plant- and animal-based products [2, 3]. Regarding the Egyptian food security of wheat, Egypt is the largest wheat importer in the world; it has been severely affected economically, especially after the Corona crisis, the Ukrainian-Russian War, and exaggerated inflation in grain prices [7]. Thus, the agricultural sector in Egypt has to face these unprecedented food security challenges. Increasing wheat production by expanding land reclamation, especially in the Western Desert, is an

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inevitable strategic objective in Egypt to narrow the gap between wheat consumption and production [6-10]. The location of West El-Minya is considered the most desert area targeted for soil reclamation in Egypt, where about 250.000 hectares were reclaimed by the Egyptian government in the ‒West Minya Land Opening Project between 2013 and 2022 [11, 12]. The location of West El-Minya depends mainly on groundwater extraction through drilled wells. Moreover, it represents a stressful environment due to the partly saline irrigation water and the unfavorable environmental conditions [13]. The electrical conductivity (EC, dS m^{-1}) of the soil and irrigation water of the West-West El-Minya location ranges from 2.0 to 4 dS m^{-1}, which is classified as ‒slightly saline, and sensitive crops are affected; moreover, yield loss for more sensitive crops is taking place [14]. Wheat is considered a moderately sensitive crop to salinity stress, and the quality of wheat varieties depends mainly on extrinsic factors such as the stress conditions; besides the intrinsic factors such as the physicochemical properties of the varieties, both of them closely influence the flour and bread qualities, especially the protein composition, baking properties, and the ability to make quality dough [15- 17]. Despite many reports that discuss the yield productivity of the bread wheat varieties grown under normal and salinity conditions in the Western Desert Region [6, 7, 18-21], there is a need for more studies that extensively correlate between the extrinsic and intrinsic factors and the flour and bread qualities. Accordingly, with the above in mind, the objectives of this research were: (a) to evaluate the yield and quality performance of two bread wheat varieties, including Sids-14 and Misr-2, at two locations representing the favorable one in Sids Agricultural Station, Beni Swef Governorate, and the newly reclaimed lands in Experimental Farm of West-West El-Minya, El-Minya Governorate, during the two growing seasons of 2018-2019 and 2019-2020; (b) to assess the quality of the milled flour in terms of chemical and rheological properties; and (c) to assess the quality of the Balady Bread in terms to physical properties, staling rates, nutritional quality and sensory characteristics.

2 Materials and Methods

2.1 Materials

Two local bread wheat varieties were evaluated at two locations representing favorable and newly reclaimed lands during the two growing seasons of 2018–2019 and 2019–2020. The first location was Sids Agricultural Station, Beni Swef Governorate (latitudes 29° 3' North, longitudes 31° 6' East), representing a favorable environment. The second location was the Experimental Farm of West-West El-Minya, El-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 due to the partly saline irrigation water and the unfavorable environmental conditions. The location of West El-Minya is considered the desert area targeted for soil reclamation in the past decade, depending mainly on groundwater extraction through drilled wells. Table 1 represents some of the physicochemical properties of the soil and the irrigation water at the two studied locations. The name and pedigree of the two wheat varieties are as follows:

Sids-14: BOW "S"/VEE "S"/BOW S"/TSI/3/" BANI SEWEF 1
Misr-2: SKAUZ/BAV92

Pancreatic α-amylase (1: 2000 activity) was obtained from Oxford Lab. Chem, India. Amyloglucosidase (amylo 300) was obtained from Biocon. India Pvt. Ltd., India. *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 Giza, Egypt. The instant dry yeast ingredients mentioned on the label were *Saccharomyces cerevisiae* and the emulsifier (E491): sorbitan monostearate. All chemicals used in this study were analytical reagent grade.

2.2 Methods

Field trial design

The experiment was laid out in a randomized complete block design (RCBD), with three replications for each planting date. Each plot consisted of 6 rows, 3 m long and 20 cm apart. All other agricultural practices were applied as recommended. The studied characters were the earliness characters: days to heading (DH), days to maturity (DM), and agronomic characters: plant height (PH); number of spikes per meter square (S/M^2); number of kernels per spike (NK/S); grain yield (GY, Kg/plot $3.6m^2$); Hectoliter (HL, Kg/L); thousand kernel weight (T-KWT); Normalized Difference Vegetation Index (NDVI); Total Chlorophyll Content (TCC). The TCC was determined using the Chlorophyll Meter, 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. on a sunny day. Three replicates for each plot were measured.

Wheat grain milling and Extraction rate

Wheat grain was tempered overnight at 38–40 °C to 14% moisture content and milled into a flour extraction rate of 72 g/100 g 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 combined with a flour extraction rate of 72 g/100 g to obtain a flour extraction rate of 82 g/100 g following equation 1:

$$\text{Extraction rate (g/100 g)} = \frac{\text{flour (g)}}{\text{crude wheat (g)}} \times 100 \quad (1)$$

After flour extraction from each wheat variety (Sids-14 and Misr-2) , the extracted flour of the two seasons (2018–2019 and 2019–2020), were combined for further rheological and breadmaking assessments.

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

	Sids location		West-West El-Minya location		
Properties	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 dSm^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	–	–

Mixolab analysis

Dough mixing properties, quality of starch, and protein of wheat flour extraction rate of 82 g/100 g were determined using a Mixolab 2 (Chopin Technologies, France). Standard Chopin+ analysis protocol according to AACC International [22] Approved Method 54-60 in compliance with ISO ICC173/1. A mixing bowl of 50 g and a mixing speed of 80 RPM were used. 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.

Balady Bread preparation and baking

The baking formula of 1000 g of the obtained flour extraction rate of 82 g /100 g (14% moisture basis), 10 g of instant dry yeast, and 10 g of table salt. All ingredients 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 one hour at 35–37 °C and 80 % relative humidity and then was transferred to a wooden bowl and allowed to ferment at 35–37 °C and 80 % relative humidity for an additional 30 minutes. Dough is portioned by hand into 120–130 g parts on wooden racks (covered with a layer of fine bran) and then dusted with flour. After proofing and fermentation for an additional 15 minutes, dough pieces were dusted again with fine bran, flattened, degassed by gentle hand pressing, and then baked in a hot steel belt oven at 450±50°C for one minute. Balady Bread loaves were allowed to cool down for about one hour before a different assessment.

Sensory evaluation of Balady Bread loaves

A panel of 15 subjects from the staff of the Food Technology Research Institute, Agricultural Research Center, Al Giza, Egypt, evaluated the sensory properties of Balady Bread loaves according to Hegazy & Faheid [23]. The panelists give 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*).

Balady Bread specific volume (cm^3/g)

The specific volume of Balady Bread loaves was determined according to the AACC International [22] Approved Method 10–05.01, using the rapeseed displacement procedure. The specific volume was calculated as loaf volume (cm^3) divided by Balady bread weight (g).

Chemical analyses

Total starch in wheat flour was hydrolyzed by heat-stable α-amylase, followed by amyloglucosidase, according to the AACC International [22] Approved Methods 76–13.01. The released glucose from digested starch maltodextrin was determined against the standard curve of *D*-glucose. A molar mass of 0.9 was used to convert glucose to the starch monomer unit. The contents of moisture, crude protein, crude fat, ash, and crude fiber were determined according to the AACC International [22] Approved Methods 44-16, 46-30, 30-10, 08-01, and 32-10.01, respectively. Total carbohydrates was calculated by subtracting the sum of the percentages of moisture, crude protein, crude fat, ash, and crude fiber from 100. Crud protein content was calculated as N × 5.7. The energy of Balady Bread loaves was calculated by the formula of James [24], following equation 2:

$$\text{Energy (kcal/100g)} = \text{Crude fat} \times 9 + \text{Crude protein} \times 4 + \text{Total carbohydrates} \times 4 \quad (2)$$

Sodium (Na), potassium (K), phosphorous (P), calcium (Ca), magnesium (Mg), zinc (Zn), and iron (Fe) contents were determined according to the AACC International [22] Approved Method 40-75.01, using the Agilent Technologies Microwave Plasma Atomic Emission Spectrometers (Model 4210 MPAES, USA). Wet gluten, dry gluten, and gluten index were determined using the method described by AACC International [22] 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:

$$\text{Flour yield (\%)} = \frac{\text{Total Flour}}{\text{grain weight}} \times 100 \quad (3)$$

Percentage of staling rates (%SR)

Percentage of staling rates (%SR) were calculated using the Alkaline water retention capacity method according to Yamazaki [25] as modified by Kitterman,& Rubenthaler [26] following equation 4:

$$\text{SR(\%)} = \frac{AWRC_0 - AWRC_n}{AWRC_0} \times 100 \quad (4)$$

Where SR (%):Percentage of staling rates; $AWRC_0$: 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 Balady bread sample, was put in 15 ml tube (W_1), then 5 ml of 0.1 N $NaHCO_3$ were added and mixed for 30 s and were let at room temperature for 20 min. The slurry was centrifuged at 3000 rpm for 15 min, the supernatant was discarded and tubes were let to drip upside down for 10 min. Dried tubes were then weighed (W_2). The percentage of AWRC was calculated following equation 5:

$$\text{AWRC (\%)} = \frac{W_2 - W_1}{W_1} \times 100 \quad (5)$$

Where AWRC: Alkaline water retention capacity, W_1: weight of tube containing the dry sample; W_2: 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 evaluations were analyzed using computer software CoStat 6.303, CoHort, USA, 1998–2004 for Windows; an analysis of variance (ANOVA) followed by Duncan's multiple range tests at $P \leq 0.05$ to compare between means.

3 Results and Discussion

Agronomic and physiological characteristics and yield performance

Table 2. represents the mean values of all studied traits under Sids and West-West El-Minya locations during seasons (2018–2019) and (2019–2020). The results revealed the presence of significant ($P \leq 0.05$) differences between the two locations in terms of all traits except plant height (PH) and the normalized difference vegetation index (NDVI). This result confirms the existence of substantial differences between the two locations about salinity stress, which affected the characteristics and productivity of the wheat plants. The results showed that the wheat plants grown at the West-West El-Minya location were earlier in heading (DH) and maturity (DM) than those cultivated under Sids conditions. Wheat plants tend to early mature under stressful conditions as a type of adaptation. The plant height (PH) was shorter at the West-West El-Minya location than those cultivated at the Sids one. Concerning yield productivity and its attributes, it can be noticed the grain yield (GY) and the number of kernels per spike (NK/S) produced from the West-West El-Minya location were decreased compared to those from the Sids location. Concerning T-KWT (g), it is shown that the T-KWT produced from the West-West El-Minya location was significantly decreased in Sids-14 by 10.0, and 22.14%, and Misr-2 by 9.4 and 5.0% for both seasons, respectively, compared to those produced from the Sids location. It means that the wheat variety Misr-2 caused less reduced T-KWT in the West-West El-Minya location. These results are in agreement with the findings of Darwish *et al*. [7], Ibrahim, & Said [19], and Sayed *et al*. [20], who demonstrated that wheat plants are significantly affected by the surrounding stressed locations. The decrease in T-KWT was due to reduced grain filling as affected by various environmental stresses, such as salinity, drought, or heat, as it may cause losses in kernel density and weight and shriveling of the grains [27, 28].

The hectoliter weight is a significant physical quality criterion designating the flour yield. Hectoliter (HL, Kg/L) depends on the shape, size, and soundness of grains. The hectoliter weight showed a reduction in the West-West El-Minya location with a wide range of variations for both seasons, from a minimum of 204.57 kg/l to a maximum of 211.63 kg/l. The difference in the HL may be attributed to the difference in T-KWT, the salinity stress, and the genetic makeup of the wheat varieties Sids-14 and Misr-2 [29].

The current results confirmed that the West-West El-Minya location is promising for future wheat cultivation due to its good yield productivity despite its stress conditions. Al-Naggar *et al*. [30] mentioned that the stress-tolerant genotypes are characterized by early maturity, short plant height, and high grain yield. The current results are in accordance with the findings obtained by Darwish *et al*. [7], Ibrahim & Said [19], and Abdelkhalik *et al*.[31], who confirmed that wheat plants are strongly affected by the surrounding environmental conditions.

The quality characteristics of wheat flour

Table 3 represents the quality characteristics of wheat flour from Sids and West-West El-Minya locations at seasons 2018–2019 and 2019–2020. Data in Table 3 showed a ($P \leq 0.05$) reduction in total starch contents in the West-West El-Minya location by 2.2 & 0.4 and 3.2 & 1.35 % in the wheat varieties Sids-14 and Misr-2 for both seasons, respectively. The reduction in total starch content was more ($P \leq 0.05$) in the wheat variety Misr-2. The decrease in total starch content could be attributed to two main reasons: The first reason is that the salinity stress in the West-West El-Minya location inactivates starch synthase, the key enzyme of starch biosynthesis, which leads to a lower accumulation of starch in the endosperm reaction pathway. The second reason is the decrease in the number and surface area (less than 9.9 µm) of the β-granules that store starch in the wheat kernel [28, 32].

The protein quantity of cereal is known to be influenced by variety and environmental conditions [33]. The salinity stress in the West-West El-Minya location influenced ($P \leq 0.05$) the protein content in wheat flour compared to the favorable conditions in the Sids location. The protein contents increased in the West-West El-Minya location from 2.3% to 7.8% and 8.8% to 11.63% in the wheat varieties Sids-14 and Misr-2 for both seasons, respectively. The increase in protein content was more ($P \leq 0.05$) in the wheat variety Misr-2. Similarly, Salehi & Arzani [27] and Nadeem *et al*. [34] observed a higher protein content of wheat flour in salinity-stressed conditions, which could be explained by the yield loss and decreased T-KWT due to the reduction in starch production [35, 36]. Noteworthy, the protein contents in wheat varieties Sids-14 and Misr-2 comply with the Egyptian Standard ES: No. 1251-1 [37], which states that wheat flour with different extraction rates should have a protein content of around 9% on a wet base.

The gluten index is a measurement for determining gluten quality and quantity [22]. Wet and dry gluten contents and compositions are the key determinants that influence the quality of the bread making of wheat flour. However, they are influenced by environmental conditions and the genetic background of wheat cultivars [27, 38].

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

Season	First season 2018/ 2019				
Location	Sids location		West-West El-Minya location		
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±0.577b^{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		West-West El-Minya location		
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/M2): no. spikes m-2, NK/S: no. kernels spike, NDVI: normalized difference vegetation index, TCC: total chlorophyll content, GY: grain yield (Kg/plot 3.6m2), - 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 $P \leq 0.05$.

Salinity stress in the West-West El-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%, first season only) in the flour of the wheat variety Misr-2 for both seasons, compared to the favorable conditions in the Sids location. Inversely, salinity stress in the West-West El-Minya location caused a ($P \leq 0.05$) reduction in wet gluten (33.34–1.48%), dry gluten (22.45–4.9%), and a ($P \leq 0.05$) increase in gluten index (4.73, second season only) in the flour of the wheat variety Sids-14. The same observation was obtained by El Sabagh et al. [38], who found that salinity tends to boost wet and dry gluten contents in salt-tolerate wheat varieties, while the opposite has been observed for salt-sensitive cultivars. That means Misr-2 could be classified as a salt-tolerant wheat variety, while Sids-14 could be salt-sensitive. It seems that the genotypic background could be the reason for the different gluten contents under the same condition [39].

A decrease in the ratio of glutenin (responsible for dough elasticity) to gliadin (responsible for dough extensibility) and ultimately lessening 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, being less influenced by phenotypic factors [16, 27, 40]. However, the present findings revealed that wet gluten is at an optimal value for Balady Bread making, where the Egyptian Standard (ES: No. 1251-1 [37] stated that wheat flour with an extraction rate of 82% should have a percentage of wet gluten ranging ~ 25% at a moisture base of 14%. Also, the higher values of the gluten index than 80 [40] emphasize that both Misr-2 and Sids-14 varieties have strong gluten.

Data in Table 3 showed a ($P \leq 0.05$) reduction in flour yield (%) in the West-West El-Minya location by 17.67 and 5.75% and 10.4 and 3.56% in the wheat varieties Sids-14 and Misr-2 for both seasons, respectively.

The reduction in flour yield was ($P \leq 0.05$) in the wheat variety Sids-14 than that of Misr-2. This reduction could be attributed to the reduced T-KWT, hectoliter weight (Table 2), and total starch contents (Table 3).

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

Season	First season 2018/2019					
Location	Sids location		West-West El-Minya location			
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 $P \leq 0.05$.

The same findings observed by Dhaka *et al*. [29], McDonald & Kheir [41], Wang *et al*. [42], and Gebreil, & Mohamed [43] who stated that wheat varieties possessing better test weight, thousand kernel weight, and starch content offer great potential for better milling yield; however, increasing groundwater salinity levels lead to a decrease in grain weight, total starch content, and, in consequence, flour yield. Interestingly, Ragab & Kheir (2021) [44] and Mitura *et al*. [45] confirmed that bread wheat should be cultivated in a way ensures a high yield of perfected quality characteristics to meet the requirements of millers.

The rheological behavior of Balady Bread dough

Table 4 summarizes the rheological behavior of Balady Bread dough at the two studied locations, obtained from Mixolab curves. The first stage of Mixolab curves determines the protein behavior during dough mixing: water absorption (% WA), development time (DT), and stability time (ST). Data showed that the percentage of water absorption in the West-West El-Minya location was significantly ($P \leq 0.05$) lower compared to the Sids location, and the flour of the wheat variety Sids-14 absorbed an insignificant ($P \leq 0.05$) lesser amount of water than that of the Misr-2 variety. The decrease in WA could be attributed to the fact that salinity stress may alter the net charges on the protein surface, speed up the hydrophobic protein-protein interactions, and decrease the level of gluten hydration, thereby strengthening the gluten network. Besides, the osmosis delays gluten hydration [46, 47].

The time required for the dough to reach the C1 torque (DT, min) in the West-West El-Minya location was ($P \leq 0.05$) longer compared to that time in the Sids location, and the dough of the wheat variety Sids-14 takes more ($P \leq 0.05$) time to develop than that of the Misr-2 variety. This behavior could be attributed to the fact that salinity decreased the free sulfhydryl interactions and increased the β-sheet structure and the non-covalent interactions of gluten, implying that more polymeric or fibrous structures and less soluble protein networks were formed [48],

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

Flour	WA	DT	ST	C1	C2	α	C3	β	C4	γ	C5	C5-C4
	(%)	(min)	(min)	(Nm)	(Nm)	(Nm/min)	(Nm)	(Nm/min)	(Nm)	(Nm/min)	(Nm)	(Nm)
Location	Sids location											
Sids-14	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 El-Minya location											
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 $P \leq 0.05$.

which increased the mixing tolerance of the dough, delayed the dough development time to reach the C1 torque, and extended the dough mixing time. Besides, part of this dough resistance effect is due to the ($P \leq 0.05$) decrease in the water absorption of the flour in saline-stressed wheat, as mentioned above [49, 50]. The dough development time values are very significant for Balady Bread making, as the development of the gluten protein network should be perfected to ensure a high volume of loaves [51].

Dough stability time (ST, min) underwent the same behavior as that of (DT), where the dough of the West- West El-Minya location showed ($P \leq 0.05$) resistance against mixing and exhibited higher ($P \leq 0.05$) dough stability values. It is usually related to the strength of the gluten network or the C2 values, where strong proteins with higher C2 (0.44 Nm) have developed (5:42 min) and improved their stability (8:77 min) lately.

C2 determines protein weakening as a function of thermal and mechanical constraints. The C2 values (Nm) of dough in the West-West El-Minya location showed a significant ($P \leq 0.05$) increase compared to those values of the Sids location. The dough of wheat variety Sids-14 exhibited the highest ($P \leq 0.05$) protein weakening, meaning that higher mechanical and thermal energy would be required to resist the gluten and break the protein networks of Sids-14 dough than that dough of protein networks of Misr-2 to rich C2 torque, implying higher ($P \leq 0.05$) mechanical and thermal stabilities of Sids-14 dough. Besides, the protein weakening speed under heating constraints (α, Nm/min) also decreased. The same observation was obtained by Kim *et al*. [50] and Singh *et al*. [52].

C3 (Nm) determines the starch gelatinization ability. The C3 values of dough in the West-West El-Minya location showed a numerical (insignificant) increase in reference to those values in the Sids location. However, the β slope that determines the speed of the starch gelatinization process exhibited an increase ($P \leq 0.05$). It is well known that salinity stress increased protein accumulation and decreased starch content, especially the content of the short-branched chain of amylopectin; the stability of the starch crystals increased; the gelatinization temperature increased; and the further torque C3 and β slope values increased [53]. Another concern is that as the decrease in starch contents is associated with decreased number and surface area of the β-granules that store starch in the wheat kernel, the *A*-type granules increased [28, 32, 54]; those *A*-type granules are associated with higher thermal properties of starch [55].

C4 measures the stability of starch-hot gel under the thermal constraints of Mixolab as affected by the α-amylase of wheat flour. The C4 values (Nm) of starch hot gel in West-West El-Minya location showed a significant ($P \leq 0.05$) increase in reference to those values of Sids location, and the hot gel of wheat variety Sids-14 exhibited the highest ($P \leq 0.05$) stability and superior ($P \leq 0.05$) speed of enzymatic amylosis (γ-slope).

C5 measures starch retrogradation in the cooling phase [56]; C5 underwent the same behavior as C4 [50], in which the starch of West-West El-Minya location exhibited a ($P \leq 0.05$) increase in retrogradation in the cooling phase, in reference to those values of Sids location, due to the higher degree of starch gelatinization in the heating phase (C4). The starch of Misr-2 showed a slight ($P \leq 0.05$) anti-retrogradation than Sids-14, which may be significant to postponed staling in Balady Bread of Misr-2 [51].

The sensory acceptability scores of Balady Bread loaves

Table 5 represents the sensory acceptability scores of Balady Bread loaves. The sensory acceptability scores of Balady Bread loaves showed ($P \leq 0.05$) changes in general appearance, distribution of crumb, crust color, taste, and odor, as affected by the salinity stress in the West-West El-Minya location, compared to the optimal conditions in the Sids location. However, no ($P \leq 0.05$) changes observed in the scores of the separation of layers, roundness and overall acceptability. The panelists gave lower ($P \leq 0.05$) scores (from "*like extremely*" to "*like very much*") for the general appearance and distribution of crumb for the loaves of the West-West El-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 Balady Bread loaves [36, 51, 57, 58]. Interestingly, in one study, it was observed that the general appearance of bread samples varied depending on the water content in the dough, with intermediate water content being preferred by panelists [59]. Moreover, salinity stress ($P \leq 0.05$) affects the gluten behavior (C2, Table 4) and contents (Table 3), which impact the elasticity and structure of the dough. That can result in variations in the size and distribution of air pockets within the Balady Bread, potentially making it denser or affecting its crumb texture or distribution [58, 60, 61]. 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 Balady Bread loaves of the West-West El-Minya location. Salinity stress significantly influences wheat grain metabolism, which can impact the aromatic profile of the bread flour [62]. It can, in turn, produce a more intense toasted aroma and flavor [63], resulting in ($P \leq 0.05$) differences in the taste and odor of the baked loaves of West-West El-Minya location compared to those loaves made from optimal conditions in Sids location. Additionally, different salt levels have been found to affect the sensory profile of bread, with higher levels promoting the formation of Millard reaction products and caramelization during baking [64], resulting in ($P \leq 0.05$) differences in crust color of Balady Bread loaves.

Table 5. Sensory acceptability scores of Balady Bread loaves.

Balady Bread	General Appearance (9)	Separation of Layers (9)	Roundness (9)	Distribution of Crumb (9)	Crust Color (9)	Taste (9)	Odor (9)	Overall Accept-ability (9)
Location	Sids location							
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 El-Minya location							
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 $P \le 0.05$.

It is important to note that the ($P \le 0.05$) differences in the sensory scores can depend on the severity of salinity stress as well as the wheat variety. The electrical conductivity (EC dS m^{-1}) of the soil and irrigation water of the West-West El-Minya location ranges from 2.5 to 3.41 dS m^{-1} (Table 1), which is classified as slightly saline according to the guidelines of Scianna [65]. That explains why there were ($P \le 0.05$) differences in some of the sensory scores of the Balady Bread, while the transition on the hedonic scale was changed slightly from 9: *like extremely* to 8: *like very much*.

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

Fig. 1 & 2 represent the specific volume (cm^3/g) of Balady Bread loaves. The specific volume (cm^3/g) of Balady Bread in the West-West El-Minya location showed a significant ($P \le 0.05$) decrease in reference to those values of Sids location, and the specific volume of wheat variety Misr-2 (■) showed a ($P \le 0.05$) reduction (7.28%) than that specific volume of Sids-14 (□) showed a reduction of 3.69% (Fig. 1). Other reports obtained by Caffe-Treml *et al*. [57] and Karimzadeh *et al*. [36] confirmed the same reduction of bread volume under salinity stress conditions. This behavior is attributed to the lower percentage of water absorption, extended dough stability, and dough development times in the West-West El-Minya location, as obtained from Mixolabe curves (Table 4). Caffe-Treml *et al*. [57] and Schmiele *et al*. [51] found significant correlations between loaf volume, dough stability, dough development time, and WA. Also, Okuda *et al*. [58] observed a reduced bread volume when the water hydration of flour was <45%. The lower water hydration of the flour below the optimal amount keeps up protein-protein hydrogen bonding and limits gliadin protein from being embedded into the network structure. Moreover, a weak viscoelastic protein networking is formed, which cannot retain the CO_2 produced during dough fermentation, resulting in lower bread-specific volume [61]. Another concern is that the flour quality and composition of the gluten protein play a significant role in determining the loaf-specific volume of the Balady Bread. The protein content and the amount of wet gluten of wheat variety Sids-14 in the West-West El-Minya location were ($P \le 0.05$) higher than those of wheat variety Misr-2 (Table 3). The higher the gluten content, the more favorable the rheological characteristics and the higher the bread volume [60]. Moreover, the dough of wheat variety Sids-14 showed a higher ($P \le 0.05$) C2 value and a lower ($P \le 0.05$) protein weakening speed (α) than that of wheat variety Misr-2 in the West-West El-Minya location (Table 4); Flour with more strong gluten networks, characterized by higher resistance to mechanical and thermal constraints, has a higher ability of the network to enclose carbon dioxide during fermentation and produces bread with a higher specific loaf volume [66, 67].

Fig. 3 (a & b) represents the percentages of crumb moisture loss and staling rates of Balady Bread loaves at zero time, 24, 48, and 72 hours at 25°C. The percentages of staling rates (Fig. 3b) of Balady Bread loaves exhibited a significant ($P \le 0.05$) increase in the West-West El-Minya location after 0, 24, 48, and 72 hours compared to those rates (%) in the Sids location. The loaves of wheat variety Sids-14 (¨■) exhibited higher ($P \le 0.05$) staling rates than loaves of wheat variety Misr-2 (- ˙-•˙-˙-) after 48 and 72 hours.

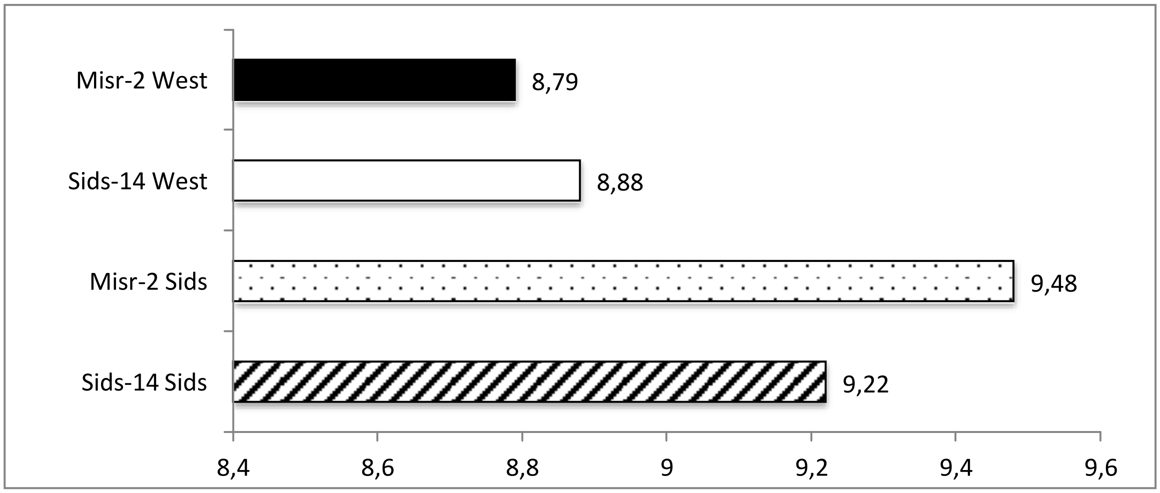

Fig. 1 Specific volume (cm^3/g) of Balady Bread loaves.

(▨):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 El-Minya location; (■):loaves of wheat variety Misr-2 in West-West El-Minya location.

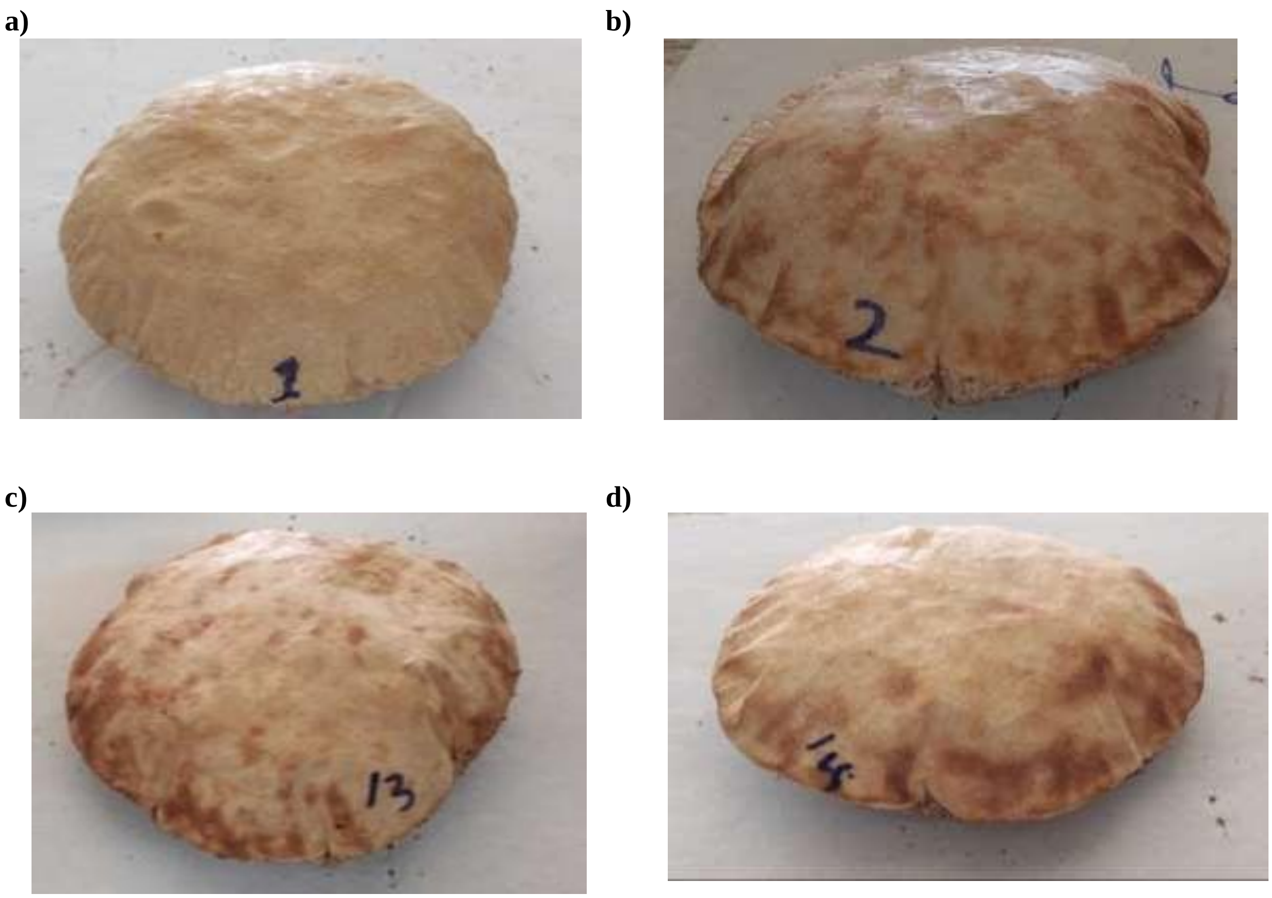

Fig. **2** Balady Bread loaves; **a)**: wheat variety Sids-14 of Sids location; **b)**: wheat variety Misr-2 of Sids location; **c):** wheat variety Sids-14 of West-West El-Minya location; **d)**: wheat variety Misr-2 of West-West El-Minya location

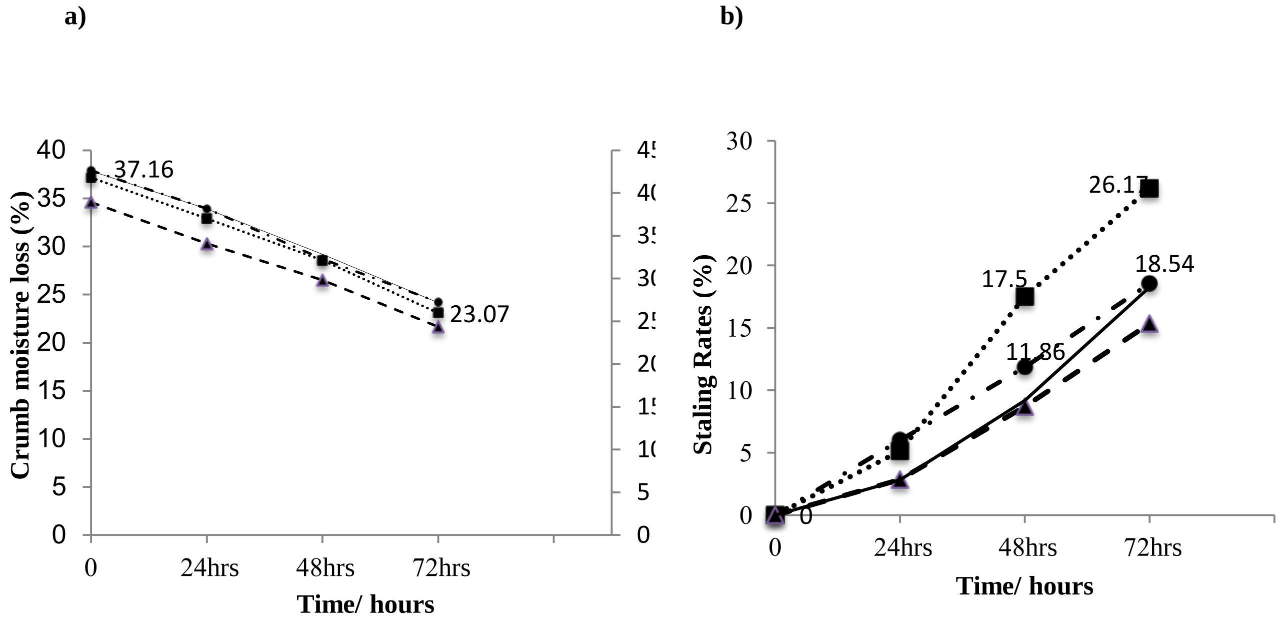

Fig. 3 Percentages of the Crumb moisture loss (a) and Staling rates (b) of Balady Bread loaves at zero time, 24, 48, and 72 hours at 25°C.

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 El-Minya location. (┈■┈) ; loaves of wheat variety Misr-2 in West-West El-Minya location. (-·- ·-●·-·- ·-).

It means Balady Bread loaves of wheat variety Misr-2 may have an extended shelf life than those loaves of wheat variety Sids-14, as they turned staled later. Due to the lower ($P \leq 0.05$) loss in crumb moisture (Fig. 3a) of Balady Bread loaf of wheat variety Misr-2 (36%, - ·-●·-·-), than that loss of moisture in Balady Bread loaf of wheat variety Sids-14 (37.92%, ┈■┈) where a lower loss in crumb moisture tends to slow down the percentage of the staling rates [68]. Also, due to the lower ($P \leq 0.05$) C5 of the flour of the wheat variety Misr-2 (Table 4), the flour with a lower retrogradation capacity ensures a longer Balady Bread shelf life [69]. Moreover, the starch of the wheat variety Misr-2 showed a decreased C5-C4 value, suggesting improved Balady Bread shelf-life. It is believed that the retrogradated amylopectin in the starch molecule absorbs the water from the gluten protein, causing the moisture to migrate from the bread crumb to the crust. As a result, thebread becomes more firm, less fresh, less crisp, and less palatable [70].

The nutritional quality of Balady Bread

Table 6 represents the nutritional facts and the elemental composition of Balady Bread on dry weight. The crude protein contents in Balady Bread underwent a similar trend as those for its flour (Table 3), wherein the Balady Bread of West-West El-Minya location had higher ($P \leq 0.05$) crude protein contents than those from the Sids location, and the Balady Bread of wheat variety Sids-14 was ($P \leq 0.05$) superior. Noticeably, many researchers noticed that the amino acid proline is one of the most predominant amino acids that is produced and stored in wheat and its products under salinity stress [71], meaning that the Balady Bread of the West-West El-Minya location may contain more proline. 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, there were no ($P \leq 0.05$) differences in crud fat contents in Balady Bread rather than the two locations or the two wheat varieties. That may be because wheat flour is not known for being high in crude fat. Therefore, if there were changes in the crud fat contents of the Balady Bread under salinity stress, they were likely to be minimal and may not be a ($P \leq 0.05$) change in the overall composition of the bread, wherein the higher components of the bread were crude protein and total carbohydrates.

The ash content of Balady Bread represents the mineral constituents of bread. Noticeably, Balady Bread of wheat variety Misr-2 had higher ($P \leq 0.05$) ash content and elemental compositions (except for Zn and Fe) than the contents and compositions of Balady Bread of wheat variety Sids-14. Salinity stress in the West-West El-Minya location ($P \leq 0.05$) lowered the ash contents of Balady Bread compared to the optimal growing conditions in the

Sids location. That is owing to improved mineral uptake from the soil and irrigation water in the Sids location (Table 1); however, salinity stress in the West-West El-Minya location pertains to mineral uptake, translocation, and accumulation processes, which result in a severe decline in ash content in Balady Bread [27, 34, 38]. Another significant concern is the extreme increase of Na levels and lower Zn and Fe levels in the West-West El-Minya location, especially in Balady Bread from the wheat variety Misr-2. Nadeem *et al*. [34] found that high soil salinity increased Na levels and affected the balance of the essential minerals in wheat grain and its products. Accordingly, special considerations should be taken if this Balady Bread is subjected to a bread subsidy system for Egyptians, as an excessive Na intake is generally not desirable for human health. Besides, the imbalance of the essential minerals could potentially affect the bioavailability of iron and zinc.

For crude fiber, no ($P \leq 0.05$) changes were observed in the crud fiber contents of Balady Bread, whether in the West-West El-Minya or Sids location. Worthy, Balady Bread produced from wheat flour with an extraction rate of 82 g/100g retains a significant portion of the wheat kernel, including the bran, which is rich in dietary fiber. Dietary fiber offers many nutritional significance, such as supporting digestive health, controlling satiety and weight, and regulating blood sugar. Moreover, it contains essential nutrients such as vitamins, minerals, and antioxidants [56].

The contents of total carbohydrates in Balady Bread underwent a similar trend as those for its flour starch (Table 3), wherein the Balady Bread from the West-West El-Minya location had lower ($P \leq 0.05$) total carbohydrates than those from the Sids location and the Balady Bread of wheat variety Sids-14 was ($P \leq 0.05$) the lowest. Salinity stress can alter the carbohydrate composition of wheat grains and its products. Specifically, it may lead to changes in the levels of starch, sugars, and other carbohydrates, with a strong association between dietary carbohydrates, blood glucose, and glycemic index in the human body [72, 73].

No ($P \leq 0.05$) changes were observed in the energy of Balady Bread, whether in the West-West El-Minya or Sids locations. That may be attributed to the increase in crude protein compensating for the reduction in total carbohydrates, as the calories of the Balady Bread are mainly derived from total carbohydrates, crude fats, and crude proteins.

4 Conclusions and future perspectives

Rapidly rising soil and water salinity pose a serious threat to wheat production in the Western Desert Region of Egypt. Wherein salinity stress negatively affects the growth and development of wheat plants, leading to diminished grain yield, flour rheological properties, and bread making quality, with special considerations as most wheat production in Egypt is subjected to the Balady Bread Subsidy System for achieving food security. Recently, various adaptation and management strategies have been developed to reduce the deleterious effects of salinity stress and maximize the production and nutritional quality of wheat. Nevertheless, there is a need for more studies that extensively correlate environmental stress and intrinsic factors with flour and bread qualities. Accordingly, this study was undertaken to evaluate the quality of the flour and Balady Bread produced by two wheat varieties, Sids-14 and Misr-2, that were planted in two different locations—West-West El-Minya, a saline-stressed location, and Sids Station, a favorable location—during the 2018–2019 and 2019–2020 growing seasons. The agronomic traits and yield performance of the wheat plants were significantly altered by salinity stress in West-West El-Minya. This, in turn, diminished the flour composition and rheology as well as the sensory, physical, and nutritional qualities of the Balady Bread. In comparison to those produced under Sids circumstances. Despite the challenging conditions, this study suggests that the West-West El-Minya location shows promise for future wheat cultivation due to its productivity and satisfactory flour and bread qualities. Ultimately, the wheat variety Misr-2 proves to be superior to Sids-14 under these circumstances. In the future, further study will be needed to analyze the amino acid proline in Balady Bread and determine the real bioavailability of zinc and iron. Additionally, special considerations should be taken if this Balady Bread is subjected to a bread subsidy system for Egyptians, as an excessive sodium intake is generally not desirable for human health. For that reason, a biological trial will be needed to assess the sodium intake in relation to bread consumption patterns and the related health consequences.

Table 6: Nutritional facts and elemental composition of Balady Bread on dry weight.

Balady 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)	Na (mg/100g)	K (mg/100g)	P (mg/100g)	Ca (mg/100g)	Mg (mg/100g)	Zn (mg/100g)	Fe (mg/100g)
Location	Sids location													
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]	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	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]	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 El-Minya location													
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]	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	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]	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 $P \leq 0.05$.

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