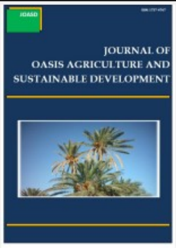
Journal of Oasis Agriculture and Sustainable Development
www.joasdjournal.org

RESEARCH ARTICLE



JOURNAL OF OASIS AGRICULTURE AND SUSTAINABLE DEVELOPMENT

www.joasdjournal.org

JOASD

p-ISSN: 2724 – 699X
e-ISSN: 2724-7007

Genetic variation of technological quality in durum wheat

Nejla Turki*[1], Hassiba Chahdoura[2], Safia El Bok[3] & Moncef Harrabi[4]

[1] *Higher Institute of Applied Science and Technology Mahdia.*
[2] *Genomics, Biotechnology, and Antiviral Strategies Research Unit at the Higher Institute of Biotechnology, University of Monastir, Tunisia, is as follows: BP74, Avenue Tahar Hadded, 5000 Monastir.*
[3] *Biodiversity, Biotechnology & Climate Change Laboratory at the University of Tunis El-Manar, Department of Biology, Faculty of Sciences of Tunis, University Campus, Tunis 2092, Tunisia.*
[4] *National Institute of Agronomy (INAT), Tunisia.*

Article info

Article history:
Received: 22 July 2024
Accepted: 29 December 2024

Keywords: Durum wheat, quality related parameters, farmer's needs, semolina industry's needs.

***Corresponding author**
turkinajla@gmail.com

Conflict of Interest: The authors declare no conflict of interest.

Abstract

Durum wheat (Triticum durum) is a widely cultivated wheat species, with approximately 75% of global production consumed in the Mediterranean region. Its cultivation has remained a staple food for local populations, particularly in Tunisia and other Maghreb countries, where it is primarily used for pasta, couscous, and bread. Despite the widespread cultivation of wheat in Tunisia, the country is currently facing food insecurity, and the conditions under which durum wheat is grown have a significant impact on its quality-related parameters. This study aims to investigate the genetic variation of technological quality in both local and imported durum wheat varieties, with the goal of identifying useful parameters for future breeding requirements. The results indicate that the imported varieties Ismur and Portodur, which exhibit resistance to lodging and various diseases, are suitable for the needs of farmers. Additionally, the imported varieties Ismur and Silur, along with the local variety Nasr, meet the criteria for gluten and protein content, making them valuable for the semolina industry.

1. INTRODUCTION

Durum wheat (*Triticum durum*) is a prominent cultivated wheat species, with approximately 75% of global production consumed in the Mediterranean region (Morancho 1995; Belaid 2000). It is primarily utilized for pasta, couscous, and bread. The cultivation of durum wheat expanded from the Mediterranean basin to the Iberian Peninsula and North Africa around 7000 years ago [1,2]. In Tunisia, durum wheat occupied 0.5 million hectares during the 2018/2019 season, accounting for approximately 85% of the total wheat area. Wheat, including both common and durum varieties, constituted over half of the cereal cultivated area [USDA, 2019]. Despite the widespread cultivation of wheat in Tunisia, the country is currently experiencing a food deficit. Durum wheat imports have increased by 88.5% between 1984 and 2016 (Khaldi and Saaidia, 2017), with significant year-to-year fluctuations attributed to variations in rainfall (World Food Program) (WFP, 2011). Local durum wheat yields also vary annually, with national averages never surpassing 25 q ha1 (Khaldi and Saaidia, 2017). Given the fluctuating production and the adverse impacts of climate change, it is imperative to implement a national strategy aimed at improving crop production per hectare. This can be achieved by selecting new durum wheat varieties with high yield potential that are resilient to climate change, thereby significantly increasing local production and productivity. Two crucial agronomical factors to consider are yield and grain quality. However, breeding for these parameters is particularly challenging due to the polyploidy of durum wheat. Additionally, the growing conditions greatly influence most durum wheat characteristics. Nevertheless, recent studies on the genetic structure of durum wheat have made significant contributions to improving its parameters, particularly in relation to quality. This research aims to investigate the genetic variation in technological quality among local and imported durum wheat varieties, as well as establish useful parameters for future breeding demands.

2. MATERIAL AND METHODS

2.1 Plant materials and growth conditions

This study examined a total of fourteen durum wheat varieties, consisting of seven locally sourced varieties and seven imported varieties. The experiment employed a randomized complete block design with three replications. The genotypes were planted in a "Mateur" field located in Tunisia, which is characterized as semi-arid. The soil in the surface layer, specifically at a depth of 0-30 cm, exhibited a silty clay loam texture. Prior to the durum wheat planting, the field had been utilized previously for hay production.

2.2 Field data

Several parameters were measured during this experiment, including plant height, lodging tolerance, and the presence or absence of fungal diseases.

2.3 Grain parameters

2.3.1 Water content

The water content was determined using the NT 50.21 standard (1989). The moisture percentage is calculated using the following formula:
% Moisture = (initial weight - final weight) * 100 / initial weight).

2.3.2 Protein content

Protein content in wheat kernels was determined using Inframatic Analyzer.

2.3.3 Ash content

The ash content was determined using the ISO 2171 method (2007). Flour samples ranging from 3-5 g were placed in ash plates. The samples were then heated in a 550 °C muffle furnace. They were burned for 7 hours, producing light gray ash or a constant weight. The samples were weighed after cooling, and the ash contents were calculated using the following formula:
Ash content = $m_1 * 100/100 * m_0 / (100- H)$
m_1: mass of the residue
m_0: Initial mass of the sample
H: Water content of the sample (in %)

2.3.4 Test weight (Kilograms/Hictolitre)

The NT 51.61 method (1993) was used to determine this parameter. The test weight was calculated using the following formula:

$$M = [(M_1 + M_2) / 2] * 0.1$$

M_1 and M_2: mass of samples

2.3.5 Non-vitreous Kernel

This rate is evaluated according to the method NT.51.04, 1983 and it is calculated using the following formula:
Non-vitreous Kernel (%) = $M_1 / (M_1+M_2) *100$
M_1: Mass of non vitreous Kernels (in g)
M_2: Mass of vitreous Kernels (in g)

2.3.6 The falling number Hagburg

This parameter was calculated using the following formula:

Falling number (sec) = 5 sec stand +55 sec stirring +time taken to fall in sec

2.4 Flour parameters

2.4.1 Wheat conditioning

After the primary cleaning process, the subsequent phase in the wheat pre-milling procedure entails conditioning, which entails the infusion of water into the wheat to reach its ideal milling moisture level. In order to ascertain the optimal duration of the resting period for the given process, a study was conducted wherein the local variety "Chili" was subjected to four distinct intervals of 7, 9, 11, and 12 hours. This experiment involved the addition of water in accordance with the initial moisture content of the wheat grain, aimed at facilitating the separation of the husks and kernel during the milling process. The remaining varieties shall be allocated with the requisite duration subsequently.

2.4.2 Wheat grinding

Following packaging, wheat will be ground in a CD2 type mill and successively converted to semolina.

2.4.3 Semolina parameters

2.4.3.1 Semolina yield

To calculate semolina yield, the amount of semolina after milling is divided by the amount of wheat after packaging.

2.4.3.2 Semolina color

The presence of yellow pigment within the raw materials utilized for pasta production is a crucial indicator of quality. It refers to the amount of carotenoids that can be extracted from the endosperm and is quantified as the quantity of -carotene per 100 grams of dry matter.

In our study, the 14-30.01 Agtron Color Test was utilized to ascertain this parameter.

2.4.3.3 Semolina water content

The water content was determined using the NT 50.21 standard (1989). This parameter was calculated using the following formula:

% moisture =
(initial mass – final mass) * 100/initial mass

2.4.3.4 Semolina ash content

The fundamental premise underlying the process of ashing involves subjecting the sample to extreme temperatures that causes the organic constituents of the material to oxidize and combust, yielding inorganic residues as the ultimate product of the procedure. These inorganic remains are subsequently employed to determine the amount of non-organic matter among durum varieties. The heating process is conducted within a muffle furnace, maintained at a temperature of 555°C. The parameter under investigation was ascertained through the utilization of the ISO 2171 (2007) methodology, and subsequently computed via the prescribed formula:

Ash content = m_1 *100/ m_0*100/ (100- H%)
m_1: Mass of the residue
m_0: Mass of the sample
H: The water content of the sample expressed in percentages.

2.4.3.5 Semolina gluten content

The wet and dry gluten amounts in the flour samples under investigation were determined through manual gluten washing and GIM methodology. Moreover, in pursuit of a comprehensive analysis of the flour samples, assessing the gluten index values was carried out through the utilization of the Glutamatic 2200 system, in addition to measurements of their respective wet and dry gluten quantities.

2.4.3.6 Protein content of semolina

Protein content was determined according to the Kjeldahl method as described in ICC standards n°110/1 (ICC, 2003).

2.5 Data analysis

The data acquired on a multitude of traits were subjected to analysis utilizing a one-way analysis of variance (ANOVA). The statistical analysis of the data was conducted utilizing SPSS software by the Turkey test. Differences were considered statistically significant at p≤0.05.

3. RESULTS AND DISCUSSION

3.1 Morphological analysis and study of varieties susceptibility to lodging and diseases

Table 1 presents the variation in plant height observed among different varieties of durum wheat. Notably, certain local varieties, including Om Rabii, Maali et Nasr, exhibited greater average heights of 120.66 cm, 110 cm, and 105 cm, respectively, as compared to the imported varieties Chryssodur and Carioca, which had heights of 99.66 cm and 98.33 cm, respectively. Many researchers studied the phenotypic variation of this trait and its correlation with other parameters, such as yield (Bede and Petrovic´, 2006; Bilgin et al., 2010, 2011; Ibrahim, 2019).

In the context of this study, plant height was identified as a significant contributing factor to plant lodging. According to Table 1, six varieties (4 imported and 2 local) exhibit the best plant height that displays resilience towards lodging

Table 1. Origin and variation of plant height among different varieties of durum wheat.

Origin	Variety name	Plant height (in cm)			Average (in cm)	Standard deviation
R.A.G.T (imported)	Silur	94	96	88	92.66	4.16
	Sculptur	85	78	81	81.33	3.51
	Ismur	80	84	80	81.33	2.30
	Rabdo55	88	87	80	85	4.35
	Maali	105	110	115	110	5
	Razzek	95	105	87	95.66	9.01
INRAT (local varieties)	Nassr	100	110	105	105	5
	Karim	90	97	90	92.33	4.04
	Om Rabii	119	119	124	120.66	2.88
	Chili	135	125	148	136	9.41
	Khiar	79	81	84	81.33	2.51
	Chryssodur	96	101	102	99.66	3.21
	Portodur	92	86	95	91	4.58
SERASEM (imported)	Carioca	101	95	99	98.33	3.05

stress instigated by climatic adversities. These are Sculptur, Ismur, Khiar, Rabdo55, Portodur and Karim. According to Mulsanti et al. (2018) plant lodging is refers to the permanent displacement of the plant shoot from its normal upright position. This usually occurs as a combined effect of inadequate anchorage strength of the crop and impact of adverse weather conditions like rain, wind and hailstorm. The correlation between lodging tolerance and short height was evaluated by several researches including Curtis and Halford (2014) who showed that short height provides advantage over taller varieties as these are less susceptible to lodging. A strong positive correlation between plant height and lodging among a diverse population of 140 spring and spelt wheat cultivars under artificially created lodging conditions at early and late milk stage and variability was higher among cultivars of intermediate height rather than shorter and taller plant types (Navabi et al. 2006; Longin and Wurschum, 2014).

Similarly, Table 2 showed a large variation on response to Septoria and brown rust diseases among durum wheat varieties. For instance, the varieties: Ismur, Rabdo 55 and Portodur develop a certain tolerance towards Septoria however, Silur, Sculptur, Ismur and Portodur varieties showed tolerance to brown rust. Some varieties are both tolerant to Septoria and rust, such as Ismur and Portodur. Regarding the local varieties, mostly are sensitive to Septoria except the Nasr and Om Rabia varieties which developed a lower susceptibility against both diseases.

3.2 Technological and nutritional grains and semolina quality

Technological and physico-chemical analysis were carried out using local and imported durum wheat varieties in order to choose the genotypes that best meet the needs of farmers, breeders and the semolina sector.

3.2.1 Technological and nutritional grain quality

The parameter of the test weight (TW) has a significant influence on the foundational pricing of the approval scale. Throughout the course of this inquiry, the test weight values encompassed a range of 74.5 to 82.46 kilograms per hectolitre, with a mean recorded at 79.92 kilograms per hectolitre. Karim exhibited the highest total weight (TW) measuring 82.46 kg/hl, with Razzak, chili, Carioca, Portodur, Ismur, Om Rabia, and Maali consecutively following with values of 82.03, 81.87, 81.80, 81.27, 80.62, 80.45, and 80.09 kg/hl.

As per the guidelines set forth by the International Organization for Standardization in their 1995 publication "ISO5527", the regional cultivar "Khiar" demonstrated the highest incidence of vitreous kernels, with an average proportion of 1%. Nevertheless, it is noteworthy to mention that the local cultivar "Chili" exhibited the least proportion of vitreous kernel rate, standing at an average of 22.5%, as illustrated in Fig. 1. Kernel vitreousness is viewed as a significant indicator of quality for durum wheat due to its impact on both semolina milling performance and end-use quality (Dexter and Edwards, 1998).

Table 2. Classification of durum varieties according to disease tolerance

Origin	Name	Septoria tolerance/susceptibility	Brown rust tolerance/susceptibility
R .A.G.T	Silur	Lower susceptibility	Tolerant
R.A.G.T	Sculptur	Lower susceptibility	Tolerant
R.A.G.T	Ismur	Tolerant	Tolerant
R.A.G.T	Rabdo55	Tolerant	Higher susceptibility
INRAT	Maali	Higher susceptibility	Lower susceptibility
INRAT	Razzek	Higher susceptibility	Higher susceptibility
INRAT	Nasr	Lower susceptibility	Lower susceptibility
INRAT	Karim	Higher susceptibility	Higher susceptibility
INRAT	Om Rabii	Lower susceptibility	Lower susceptibility
INRAT	Chili	Higher susceptibility	Lower susceptibility
INRAT	Khiar	Higher susceptibility	Lower susceptibility
SERASEM	Chryssodur	Higher susceptibility	Higher susceptibility
SERASEM	Portodur	Tolerant	Tolerant
SERASEM	Carioca	Higher susceptibility	Higher susceptibility

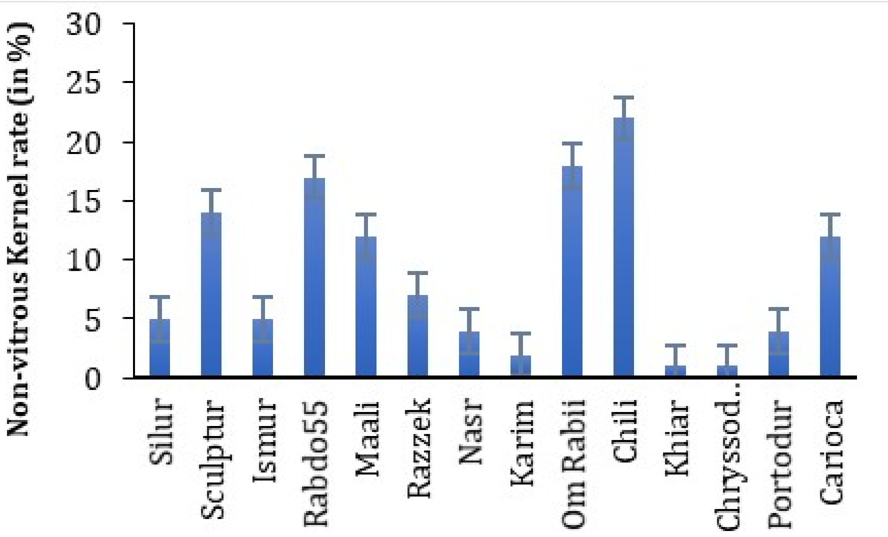


Fig. 1. Variation of non-vitreous kernel rate among local and imported durum varieties.

The moisture content constitutes a crucial attribute that bears a significant correlation with the persistent quality of semolina from its acquisition during harvest to the subsequent grain processing stages. Based on the data presented in Table 3, it can be inferred that the water content of the samples ranged from 8.34% to 16.9%, exhibiting an average value of 12.25%.

Furthermore, the local varieties of Chili and Nasr recorded the lowest water content, thereby indicating their suitability for storage purposes. Imported varieties generally exhibit a higher water content, potentially attributable to incomplete ripening of the grains.

The deficiency of nitrogen has also an adverse impact on the protein level present in grains and ultimately leads to a decrease in their overall quality. Accurately measuring the amount of nitrogen is crucial and it should be done while following the recommended dosage and treatment duration. Our findings indicate that regardless of the uniformity of cultivation conditions, including climate, soil and agricultural management, the protein content differs across various varieties due to their unique protein profiles. The range of this measurement was between 12.32 and 15.32%, with an average value of 13.79 as depicted in Fig. 2.

3.2.2 Technological and nutritional quality of Semolina

Prior to the milling process, it is common for wheat to undergo a moistening stage, which is

Table 3: Statistical variation of water content among durum varieties grains

Varieties	*WC*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
1	10.8		*	*	*	NS	NS	NS	*	*	*	*	*	*	*
2	8.9	*		NS	NS	*	NS	NS	*	*	*	*	*	*	*
3	9.1	*	NS		NS	*	NS	NS	*	*	*	*	*	*	*
4	8.3	*	NS	NS		*	NS	NS	*	*	*	*	*	*	*
5	11.9	NS	*	*	*		*	*	*	*	*	*	*	*	*
6	9.5	NS	NS	NS	NS	*		NS	*	*	*	*	*	*	*
7	9.8	NS	NS	NS	NS	*	NS		*	*	*	*	*	*	*
8	14.0	*	*	*	*	*	*	*		NS	NS	*	NS	*	NS
9	14.1	*	*	*	*	*	*	*	NS		NS	*	NS	*	NS
10	13.8	*	*	*	*	*	*	*	NS	NS		*	NS	*	NS
11	15.8	*	*	*	*	*	*	*	*	*	*		NS	NS	NS
12	14.2	*	*	*	*	*	*	*	NS	NS	NS	NS		*	NS
13	16.9	*	*	*	*	*	*	*	*	*	*	NS	*		*
14	14.3	*	*	*	*	*	*	*	*	NS	NS	NS	NS	*	
Average	12.2														
SD	2.8														

*WC: Water Content; NS: not significant; SD: Standard deviation, Statistically significant at level α = 0.05, **1** : Maali, **2**: Nasr, **3** : Razzek, **4** : Chili, **5** : Om Rabiaa, **6** : Khiar, **7** : Karim, **8** : Carioca, **9** :Silur, 10 : Chryssodur, **11** : Ismur, **12** : Portodur, **13** : Sculptur, **14** : Rabdo 55.*

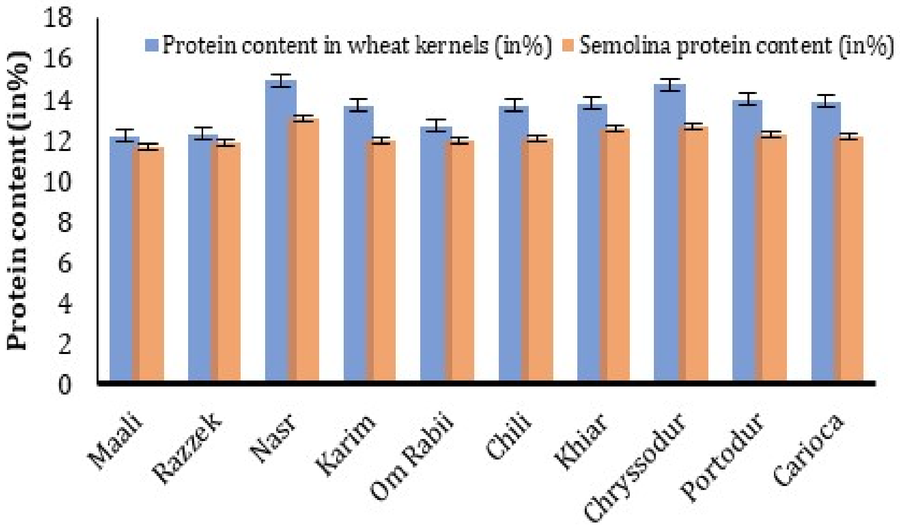


Fig. 2. Variation of kernel and Semolina protein content among local and imported durum varieties.

accompanied by a period of rest. This is done in order to guarantee that an appropriate and uniform distribution of moisture is achieved throughout the grain. Following an 11-hour resting period, superior outcomes were noted with regards to semolina yield, falling index, wet gluten, and gluten index. The conditioning period, spanning a duration of eleven hours, was implemented on the remaining varieties subsequent to the milling of wheat, in order to facilitate packaging and technological evaluations.

The investigation of moisture assumes a significant role at the industrial level due to its direct correlation with the cost of semolina, which is marketed exclusively based on its predetermined moisture content. According to Gélinas, Krushevska, and Barnes (1998), degradation of semolina initiates following a storage period of one month, in the event that the water content reaches 15%. In this investigation, the moisture content of Maali and Portodur varieties exhibited variation, ranging from 13.37% to 16.21%, with an average value of 14.76%. The local varieties Karim, Razzak, Om Rabia, Nasr, and Maali are deemed unsuitable for preservation as a result of their elevated moisture content, which initiates deleterious reactions in the semolina. Therefore, it is of utmost significance to conduct an investigation into this parameter in order to facilitate optimal preservation of the quality of semolina.

The present study investigated the semolina yield, which demonstrated a range of 47.2% to 54.29% across the Maali and Carioca crop varieties, respectively with an average of 51.09%. The imported varieties Carioca, Silur, Portodur, Chryssodur, Ismur, Rabdo recorded a higher amount of semolina yield with values equal to 54.29; 53.85; 53.85; 53.28; 52.92 and 51.18 respectively. Concerning the local varieties, only the variety Chili has the higher amount of semolina yield with 53.82%. The present study indicates a significant association between semolina yield discrepancies amongst durum varieties and the presence of protein levels in wheat kernels. Specifically, a greater concentration of protein in the wheat kernels led to an increased semolina yield. Moreover, the proportion of kernels with vitreous endosperm is known to have a significant influence on the semolina yield. Sieber et al., 2015 found that the optimization of semolina yield characterized by uniform particle size and reduction in extraneous flour, can be achieved through the incorporation of a significant proportion of vitreous kernels. Numerous studies have reported that the flour protein content exerts a significant influence on the quality of the resultant products. The protein is characterized by varying proportions of low-molecular-weight glutenin subunits (LMW-GS), high-molecular-weight glutenin subunits (HMW-GS), albumins, α-, γ-, and ω-gliadins, and globulins, as reported in Siddiqui et al (2020) and Dhaka and Khatkar (2015). In the present research, a considerable degree of variation in protein content was noted across local and imported varieties as illustrated in Fig. 2. As an example, the statistical distribution spanned from 11.7 to 13.9% and exhibited an arithmetic mean of 12.51%. Furthermore, it is worth noting that the varieties Ismur, Sculptur, Nasr, Silur, Chryssodur, Khiar, and Portodur exhibit an elevated concentration of protein, which ranges from

12.58% to 13.9%. Specifically, Ismur presents a protein content of 13.48%, while Sculptur, Nasr, Silur, Chryssodur, Khiar, and Portodur display percentages of 13.9%, 13.09%, 13.02%, 12.68%, and 12.58%, respectively. The aforementioned parameter holds significant importance with regard to the culinary quality of products that are derived from the aforementioned varieties. The insufficient nitrogen assimilation and insufficient remobilization during the grain filling phase may have resulted in a lower protein content in the Maali and Razzak varieties. According to Dalloul's (2008) findings, semolina yield is negatively affected by a lower protein content in certain types that have a smaller vitreous kernel. A clever deduction would be that a favorable correlation exists between the weight of vitreous kernels and their protein content, indicating that varieties with higher kernel weights typically exhibit relatively higher protein levels. Bilgin et al. (2010) reported a positive correlation between the amount of protein and the vitreosity. Over the last few decades, the yellow-amber color of semolina has become an important quality trait for durum wheat end products. The yellow color is due to the carotenoid (yellow) pigment content in the whole kernel, and is commercially identified as the yellow index in semolina (Ficco et al., 2014). In our study, the yellow index parameter was varied among durum varieties and ranged from 13.8 (for local varieties Nasr and Razzak) to 28.04 (for the imported variety Ismur) with an average of 20.20. Additionally, the varieties Maali, Carioca, Chryssodur, Rabdo 55, Portodur, Sculptur and Silur had a higher yellow index with 19.96, 19.5, 22.03, 22.66, 22.77, 26.8 and 27, respectively. Therefore, these varieties will be used in the production of food products with good color. The low yellow indices of the remaining genotypes (except the local variety Chili, which has a value of 18.78) are primarily the result of a high brown index, which is the cause of the semolina's browning. For instance, according to Fraignier et al. (2000) carotenoid pigment degradation is affected by the peroxidases, a class of enzymes that can oxidize a large number of compounds at the expense of hydrogen peroxide.

Similarly, the average of wet gluten among local and imported varieties is 30.46%, ranging from 24% for the local variety Maali to 35% for the local variety Nasr. In this study, the varieties Nasr, Chryssodur, Silur, Ismur, Carioca, Rabdo 55, Om Rabia, and Chili had the highest amount of wet gluten with 35, 34.5, 34, 32.5, 32, 32, 32, and 32%, respectively (Fig. 3). Additionally, the local variety Karim-derived semolina has a respectable concentration of gluten proteins, with a concentration of 31% in wet gluten. As a result, the variation in the amount of soluble gluten is highly influenced by cultural and climatic factors. Our findings are in close agreement to the study conducted by Nadeem et al., (2016) which indicated that environmental conditions affect the amount, composition, and/or polymerization of the gluten proteins. The low gluten values reported by the varieties Maali, Portodur, and Razzak have been interpreted as a result of their sensitivity to heat and insect attacks the by producing enzymes that make the gluten softer. Furthermore, excessive heating affected protein

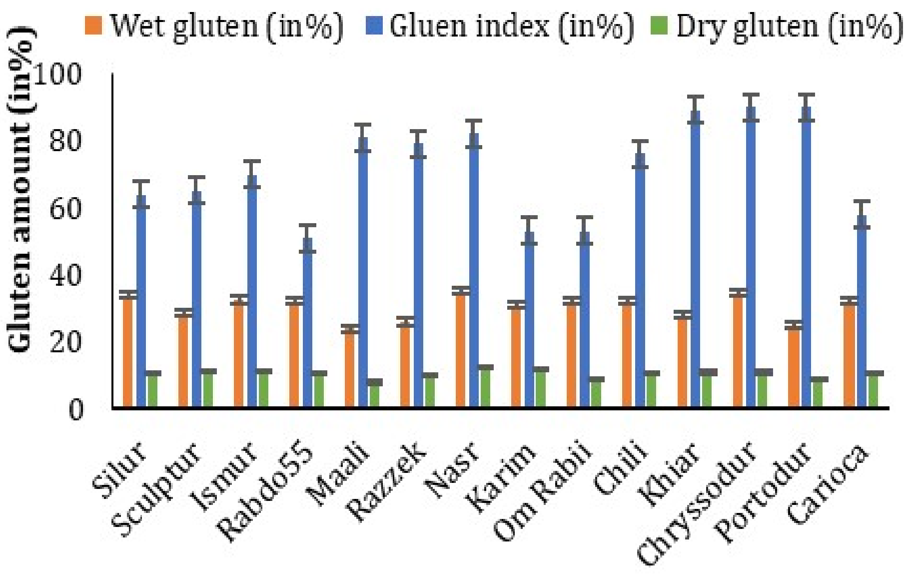


Fig. 3. Variation of gluten amount among local and imported durum varieties.

quality and may prevent gluten formation (Quayson et al., 2015); However, in Tunisia, only high temperatures during maturation stage may be the main cause of these variations. The gluten index ranges from 65.5 to 102.5% in semolina. Some varieties have high gluten levels and can be brittle, such as Razzak, Maali, Nasr, khiar, and Portodur with 91.5, 93.5, 94.5, 101.5, and 102.5%, respectively, compared to the Canadian wheat, which has a gluten index of 92.5% (Fig. 3).

With a gluten content of 88.5%, the local variety Chili outperforms the imported varieties Ismur and Chryssodur, with an average of 82.5 and 80.5%, respectively. However, the local varieties Om Rabia and Karim have an intermediate gluten quality (not too strong nor too soft). Similarly, the dry gluten rate in Maali and Nasr local varieties ranged from 8 to 12.70 respectively with an average of 10.55 (Fig. 3). At this level, and according to Landi's results, a wheat is considered to be of good quality if its dry gluten content is greater than 12%, hence only the Nasr variety may be utilized to improve the quality of derived products. The assessment of gluten quality is a pertinent subject matter, given the growing number of research studies focused on evaluating the pasta-making capacity of durum wheat samples. This attention to quality is motivated by a need to select new and improved wheat varieties, as well as an increasing concern about the effects of climate change on wheat crop yields and resultant gluten quality (Cecchini et al., 2021).

5. CONCLUSION

This study aimed to evaluate the genetic potential of fourteen durum wheat varieties, comprising seven locally-grown and seven imported, with regard to their technological qualities and yield parameters. The investigation into varietal selection for agricultural practitioners necessitates the acquisition of genotypes that exhibit resistance to lodging and an array of diseases. In this regard, imported varieties Ismur and Portodur serve as prime examples of such varieties. The particular requirements of the semolina sector are highly distinctive with the objective to select wheat varieties that exhibit desirable characteristics in terms of their nutritional, hygienic, organoleptic, culinary, and semolina quality. To this end, the imported varieties Ismur and Silur, as well as the local variety Nasr, have been evaluated with respect to their gluten and protein content, two key criteria. Opportunities for improvement could be heightened through the selection of varieties that possess a confluence of disease resistance and comprehensive technological attributes. The endeavor of effecting this enhancement may present challenges, however, it has the potential to serve as a protracted and sustainable objective of mono-varietal collections to exploit the inherent genetic characteristics of these varieties.

REFERENCES

Bilgin, O., Korkut, K., Başer, İ., Dağlioğlu, O., Öztürk, I., Kahraman, T., Balkan, A., 2010. Variation and heritability for some semolina characteristics and grain yield and their relations in durum wheat (Triticum durum Desf.). World J Agric Sci 6, 301–308.

Dexter, J.E., Marchylo, B.A., Macgegor, A.W., Tkachuk, R., 1989. The structure and protein composition of vitreous, piebald and starchy durum wheat kernels. J. Cereal Sci. 10, 19e32.

Dhaka, V.; Khatkar, B.S. Effects of gliadin/glutenin and HMW-GS/LMW-GS ratio on dough rheological properties and breadmaking potential of wheat varieties. J. Food Qual. 2015, 38, 71–82. [CrossRef]

Feldman M. Origin of cultivated wheat. In: Bonjean A.P., Angus W.J., editors. The World Wheat Book: A History of Wheat Breeding. Lavoisier; Paris, France: 2001. pp. 3–56.

Ficco, D., Mastrangelo, A., Trono, D., Borrelli, grazia maria, De Vita, P., Fares, C., Beleggia, R., Platani, C., Papa, R., 2014. The colours of durum wheat: A review. Crop Pasture Sci. 65. https://doi.org/10.1071/CP13293

Fraignier MP, Michaux-Ferrière N, Kobrehel K (2000) Distribution of peroxidases in durum wheat (Triticum durum). Cereal Chemistry 77, 11–17. doi:10.1094/CCHEM.2000.77.1.11

Gödecke T, Stein AJ, Qaim M. The global burden of chronic and hidden hunger: Trends and determinants. Global Food Security. 2018; 17:21-29

Gluten Index ICC Draft Standard No. 155, June (1992). 9.

Wet gluten and Gluten Index, AACC Method 38–12 (1994).

Khaldi, R., Saaidia, B., 2017. Analyse De La Filière Céréalière En Tunisie Et Identification Des Principaux Points De Dysfonctionnement à l'Origine Des Pertes (FAO, 2017). W. Sadok, et al. European Journal of Agronomy 107 (2019) 1–9 8 http://www.onagri.nat.tn/uploads/Etudes/RapportIVF.pdf

Latiri K, Lhomme JP, Annabi M, Setter T. Wheat production in Tunisia: progress, inter-annual variability and relation to rainfall. Eur J Agron. 2010;33(1):33–42.

Nadeem, M., Anjum, F.M., Khan, M.R., Sajjad, M., Hussain, S., Arshad, M.S., 2016. Electrophoretic Characteristics of Gluten Proteins as Influenced by Crop Year and Variety. Int. J. Food Prop. 19, 897–910. https://doi.org/10.1080/10942912.2015.1045518

Nazco R., Villegas D., Ammar K., Peña R.J., Moragues M., Royo C. Can Mediterranean Durum Wheat Landraces Contribute to Improved Grain Quality Attributes in Modern Cultivars? Euphytica. 2012; 185:1–17. doi: 10.1007/s10681-011-0588-6.

Quayson, E.; Marti, A.; Bonomi, F.; Atwell, W.; Seetharaman, K. Structural modification of gluten proteins in strong and weak wheat dough as affected by mixing temperature. Cereal Chem. J. 2015, 93

Siddiqi, R.A.; Singh, T.P.; Rani, M.; Sogi, D.S.; Bhat, M.A. Diversity in Grain, Flour, Amino Acid Composition, Protein Profiling, and Proportion of Total Flour Proteins of Different Wheat Cultivars of North India. Front. Nutr. 2020, 7, 141. [CrossRef]

Sieber, A.-N., Würschum, T., Longin, C.F.H., 2015. Vitreosity, its stability and relationship to protein content in durum wheat. J. Cereal Sci. 61, 71–77. https://doi.org/10.1016/j.jcs.2014.10.008

United Nations, Department of Economic and Social Affairs (2003). World Urbanization Prospects – The 2003 Revision. New York: United Nations Publications

USDA. Available online: http://www.fas.usda.gov/data/tunisia-grain-and-feed-annual-2 (accessed on 30 April 2019).

World Food Programme (WFP), 2011. Secondary Data Analysis of the Food Security Situation in Tunisia (WFP, 2011). https://www.wfp.org/content/tunisia-secondarydata-analysis-food-security-situation-april-2011.