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ORIGINAL ARTICLES

Compositional and functional quality evaluation of Egyptian and Saudi triticale cultivars

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ABSTRACT

Eleven triticale cultivars grown at two different locations namely; Egypt and Saudi Arabia were evaluated and compared. The effects of location and cultivar on thousand kernel weight, proximate composition, mineral content, anti-oxidants content and color of triticale cultivars were determined. Significant differences among tested lines in most of the studied characters were reported. The thousand kernel weights of triticale grown at Saudi Arabia were significantly higher than that of triticale grown in Egypt. Proximate composition i.e. dry matter; protein, ash, fat, fiber, and carbohydrates showed significant differences illustrating the effect of genetic as well as environmental factors. A wide range of mineral elements in varying concentration were detected in the tested samples but the most abundant was potassium 275.00±0.00 to 383.50±0.71ppm followed by phosphorus 75.00±0.40 to 245.30±1.84 ppm. Total phenolic content of the tested cultivars ranged from 1.54 to 2.35 mg GAE/g as measured by Folin–Ciocalteau method. DPPH* radical scavenging activities (RSA) of the Saudi triticales were all higher than the Egyptian cultivar. The free RSA as a proportional of total estimated RSA ranged from 41.98% for ST07 to 48.84% for ET21. Compared to free RSA, higher levels of bound RSA were found in all samples. Tested cultivars varied in color where, ST20 showed the highest lightness 42.70 and ET21 exhibited the darkest color 34.70. Total phenolic content of tested triticale cultivars were negatively correlated at 0.05 level with degree of lightness. Significant differences in total flavonoids content were found in all triticale cultivars. Two of the developed lines showed higher values for corresponding flavoniods than all other developed lines and the Egyptian cultivar as well. Triticale cultivars possessing higher concentrations of trace minerals and polyphones could be explored for commercial exploitation and may serve as sources of valuable phenolics for food and nutraceutical applications.

Key words: Triticale, Cultivars, Quality, Antioxidants activity, Polyphenolic compounds.

Introduction

Triticale (*Triticosecale Wittmack*) is a hybrid crop developed by crossing wheat (*Triticum spp.*) and rye (*Secale cereale*) that combines the properties of both parental cereals (Jonnala *et al.,* 2010). Triticale shows a number of advantages for the grower as follows: higher grain yield even in unfavorable conditions, higher test weight, resistance to soil-climatic conditions, tolerance to dryness, tolerance to more acid soils and a lower requirement of nutrient substances. Also, it does not need as much fertilizer when compared to types and varieties providing the same yields (Holguín-Acuña *et al.,* 2008).

In the current unfavorable changing climate, this can be of great value, especially in third world countries facing impeding food shortages. This condition, together with the fact that triticale production is increasing steadily worldwide, seems to indicate that triticale could soon become important in serving a source of food to the rapidly growing population on the earth.

Furthermore it has a good nutritional composition which compares well with that of wheat, and it is generally good source of vitamins and minerals, and essential amino acids (Lorenz, *et al.,* 1974). It is high in starch, lipids, dietary fiber and mineral ash, and its protein content is comparable to that of wheat (kent and Evers 1994; Stallknecht, *et al.,* 1996; Dyson, 2006). Furthermore, triticale has high lysine content, which is significant due to the fact lysine is usually limiting amino acid in cereals (Kies and fox 1970; Villegas, *et al.,* 1970).

Although antioxidant activity and phenolic acid profiles of cereals have been reported extensively (Andersson *et al.,* 2008; Verma, *et al.,* 2009; Zielinski and Kozlowska, 2000), only a few recent studies are available on bioactive components of triticale (Hosseinian and Mazza, 2009; Hung *et al.,* 2009; Menga *et al.,*

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2010). On the other hand, literature on the genotype effect and correlation with phenolics in those grains is limited (Jonnala *et al.*, 2010).

Studies on the functional and compositional quality have been conducted in other parts of the worlds, however little is known regarding cultivars developed in Egypt and Saudi Arabia. At present, literature about the quality indices of triticale cultivars is scare. The evaluation of the compositional and functional quality of triticale in order to obtain a profile for cultivars is thus of importance. The objective of this study is therefore to determine the compositional and functional quality of triticale from different locations in terms of 1000 kernel mass, proximate composition, color, total phenol and antioxidants contents.

Materials And Methods

Materials:

Reagents:

All chemical reagents 2,4,6-tris(2-pyridyl)–1,3,5-triazine, 1,1-diphenyl-2-picrylhydrazyl (DPPH), Folin – Ciocalteu reagent, and gallic acid were purchased from Sigmae Aldrich Chemie Gmbh (Munich, Germany). Other chemicals used were of analytical grade.

Samples:

Eleven triticale cultivars from two locations i.e. Egypt and Saudi Arabia were used in this study. Saudi triticale varieties were developed by Plant Production Department, College of Food and Agricultural Sciences, King Saud University. Egyptian triticale sample, grown in 2011, was obtained from a local plant breeding station, Agriculture Research Centre, Giza, Egypt Table (1). These triticale samples were derived from a breeding program that was not focused on baking quality.

Table 1: Triticale cultivar samples code and source.

Sample	*Sample code	(**CIMMYT) code No	
1	ST-01	Introduce from Egypt (Kawmy-1) under registration	
3	ST-03	CIMMYT	8019
4	ST-04	CIMMYT	8065
6	ST-06	CIMMYT	8075
7	ST-07	CIMMYT	8045
8	ST-08	CIMMYT	8067
11	ST-11	CIMMYT	8018
12	ST-12	CIMMYT	8019
15	ST-15	CIMMYT	8040
20	ST-20	CIMMYT	8027
21	ET-21	Commercially released Egyptian variety	

* ST: Saudi Triticale, ET: Egyptian Triticale
**International Maize and Wheat Improvement Center

Sample preparation:

Triticale cultivars were harvested at maturity and cleaned of impurities. All samples were ground in a laboratory mill to pass through 0.5 mm screen and were stored in plastic containers at 4^{o}C until analysis. One commercially released line from the Egyptian breeding programs used for comparison against 10 Saudi cultivars. Sample sizes available were small as the new lines in the breeding process were already limited.

Analytical methods:

Thousand kernel weight:

Thousand kernel weights were measured by the International Seed Testing Association method (ISTA, 2006).

Proximate composition:

Samples were analyzed for proximate composition i.e. moisture, crude protein (N×5.7), ether extract, total ash and crude fiber (%) according to (AACC, 2000) methods. Total carbohydrates were calculated by difference.

J. Appl. Sci. Res., 9(8): 4867-4876, 2013

Mineral content:

The flour samples of each triticale variety were tested for mineral contents: potassium, phosphorous, calcium, sodium, iron, zinc and copper as described by (AACC method 40-41.03.) Iron and calcium were determined using Atomic Absorption Spectrophotometer Atomic1100B Perkin-Elmer; while phosphorus was determined using Perkin-Elmer UV/VIS Spectrometer Lambda2.

Extraction of free and bound phenolic compounds:

Phenolic compounds of triticale cultivars were extracted into free and bound phenolics according to the methods of (Adom and Liu 2002; Sosulski, *et al.,* 1982).

Determination of total phenolic content:

Phenolic content was determined by the Folin–Ciocalteau colourimetric method as described previously (Inglett *et al.,* 2011, Waterhouse, 2001; Yu and Zhou, 2004).

DPPH radical scavenging assay:

DPPH radical scavenging capacities of triticale cultivars extracts were determined by the reduction of the reaction color between DPPH solution and sample extracts as previously described by (Huang, *et al*.,, 2005). The scavenging of DPPH was calculated according to the following equation (Liyana-Pathirana and Shahidi, 2007):

% DPPH scavenging= $\{Abs_{(t=0)} - Abs_{(t=30)/} Abs_{(t=0)}\}$ X 100,

Where:

$Abs_{(t=0)}$ = absorbance of DPPH radical + methanol at t = 0 min;

$Abs_{(t=30)}$ = absorbance of DPPH radical + phenolic extracts at t = 30 min.

Determination of free and bound flavonoid content:

Flavonoid contents of free and bound phenolics in triticale fractions were determined using the aluminum chloride colorimetric method of (Chang, *et. al*., 2002) based on the method of (Woisky and Salatino 1998).

Color quality determination:

Ground samples were analyzed with a Spectro Colorimeter (Tristimulus Color Machine) with CIF lab color scale (Hunter, Lab Scan XE, Germany). Lightness (L), redness (a), and yellowness (b) values were recorded (Vaca-García *et al*., 2011). Each value was an average of three different independent measurements. Color index E was determined by the equation

$E = (L^2 + b^2 + a^2)^{1/2}$

Statistical analysis:

All assays were carried out in triplicates and results are expressed as mean ± SD. Statistical comparisons were done with the Anova test. Differences were considered to be significant at $p \leq 0.05$.

Results and Discussion

Thousand kernel weight and proximate composition of whole triticale grains:

All triticale cultivars grains were small in size with shrunken endosperm. The thousand kernel weights of triticale grown at Saudi Arabia were significantly higher than that of triticale grown at Egypt Table (2). A recent study carried out by (Boros, 2006) observed that some modern Polish cultivars had a 1000-kernel weight that was equal to or even exceeded that of wheat. Based on a relationship in wheat where increased 1000-kernel weight correlates to an increase in flour yield, it could be expected that an increased 1000-kernel weight could result in an increased flour yield in triticale.

The 1000 kernel weight is a useful tool for the assessment of the potential milling yield. The kernel size contributes directly towards the improvement of grain yield as well as milling yield. The present study suggests that all triticale cultivars possessing better grain weight offering great potential for better milling yield and wide variation in grain weight can be exploited by the triticale breeders to improve this trait in the new genotypes.

The chemical composition of triticale is more similar to the composition of wheat than it is to that of rye, due to the fact that triticale received two genomes from its wheat parents, and only one genome from its rye parents (Varughese, *et al*.,, 1997; Peña, 2004). The means of dry matter, ash, protein, crude fat, crude fiber and total carbohydrate contents (%) in the whole grain of triticale cultivars are shown in Table (2). The triticale grain grown in Egypt had significantly higher moisture and ash content than those grown in Saudi Arabia. The variation in the moisture content of different triticale cultivars might be attributed to genetic and climatic factors. The present findings are in consistent with the findings of different workers (Slaughter, *et al.,* 1992; Mahmood, 2004) who reported that moisture content is dependent both on genetic makeup of varieties, climatic factors and agronomic conditions experienced during growth period.

The ash contents for triticale grains were within the range reported in the literature i.e. 0.44 -3% with values between 1.73 to 2.22%. Significant difference between cultivars was reported where ST06 exhibited the lowest ash content and ET21 the highest. The ash content is also one of the best indicators of flour yield; hence the triticale with lower content of ash may have more endosperm and ultimately yield good flour extraction (William *et al*., 1986).

Protein content of the tested cultivars ranged from 12.35 to 14.8%. A notable fluctuation in protein content in triticale grain, due to weather conditions and genetic variations, has previously been described (Alaru, *et al*., 2003; Erekul and Köhn, 2006). The statistical analysis of the data showed that ash and protein were still the main factors responsible for the discrimination of the quality of triticale grain. Therefore, the triticale grain with a high content of protein and ash seems to be more required for the cereal industry for further processing.

Wide variation for the crude fat content of the Saudi cultivars was reported where ST07 exhibited the highest fat content i.e. 2.31 % and ST11 as well as ST12 showed the lowest fat content i.e. 0.93 and 0.95% respectively. The crude fiber contents varied significantly and ranged from 4.37 to 2.29%.

Whole grain ST03 had the highest carbohydrate contents; however, carbohydrate contents noted in this variety was lower by 5% and 2% when compared to ST20, ST08, ST06, ET21, ST01, ST04, ST12, and ST15, respectively. Carbohydrate content is an important parameter for end-use of cereals. The average carbohydrate content in triticale cultivars grown at Saudi Arabia (range 68.27-73.39%) was significantly higher than in that grown at Egypt. These values were somewhat higher than contents previously reported by (Heger and Eggum, 1991).

Table 2: Thousand kernel weight and *proximate chemical composition of triticale cultivars on dry matter basis.

Sample	1000 kernel weight	Moisture	Ash	**Protein	Fat	Fiber	Carbohydrate (by difference)
ST-01	39.73^{cd} ±0.91	9.63^{bc} ±0.21	2.11^{ab} ±0.05	13.40^{b} ±0.42	1.69^{bc} ±0.11	2.52^{b} ±0.38	70.65
ST-03	44.27^{b} ±0.16	8.61^{fg} ±0.04	1.99^{bc} ±0.09	12.35^{c} ±0.50	1.27^{cd} ±0.10	2.39^{b} ±0.14	73.39
ST-04	41.88^{b} ±0.10	9.44^{cd} ±0.10	2.10^{ab} ±0.17	12.90^{cd} ±0.57	1.23^{cd} ±0.23	3.39^{ab} ±1.38	70.94
ST-06	42.3^{b} ±0.56	9.37^{cd} ±0.15	1.73^{e} ±0.10	13.70^{b} ±0.28	1.71^{bc} ±0.13	2.29^{b} ±0.26	71.20
ST-07	36.18^{d} ±0.84	9.90^{b} ±0.00	1.89^{cd} ±0.14	12.77^{cd} ±0.27	2.31^{a} ±0.60	2.79^{b} ±0.74	70.34
ST-08	38.0^{dc} ±0.36	9.20^{de} ±0.14	1.96^{bc} ±0.01	14.95^{a} ±0.64	1.33^{cd} ±0.02	3.07^{ab} ±0.24	69.49
ST-11	42.87^{b} ±0.67	8.90^{ef} ±0.28	2.11^{ab} ±0.03	12.90^{cd} ±0.00	0.95^{e} ±0.05	2.68^{ab} ±0.19	72.46
ST-12	42.81^{b} ±0.93	8.76^{fg} ±0.18	1.90^{cd} ±0.07	13.90^{bc} ±0.00	0.93^{e} ±0.02	2.79^{ab} ±0.59	71.72
ST-15	44.52^{a} ±0.59	8.94^{ef} ±0.02	1.98^{bc} ±0.01	12.80^{cd} ±0.14	2.06^{ab} ±0.03	2.76^{ab} ±0.59	71.46
ST-20	43.00^{b} ±4.16	8.43^{h} ±0.39	2.15^{ab} ±0.27	14.80^{a} ±0.00	1.98^{ab} ±0.02	4.37^{a} ±1.82	68.27
ET-21	28.70^{e} ±0.39	11.29^{a} ±0.02	2.22^{a} ±0.13	12.15^{c} ±0.21	1.41^{cd} ±0.13	2.38^{b} ±0.34	70.55

*Values are means of three repetitions
**N X 5.7
Values within columns followed by different upper case letters are significantly different ($p \leq 0.05$)

Minerals and trace elements:

Minerals such as zinc (Zn) and iron (Fe), and trace elements including copper (Cu) are cofactors of several antioxidant enzymes. The mineral and trace element contents for the tested cultivars were measured. A wide range of mineral elements in varying concentration were detected especially for calcium and sodium. The most abundant mineral was potassium 275.00±0.00 to 383.50±0.71ppm followed by phosphorus 75.40±3.68 to

245.30±1.84ppm. Significant difference ($p \leq 0.05$) in the sodium, calcium, iron, zinc and copper content were reported for the tested triticale cultivars Table (3).

The triticales possessing higher concentration of these micronutrients should be explored for commercial exploitation in biofortification programmes to alleviate the micronutrient deficiencies prevailing in the region.

Table 3: Mineral concentration (ppm/100g) of the triticale samples.

Sample	K	P	Ca	Na	Fe	Zn	Cu
ST-01	327.50^{c} ±7.78	164.10^{e} ±4.10	3.75^{bcd} ±0.35	25.25^{b} ±1.06	2.34^{abc} ±0.20	4.97^{a} ±0.06	0.45^{cd} ±0.01
ST-03	290.50^{d} ± 4.95	245.30^{a} ±1.84	3.75^{bcd} ±0.35	15.25^{e} ±0.35	2.07^{c} ±0.05	4.48^{c} ±0.18	0.44^{cd} ±0.00
ST-04	332.00^{c} ± 5.66	221.85^{c} ±0.21	4.50^{bcd} ±0.71	20.25^{cd} ±0.35	2.70^{ab} ±0.42	4.40^{c} ±0.05	0.52^{a} ±0.00
ST-06	288.00^{d} ±8.49	98.10^{f} ±2.69	3.00^{d} ±0.00	37.75^{a} ±3.18	2.56^{abc} 2±0.34	4.77^{b} 4±0.04	0.47^{bc} ±0.00
ST-08	292.50^{d} ±2.12	75.40^{h} ±3.68	3.00^{d} ±0.00	16.00^{de} ±2.83	2.14^{bc} ±0.19	4.70^{b} ±0.00	0.47^{c} ±0.01
ST-11	287.50^{d} ±3.54	236.05^{b} ±5.59	3.50^{bcd} ±0.71	18.50^{de} ±2.12	2.36^{abc} ±0.12	4.14^{d} ±0.11	0.42^{d} ±0.02
ST-12	275.00^{e} ±0.00	86.60^{g} ±4.81	3.25^{cd} ±1.06	20.25^{cd} ±0.35	1.20^{c} ±0.01	4.14^{d} ±0.06	0.47^{d} ±0.02
ST-20	383.50^{a} ±0.71	211.60^{d} ±2.26	7.25^{a} 0.36	23.25^{bc} ±1.06	2.80^{a} ±0.29	5.06^{a} 0.08	0.43^{d} ±0.03
ET-21	363.50^{b} ±4.95	203.35^{d} ±4.74	4.75^{b} ±0.35	16.25^{de} ±1.77	2.72^{ab} ±0.27	3.50^{e} ±0.02	0.51^{ab} ±0.02

*Values are means ± SD of triplicate determinations
Values within columns followed by different upper case letters are significantly different ($p \leq 0.05$)

Screening of triticale cultivars for total phenol content, DPPH radical scavenging activity and flavonoids

Total phenol content of triticale cultivars:

The total phenolics expressed as mg gallic acid equivilant per g dry matter (mg GAE/g) dry matter per cultivars are presented in Figure (1). A wide range of total phenols content in the triticale grains analyzed in this study was reported. Values of total phenols varied from 1.54 to 2.35 mg GAE/g as measured by Folin–Ciocalteau (FC) method. The triticale cultivar with the lowest value of total phenols was ST04 while the one with the highest value was ST01. Although the FC assay is very useful in determining phenolic concentrations, it does have disadvantages in that it is not specific and may not react with some phenolics within the extract so that phenolic concentrations may be underestimated (Stalikas, 2007). Conversely, the FC reagent can be reduced by some sugars and proteins, cyclic organic compounds and chelating agents leading to overestimation of phenolic concentrations (Peterson, 1979).

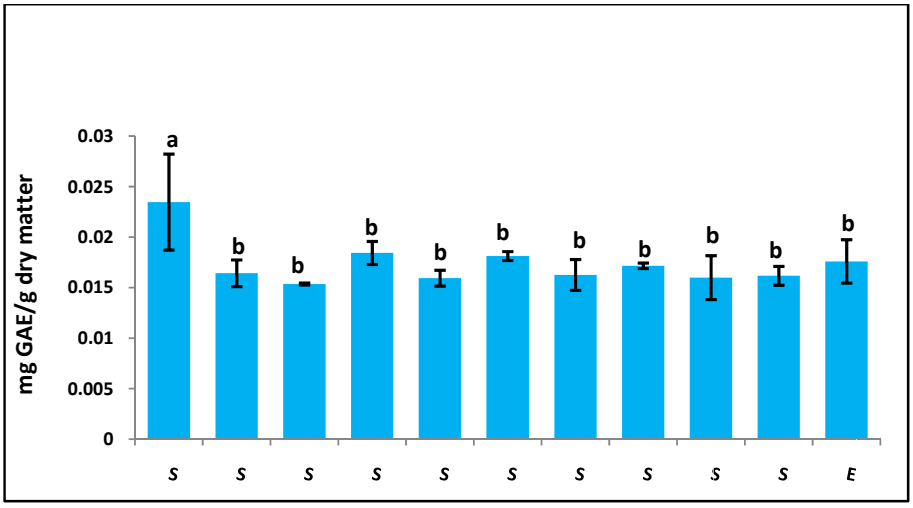

Fig. 1: Mean total phenolic content of tested triticale grains.
Vertical bars represent the standard deviation (n=3)
Different letters denote significantly ($P \leq 0.05$) differences in total phenolic content

J. Appl. Sci. Res., 9(8): 4867-4876, 2013

Radical Scavenging Activity (RSA) of triticale cultivars:

The second method used here refers to free radical scavenging activity of DPPH* to measure the antioxidant capacity of triticale extracts. Values obtained for this DPPH* assay are shown in Table (4). The DPPH* radical scavenging effects of the Saudi triticale were all higher than the Egyptian cultivar. Triticale grain with the highest total DPPH* radical scavenging effect was that of ST04 i.e. 156.55 RSA while the triticale cultivar with the lowest DPPH* radical scavenging effect was ET21 i.e.74.86 RSA. Between those high and low values a wide range of antioxidant abilities DPPH* were obtained among the 11 triticale grains.

The free RSA as a proportional of total estimated RSA ranged from 41.98% for ST07 to 48.84% for ET21. Compared to free RAS, higher levels of bound RAS were found in all samples. This result is in accordance with previous studies where, it was reported that bound fractions from cereals had higher antioxidant capacities than those of free fractions (Pellegrini *et al.,* 2006). In addition, the antioxidant capacity of the bound fraction in the residue could be significant. The obtained results revealed that triticale may serve as sources of valuable phenolics for food and nutraceutical applications.

Table 4: The Radical Scavenging Activity (RSA) of triticale cultivars.

Cultivar	Radical Scavenging Activity (RSA)		Estimated total RSA	% of total RSA		Total falvoniods mg/g
	Free	Bound		Free/Total (%)	Bound/Total (%)	
ST-01	70.10^{b} ±0.87	83.87^{a} ±0.09	153.97	45.53	54.47	28.68^{d} ±3.92
ST-03	43.61^{g} ±1.64	56.42^{c} ±0.50	100.03	43.60	56.40	29.92^{cd} ±0.67
ST-04	72.36^{a} ±0.05	84.19^{a} ±0.27	156.55	46.2	53.8	88.85^{a} ±0.50
ST-06	68.48^{c} ±0.32	83.00^{a} ±1.23	151.48	45.21	54.79	40.11^{bc} ±0.58
ST-07	59.81^{f} ±0.18	82.65^{a} ±0.37	142.46	41.98	58.01	9.58^{ef} ±2.41
ST-08	65.39^{d} ±1.05	84.48^{a} ±7.25	149.87	43.63	56.37	26.76^{d} ±6.25
ST-11	69.90^{bc} ±0.14	82.84^{a} ±0.37	152.74	45.76	54.24	54.74^{b} ±3.46
ST-12	64.48^{d} ±0.50	76.90^{b} ±0.55	141.38	45.61	54.39	30.49^{d} ±1.18
ST-15	60.52^{ef} ±0.00	82.97^{a} ±0.18	143.49	42.18	57.82	15.93^{e} ±0.23
ST-20	61.52^{e} ±0.05	72.97^{b} ±0.37	134.49	45.74	54.26	14.15^{e} ±2.15
ET-21	36.56^{h} ±0.21	38.30^{d} ±0.04	74.86	48.84	51.15	13.52^{f} ±0.44

Means with the same letter in same column are not significantly different at $P \leq 0.05$
Values are mean of triplicate determinations.

The flavoniod content of triticale cultivars:

Significant differences in total flavonoids content were found in all triticale cultivars, where ST04 had the highest content i.e. 34.34±0.60 and ST20 exhibited the lowest content i.e. 6.59 ±0.51. In general, two of the developed lines namely ST04 and ST11 showed higher values for corresponding flavoniods than all other developed lines and the Egyptian cultivar.

The free to bound flavoniod fractions in the studied cultivars showed the same trend as was shown in the DPPH and Total phenol content. Overall, bound flavoniod content was higher by comparison with free fraction in all cultivars Figure (3).

No correlation between total phenol and the antioxidant power were found Table (5) as reported by others (Ou, *et al.,* 2003).

Color quality of triticale cultivars:

The color of triticals was measured by the Hunter system using L, a and b values Table (6). The results of L value, a measure of the light-dark (brightness) of triticale cultivars, showed that triticale grains varied in color. ST20 cultivar exhibited the highest lightness and E values (42.70 and 45.24), meanwhile ET21showed the darkest color and lowest E value (34.70 and 37.03). Total phenolic content of tested triticale cultivars were negatively correlated at 0.05 level with degree of lightness (Table 5).

J. Appl. Sci. Res., 9(8): 4867-4876, 2013

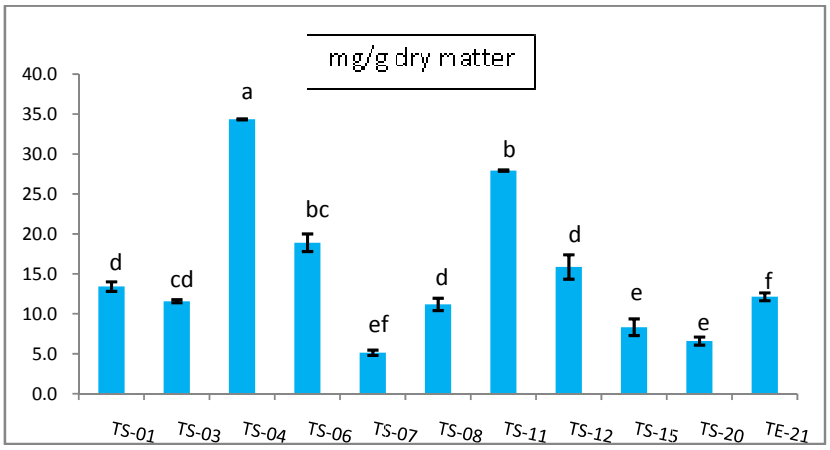

Fig. 2: Mean total flavoniods content of triticale grains.
Vertical bars represent the standard deviation (n=3)
Different letters denote significantly (P≤0.05) differences in total flavoniod content

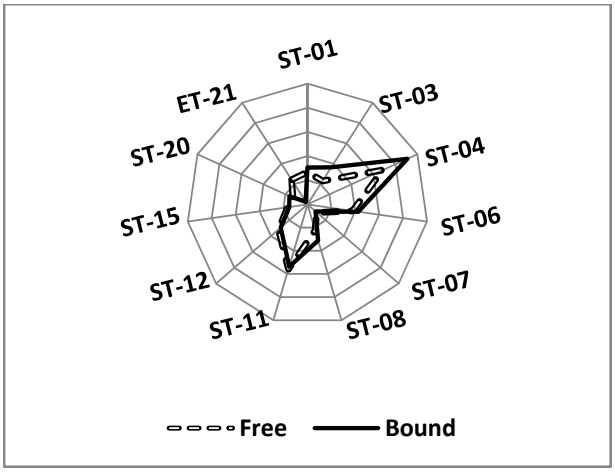

Fig. 3: Free and bound flavonoids content of triticale cultivars.

Table 5: Correlations between antioxidant contents, total phenol and degree of lightness.

	Total phenol	lightness	DPPH-bound	DPPH-free	DPPH-total	Falvonoid-free	Falvonoid-bound	Flavonoid-total
Total phenol	1.000							
lightness	-0.662(*)	1.000						
DPPH-bound	0.096	-0.118	1.000					
DPPH-free	0.181	-0.108	0.935(**)	1.000				
DPPH-total	0.135	-0.116	0.988(**)	.979(**)	1.000			
Falvonoid-free	-0.128	-0.191	0.239	0.468	0.344	1.000		
Falvonoid-bound	-0.173	-0.137	0.380	0.541	0.457	0.903(**)	1.000	.
Flavonoid-total	-0.159	-0.161	0.334	0.526	0.424	0.963(**)	0.986(**)	1.000

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

With regard to a and b which indicates the redness and yellowness values, ST06, ST07, ST15, ST20 and ET21 showed higher redness and yellowness values, consistent with the fact that those cultivars were beige in color. All other cultivars' colors ranged from the tan of wheat to the gray-brown color of rye. Triticale cultivar ST08 and ET21 showed the lowest color index (E=37.01 and 37.03, respectively) compared to the rest of tested cultivars. The differences in the color index therefore revealed different concentration of phenolics. Similar observation was obtained by (Daigle *et al.,* 1983) where larger amounts of flavonoids were obtained from the yellow or brownish color than those with cream or bright color. Beneficially, the browner color might be noticeable to attract consumer's attention to healthy products.

Table 6: *CIE L, a,* and *b* color values of triticale cultivars.

Sample code	L	a	b	E
ST-01	34.19^{c} ±0.01	8.36^{cb} ±0.04	12.71^{e} ±0.08	37.44^{c} ±0.03
ST-03	34.33^{b} ±0.03	8.40^{bc} ±0.04	12.22^{i} ±0.03	37.39^{b} ±0.03
ST-04	34.27^{b} ±0.02	8.34^{c} ±0.02	12.82^{d} ±0.02	37.69^{b} ±0.02
ST-06	35.10^{b} ±0.02	7.63^{h} ±0.02	12.54^{b} ±0.02	38.05^{g} ±0.12
ST-07	34.77^{b} ±0.03	7.92^{f} ±0.02	12.61^{f} ±0.02	37.82^{b} ±0.02
ST-08	33.95^{b} ±0.01	8.10^{e} ±0.02	12.32^{h} ±0.02	37.01^{bc} ±0.02
ST-11	34.18^{b} ±0.02	8.58^{a} ±0.04	12.91^{c} ±0.06	37.53^{b} ±0.05
ST-12	36.63^{b} ±0.07	8.18^{d} ±0.03	13.40^{a} ±0.04	39.85^{b} ±0.02
ST-15	34.28^{b} ±0.04	7.95^{f} ±0.03	12.45^{f} ±0.02	37.38^{b} ±0.04
ST-20	42.70^{a} ±0.03	6.76^{i} ±0.01	13.32^{b} ±0.03	45.24^{a} ±0.03
ET-21	34.07^{b} ±0.03	7.82^{g} ±0.06	12.23^{i} ±0.03	37.03^{bc} ±0.02

Means in the same column with different letters denote significant difference (P≤ 0.05)
Values are mean of triplicate determinations

Conclusions:

Cultivars under investigation are similar in composition to cultivars from other areas, and generally have protein content comparable to that of wheat. The genetic differences between cultivars as well as localities were evident, with cultivars differing significantly in all parameter.

Triticale extracts showed wide ranges of total phenolics and antioxidant activities; however, extracts containing higher phenolic content and comparable but not necessarily higher antioxidant activity. Further research on the relationship between phenolic content and antioxidant activity of triticale is necessary.

The similarity observed for some cultivars than others in terms of antioxidants capacity and composition can facilitate selection of more commercially attractive triticale cultivars.

When taking into consideration the high yield of triticale under both biotic and abiotic stress, the changing climate condition of the earth and its growing population, it is clear that triticale can make a contribution in future efforts for sustainable food production. Triticale is thus crop deserve continued research and breeding effort.

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