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Effect of Environment on Quality Parameters of Wheat

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ABSTRACT

Present investigation was carried out to study the effect of environments on the carbohydrate profile and protein profile of grains in three cultivated wheat species viz. T. aestivum (DWR-162, Raj-4037, GW-322) T. durum (DWR-1006, MACS-2846 and NIDW-295) and T. dicoccum (DDK-1009, DDK-1029 and NP-200) grown at two locations. The selected wheat varieties were grown during rabi 2007-08 at MARS, Dharwad as well as ARS Arabhavi representing the irrigated and rain-fed ecology with distinct agro-climatic conditions of transitional and dry zones respectively significant differences within the species and between the locations for carbohydrate, starch, total sugar, crude protein, nitrogen content, soluble protein and wet gluten content were recorded. The total carbohydrate content was high in T. aestivum varieties (74.17%) at Dharwad as compared to Arabhavi location (70.47%), whereas starch content was higher (69.48%) at Arabhavi as compared to Dharwad (67.48%). Nitrogen (3.14%), crude protein (17.91%) and soluble protein (1.48%) content were high in T. dicoccum varieties at Dharwad, whereas non-reducing and total sugars were higher in T. aestivum and T. dicoccum varieties at Arabhavi as compared to Dharwad, and were low in T. durum varieties. Wet gluten content was high in T. durum (43.06%) at Arabhavi location. Looking in to genotype and environmental interaction, T. dicoccum and T.aestivum genotypes seem to be more suitable for Dharwad environmental conditions and T. durum genotype for Arabhavi environment.

Key words: *Wheat varieties, Carbohydrate, Starch, Total Sugar, Protein, Nitrogen, Gluten.*

INTRODUCTION

Wheat the "versatile cereal food" is also described as the "stuff of life" or "king of cereals"[26]. It is the most important cereal crop in the world[37] due to its feeding bowl to mankind. More than 35 per cent of the world population depends on wheat[7,21] as it supplies more nutrients than any other single crop[42]. Wheat diet has been shown to reduce the incidence of major human diseases such as diabetes, cardiovascular disease and cancer[3,24,33,40,54]. The quality of wheat is largely dependent upon its chemical composition which is influenced by genetic and environmental factors and processing conditions[8,18,26,38,56,58]. Wheat is the principal source of energy, protein and dietary fiber for major portion of the world's population[1]. Grain quality is a complex trait resulting from the interactions between numerous protein components[9,49].

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The protein composition of wheat seeds is important in determining bread-making quality[19]. Wheat protein quality mainly depends upon the protein content (gluten) in the wheat grain[25,27]. Gluten proteins, a large complex composed mainly of glutenins and gliadins, play a key role in baking quality because of their impact on water absorption capacity of the dough, dough elasticity and extensibility that can affect wheat flour quality[51]. Carbohydrates are the most abundant constituents of wheat kernel, forming about 60-75 per cent of the dry matter[5,58]. Wheat contains starch, soluble sugar (2%) and cellulose (2-3 %). Starch is the major constituent of wheat endosperm[5,58].

The environmental effect is often larger than the genetic effect on wheat quality[2,9,10,30,34,39,44,50]. Such effects may include soil type, fertilizer level especially nitrogen[30,36,49], distribution of rainfall level[12] and late season factors[28]. Temperature during grain filling is the most important environmental determinant of grain quality[41]. High temperature during grain filling, especially greater than 35^0C, alters the protein biosynthetic pathways of grain, leading to protein compositional changes[6,55]. The wheat grain quality declines with increase in atmospheric carbon dioxide[11,14,23,57].

These factors influence the rate and duration of wheat grain development, protein accumulation and starch deposition[10,16]. N fertilization increases the total quantity of flour proteins, resulting in an increase in both gliadins and glutenins[10,19,20,30,32,35,49,52]. The goal of the present study was to evaluate the biochemical parameters of *T. aestivum* (DWR-162, Raj-4037 and GW-322), *T. durum* (DWR-1006, MACS-2846 and NIDW-295) and T. *dicoccum* (DDK-1009, DDK-1029 and NP-200) wheat varieties in irrigated and rain-fed ecology with distinct agro-climatic conditions of transitional and dry zones. The seeds were collected from two different locations *i.e*., Dharwad and Arabhavi to study the quality variation in varieties of cultivated species of wheat.

MATERIAL AND METHODS

This experiment was conducted during *rabi* 2008-09 at Wheat Improvement Project Field, Wheat Laboratory, University of Agricultural Sciences, Dharwad, with three leading wheat cultivars each from *T. aestivum*, *T. durum* and *T. dicoccum* collected from two different growing locations *i.e*., MARS Dharwad and ARS Arabhavi. Samples selected for the study were milled in a laboratory model Willey Mill (0.5 mm) and used for the assessment of the biochemical quality parameters.

Sugars were extracted from harvested and powdered grain sample by washing with hot 80 percent ethanol. Starch was then extracted from sugar free residue by treating with 52 percent cold (4°C) perchloric acid. Reducing sugar was estimated in alcohol free extract using Nelson-Somogyi's method[45]. Total carbohydrate content was estimated by anthrone method[45]. Available starch content in the wheat flour sample was analyzed by hydrolyzing the wheat flour in perchloric acid by anthrone method[45].

Total soluble protein content in the sample was calculated from a standard curve prepared using Bovine serum albumin[29]. Total available nitrogen content was determined by microkjeldahl method[45].

$$\% N = \frac{\text{Titre value x 0.02 N HCl x 0.014 x 100}}{\text{Weight of sample (mg)}}$$

The amount of crude protein present in the wheat sample was calculated by multiplying the N content by a factor 5.7.

Crude protein (g %) = % N x 5.7

The data collected in triplicate for all the quality parameters were statistically analysed using Completely Randomised Design[48].

The details of pedigree and silent features of the different wheat varieties taken for the experiment are furnished in Table 1.

RESULTS

Total carbohydrate and Starch

The mean total carbohydrates content (Table 2) in grains was significantly high in *T. aestivum* (72.30 %) and *T. durum* (71.07 %)

varieties as compared to *T. dicoccum* (59.04%) varieties. Among the varieties, Raj-4037 (74.30%) *T. aestivum* had significantly higher in total carbohydrate and the rest of the *T. aestivum* and *T. durum* varieties recorded carbohydrate content ranging from 70.60 – 71.60 percent. *T. dicoccum* varieties recorded significantly low total carbohydrate content (58.10 - 61.10%). Total carbohydrate content of *T. aestivum* varieties at Dharwad compared to Arabhavi (70.47%) location was significantly higher (74.17%) whereas *T. durum* varieties and *T. dicoccum* varieties recorded significantly higher carbohydrate content at Arabhavi compared to Dharwad location.

The total starch content (Table 2) in wheat grains was high in *T. aestivum* (68.44 %) and *T. durum* (63.37 %) but low in *T. dicoccum* (54.37 %) varieties. Among the varieties, *T. aestivum* variety GW-322 recorded higher starch content (70.31%). *T. dicoccum* varieties recorded significantly low starch content (49.10 – 57.60%). Arabhavi location was better in wheat grain for higher starch (57.53 – 69.48%) as compared to Dharwad (51.30 – 67.48%) location.

Reducing, non-reducing and total sugars

The reducing sugar content was higher in *T. durum* and *T. dicoccum* varieties at both the locations compared to *T. aestivum* varieties. Non- reducing sugar content of *T. durum* varieties (1.62%) were high at Dharwad compared to *T. dicoccum* (0.97%) and *T. aestivum* (1.11%) varieties whereas at Arabhavi. *T. dicoccum* varieties (1.73%) recorded higher non-reducing sugar content compared to *T. aestivum* (1.21%) and *T. durum* (1.29%) varieties. Total sugar content of *T. durum* (1.91%) varieties was higher at Dharwad compared to *T. dicoccum* (1.24%) and *T. aestivum* (1.30%) varieties, whereas, at Arabhavi location, *T. dicoccum* varieties (2.00%) recorded higher total sugar content compared to *T. aestivum* (1.38%) and *T. durum* (1.50%) varieties.

Nitrogen and Crude protein

Mean nitrogen content (Table 4) in wheat grains was high in *T. dicoccum* (3.01 %) and low in *T. durum* (2.01 %) varieties whereas *T. aestivum* varieties had 2.21 percent nitrogen content. *T. aestivum* varieties differed significantly in their nitrogen content with the change in location. Arabhavi was favorable for higher nitrogen content (2.44%) compared to Dharwad (1.97%) location. GW-322 variety of *T. aestivum* recorded higher nitrogen (2.50 %) at Arabhavi but was low at Dharwad (1.66 %). *T. durum* and *T. dicoccum* varieties were consistent in their nitrogen content at both the locations. Among the varieties DDK-1009 recorded significantly higher nitrogen content (3.13%), whereas DWR-1006 recorded significantly low nitrogen content (1.96%). *T. aestivum* and *T. durum* varieties recorded significantly higher nitrogen content at Arabhavi as compared to Dharwad.

The crude protein content (Table 4) was high in *T. dicoccum* (17.16 %) and low in *T. durum* (11.65 %) varieties. *T. aestivum, T. durum* and *T. dicoccum* varieties significantly differed in their crude protein content with the change in location. *T. aestivum* variety Raj-4037 recorded higher mean protein content of 13.10 per cent that was 14.99 percent at Arabhavi and 11.21 per cent at Dharwad. *T. durum* variety MACS-2846 recorded higher crude protein content of 13.26 per cent at Arabhavi but low at Dharwad (9.50 %) location and NP-200 variety of *T. dicoccum* recorded significantly higher crude protein content of 18.24 per cent at Dharwad but was low (15.96%) at Arabhavi. Among all the varieties of three different species evaluated, DDK-1009 had significantly higher mean crude protein content of 17.84 per cent and DWR-1006 recorded low amount of protein (11.18 %). *T. aestivum* and *T. durum* varieties recorded significantly higher crude protein content at Arabhavi (13.94 and 12.75 %) as compared to Dharwad (11.24 and 10.28 %) location, whereas *T. dicoccum* varieties had significantly higher level (17.91 %) at Dharwad but low value (16.39 %) at Arabhavi.

Soluble protein and wet gluten

Soluble protein content (Table 5) was high in grains of *T. dicoccum* (1.47 %) varieties evaluated but was low in *T. durum* (1.29 %)

varieties. *T. durum* varieties differed significantly in their soluble protein content with the change in location. *T. durum* variety DWR-1006 recorded higher soluble protein content (1.46 %) at Dharwad but it was low (1.21 %) at Arabhavi. *T. dicoccum* varieties were consistent in their soluble protein content both at Dharwad (1.48%) and Arabhavi (1.46%) locations. DDK-1029 of *T. dicoccum* recorded significantly higher soluble protein content (1.67%) and MACS-2846 recorded low soluble protein (1.21%). *T. aestivum* and *T. durum* varieties recorded significantly higher soluble protein content (1.43% and 1.32 % respectively) at Arabhavi as compared to Dharwad (1.34% and 1.26 % respectively).

Wet gluten content (Table 5) in wheat grains was high (39.00%) in *T. durum* varieties tested and low (28.50%) in *T. aestivum* varieties. *T. durum* varieties evaluated differed significantly in their wet gluten content with the change in location. MACS-2846 recorded higher wet gluten content at Arabhavi (41.00 %) but it was low (30.30 %) at Dharwad. DWR-1006 of *T. durum* recorded higher wet gluten content at Arabhavi (50.70 %) but it was low at Dharwad (43.70 %). Among all the varieties of three different species, DWR-1006 of *T. durum* recorded significantly higher mean wet gluten content (47.20 %) whereas, GW-322 of *T. aestivum* recorded low wet gluten content (25.00%). *T. aestivum* and *T. durum* varieties recorded significantly higher wet gluten (29.60 and 43.06 %) at Arabhavi as compared to Dharwad (27.80 and 34.96%) location and *T. dicoccum* varieties recorded significantly higher wet gluten content (37.26 %) at Dharwad as compared to Arabhavi (34.10 %).

DISCUSSION

The quality of wheat grains largely depends on its chemical composition[58] in general *T. aestivum* varieties recorded higher amount of total carbohydrate and starch followed by *T. durum* and *T. dicoccum* varieties. The varieties itself they are differed in their carbohydrate and starch content like the variety RAJ-4037 had significantly higher carbohydrate content where DDK-1029 had low carbohydrate content. Similarly, GW-322 had higher starch content and DDK-1029 recorded low starch content. Starch, besides energy and palatability provider also maintains the viscosity of flour to increase extensibility of the dough, an important factor for bakery products[31]. If there is increase in starch content it tends to progressive decrease in total sugars, reducing and non-reducing sugars in the developing grains[17]. *T. durum* and *T. dicoccum* varieties had higher amount of reducing, non-reducing and total sugars content as compared to bread wheat[4,43].

The grain quality of wheat is mainly dependent on its protein content[9]. The protein composition of wheat grains is important in determining bread-making quality[19]. If nitrogen content of grain is increased, the total quantity of flour protein also increases[49]. It can be seen from the data that lowest nitrogen and crude protein content was observed in *T. durum* varieties at Dharwad as compared to Arabhavi but *T. dicoccum* varieties recorded better quality traits at Dharwad as compared to Arabhavi location[15,53]. The protein content in the wheat grain also depend on genotype as it is also influenced by environmental conditions[2,9,30,34,44,50]. In present study the same species and the same varieties also differed in their nitrogen, protein, gluten, starch, soluble protein, total sugars and total carbohydrate content with respect to location which could be due to the environmental variables like temperature, rainfed, soil, moisture and fertility status of the location[6,14,26,49]. *T. aestivum* verities and *T. dicoccum* varieties were better in soluble protein content compared to *T. durum* varieties. GW-322, Raj-4037, MACS-2846 and NIDW-295 had better soluble protein content at Arabhavi, whereas DWR-1006 had higher protein content at Dharwad over Arabhavi. *T. dicoccum* variety DDK-1009 had higher soluble protein content at Dharwad compared to Arabhavi[22]. Wet gluten content was higher in *T. aestivum* and *T. durum* varieties at Arabhavi location as compared to Dharwad but *T. dicoccum* varieties had higher amount of wet gluten content at Dharwad compared to Arabhavi[13,31,46,47,49].

Table 1: Wheat varieties selected for the study

Varieties	Origin	Pedigree	Special features
T. aestivum			
DWR-162	Dharwad	Kavakaz/Buhol/ Kalyan sona/ Bob white	High grain yield, resistant to leaf stem and stripe rust diseases and heat tolerant (Irrigated condition)
Raj 4037	RAU, Durgapura	DL788-2 / RAJ-3717	High yielding resistance to all the three major rust and tough for threshing (Irrigated condition)
GW-322	GAU, Junagarh	PBW 173/GW 196	Uniform maturing, high yielding, high TGW, resistant to major races of rusts (Irrigated condition)
T. durum			
DWR-1006	Dharwad	DWL-5023/DON	High yielding, semi tall, tolerance to limited irrigation and multiple disease resistant and multiple disease resistant with diverse Sr. genes (Irrigated condition)
MACS-2846	ARI, Pune	CPAN 6079/ MACS 2340	High yielding, susceptible to leaf blight and uniform maturity (Irrigated condition)
NIDW-295	ARS, Niphad	BOOMER 33/ PLATA-8	High yielding superior over MACS-2846, high TGW and resistant to leaf blight (Irrigated condition)
T. dicoccum			
DDK-1009	Dharwad	NP 2004/ *NP-200 / ALTAR-84	Tolerant to leaf blight disease and high yielding (Irrigated condition)
DDK-1029	Dharwad	DDK 1012/HW-1093/ 276-15	Higher yield, resistant to brown and black rusts and spot blotch (Irrigated condition)
NP-200	IARI	Selection from Madhapalli local	Tall low yielding, high TGW, susceptible for lodging and most adopted (Irrigated Timely Sown)

Table 2: Total carbohydrate and starch content in *T. aestivum*, *T. durum* and *T. dicoccum* wheat varieties at different locations

Varieties	Total Carbohydrate (%)			Starch (%)		
	Dharwad	Arabhavi	Mean	Dharwad	Arabhavi	Mean
T. aestivum						
DWR-162	72.40	69.60	71.00	68.30	67.12	67.74
Raj-4037	70.60	78.00	74.30	66.90	67.62	67.26
GW-322	79.50	63.80	71.60	67.23	73.39	70.31
Mean	**74.17**	**70.47**	**72.30**	**67.48**	**69.48**	**68.44**
T. durum						
DWR-1006	70.60	72.50	71.55	61.43	60.38	60.91
MACS-2846	71.70	70.30	71.00	63.67	62.62	63.15
NIDW-295	69.40	71.90	70.60	65.09	67.00	66.05
Mean	**70.57**	**71.57**	**71.07**	**63.40**	**63.33**	**63.37**
T. dicoccum						
DDK-1009	58.40	59.60	59.00	55.30	60.00	57.60
DDK-1029	55.30	61.00	58.10	48.30	50.00	49.10
NP-200	57.30	65.00	61.10	50.03	62.60	56.45
Mean	**57.00**	**61.87**	**59.04**	**51.30**	**57.53**	**54.37**
	Treatment	**Location**	**Interaction**	**Treatment**	**Location**	**Interaction**
CD at 5%	**2.00**	**0.50**	**1.00**	**2.10**	**1.70**	**2.03**

Table 3: Reducing, Non-reducing and Total sugar content of *T. aestivum*, *T. durum* and *T. dicoccum* wheat varieties, location-wise

Varieties	Dharwad			Arabhavi			Mean
	Reducing sugar (%)	Non-reducing sugar (%)	Total sugars (%)	Reducing sugar (%)	Non-reducing sugar (%)	Total sugars (%)	
T. aestivum							
DWR-162	0.14	1.22	1.42	0.08	0.88	1.01	0.79
Raj-4037	0.13	1.17	1.36	0.11	1.33	1.51	0.94
GW-322	0.17	0.95	1.12	0.12	1.41	1.61	0.90
Mean	**0.15**	**1.11**	**1.30**	**0.10**	**1.21**	**1.38**	**0.88**
T. durum							
DWR-1006	0.16	1.76	2.01	0.10	1.32	1.49	1.14
MACS-2846	0.24	1.60	1.92	0.19	1.41	1.67	1.17
NIDW-295	0.22	1.49	1.79	0.13	1.14	1.33	1.02
Mean	**0.21**	**1.62**	**1.91**	**0.14**	**1.29**	**1.50**	**1.11**
T. dicoccum							
DDK-1009	0.22	0.92	1.19	0.11	1.80	2.01	1.04
DDK-1029	0.21	0.91	1.17	0.18	1.59	1.85	0.99
NP-200	0.20	1.09	1.35	0.24	1.79	2.13	1.13
Mean	**0.21**	**0.97**	**1.24**	**0.18**	**1.73**	**2.00**	**1.05**
	Treatment		**Location**		**Interaction**		
CD at 5%	**0.11**		**0.07**		**0.05**		

Table 4: Nitrogen and crude protein content in *T. aestivum*, *T. durum* and *T. dicoccum* wheat varieties, location-wise

Varieties	Nitrogen (%)			Crude protein (%)		
	Dharwad	Arabhavi	Mean	Dharwad	Arabhavi	Mean
T. aestivum						
DWR-162	2.29	2.21	2.25	13.05	12.60	12.83
Raj-4037	1.97	2.63	2.30	11.21	14.99	13.10
GW-322	1.66	2.50	2.08	9.46	14.25	11.86
Mean	**1.97**	**2.44**	**2.21**	**11.24**	**13.94**	**12.60**
T. durum						
DWR-1006	1.78	2.14	1.96	10.16	12.20	11.18
MACS-2846	1.66	2.32	1.99	9.50	13.26	11.38
NIDW-295	1.96	2.24	2.10	11.20	12.80	12.39
Mean	**1.80**	**2.23**	**2.01**	**10.28**	**12.75**	**11.65**
T. dicoccum						
DDK-1009	3.16	3.10	3.13	18.01	17.67	17.84
DDK-1029	3.07	2.73	2.90	17.49	15.56	16.32
NP-200	3.20	2.80	3.00	18.24	15.96	17.10
Mean	**3.14**	**2.87**	**3.01**	**17.91**	**16.39**	**17.16**
	Treatment	**Location**	**Interaction**	**Treatment**	**Location**	**Interaction**
CDat 5%	**0.42**	**0.30**	**0.20**	**2.00**	**1.10**	**1.01**

Table 5: Soluble proteins and wet gluten content in *T. aestivum*, *T. durum* and *T. dicoccum* wheat varieties, location-wise

Varieties	Soluble Protein (%)			Wet Gluten (%)		
	Dharwad	Arabhavi	Mean	Dharwad	Arabhavi	Mean
T. aestivum						
DWR-162	1.38	1.43	1.40	31.80	33.50	32.60
Raj-4037	1.33	1.43	1.38	25.10	30.80	27.90
GW-322	1.31	1.43	1.37	26.50	24.50	25.00
Mean	**1.34**	**1.43**	**1.38**	**27.80**	**29.60**	**28.50**
T. durum						
DWR-1006	1.46	1.21	1.34	43.70	50.70	47.20
MACS-2846	1.10	1.32	1.21	30.30	41.00	35.60
NIDW-295	1.22	1.45	1.33	30.90	37.50	34.20
Mean	**1.26**	**1.32**	**1.29**	**34.96**	**43.06**	**39.00**
T. dicoccum						
DDK-1009	1.38	1.22	1.30	34.40	26.60	30.50
DDK-1029	1.61	1.73	1.67	42.50	37.80	40.10
NP-200	1.44	1.42	1.46	34.90	37.90	36.40
Mean	**1.48**	**1.46**	**1.47**	**37.26**	**34.10**	**35.67**
	Treatment	**Location**	**Interaction**	**Treatment**	**Location**	**Interaction**
CDat 5%	**0.048**	**0.034**	**0.02**	**0.30**	**0.10**	**0.14**

CONCLUSION

The quality of wheat grain largely dependent upon its chemical compositions which are influenced by genetic and environmental factors. The environmental effect is often larger than the genetic effect on wheat quality. The results of this study have shown that the verities of the same species differed significantly in their quality traits when they are grown in different locations due to genotype and environmental interaction, *T. dicoccum* and *T. aestivum* genotypes recorded better quality traits at dharwad environmental conditions and *T. durum* genotype at Arabhavi environmental conditions.

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