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RESEARCH ARTICLE

Nutritional Composition of Wheat Grains and Straw Influenced by Differences in Varieties Grown under Uniform Agronomic Practices

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ABSTRACT

This study was conducted to determine the effect of different wheat varieties on nutritional value in grains and straw fed to *lohi* sheep. At harvest, samples of wheat plants (whole) from 11 irrigated and 8 varieties of rain-fed areas grown under uniform agronomic conditions were collected. Chemically dry matter (DM), crude fibre (CF), ether extract (EE), and total ash content of grains from different varieties differed significantly ($P<0.05$) except crude protein (CP) and macro-minerals concentrations. Straws of different wheat varieties were statistically similar ($P>0.05$) in DM, total ash, neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL) and macro-minerals but differences in CP, CF and EE contents were significant. Nitrogen free extract (NFE) of different varieties of wheat was different and ranged from 40.52 to 45.99%. Two *lohi* male sheep fitted with permanent ruminal cannulas (40mm diameter) were used for determining i*n-situ* digestibility (%) of DM, NDF and ADF of straw. Digestibility of these nutrients was observed highest in Wafaq-2001, while lowest in Marvi-2000, and the difference was significant. Grains to straw ratios were maximum in Chenab-2000 (1:1.95) and minimum in A.S 2003 (1:1.18). From the results, we conclude that straw of Wafaq-2001 was found to be higher quality in terms of DM, NDF and ADF *in situ* digestibility; therefore, this may be better for feeding ruminants compared to other varieties.

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INTRODUCTION

In Pakistan, wheat was grown in an area of about 8.7 million hectares with an annual production of 24.2 million tons of grains and about 47.2 million tons of wheat straw (GOP, 2012-13). Khan and Ullah (1984) reported that wheat contributes 83% of the total cereals intake and provides over 50% of the total calories and 60% of the total proteins consumed by the population.

Straw as the residue of cereals after harvesting can represent a significant amount of biomass (Kafilzadeh *et al.,* 2012). Cereal straw plays a key role in ruminants' nutrition in Pakistan especially during fodder scarcity periods. It is being predominantly used @ 25-50% as dry roughages in ruminants feeding. Feeding value of wheat straw is, however, limited due to its least crude protein and lower digestibility (Khan, 1989), minerals and metabolizable energy and vitamins. Ruminants also have unique ability to utilize the fibrous material through anaerobic fermentation (Kibria *et al*., 1991). Earlier scientists (Kernan *et al*., 1979; Kernan *et al*., 1984; Hartely *et al.*, 1984; Walli *et al.,* 1990; Susmel *et al*, 1994; Habib *et al.,* 1995; Tolera *et al.,* 2008) have reported nutritional differences of the crop residue from different wheat varieties. Shah *et al*. (1977) analysed 13 grains of wheat varieties and found range of CP and CF as 9.29 to13.36% and 2.15 to 2.36%, respectively. The values of EE, total ash and NFE were 0.98 to1.48%, 0.98 to1.69% and 71.83-76.41%, respectively. Almost similar results of chemical composition of different wheat varieties were reported by Ahmed *et al*. (1981). There is less information in the available literature about the impact of varieties on the quality and quantity of wheat grains and straw produced. It may be possible to select wheat varieties that produce high quality straw without sacrificing grain yield. Therefore, the present study was planned to compare the chemical composition and nutritional values of grains as well as straw of different wheat varieties grown in Pakistan.

MATERIALS AND METHODS

Wheat varieties of irrigated areas (n=11) including Manthar, Tatara, Inqlab-91, M.H-97, Zarlashta-99, Auqab-2000, Chenab-2000, Marvi-2000, Iqbal-2000, S.H-2003 and A.S-2003 and rainfed (n=8) namely Local white, Sariab, Kohsar-95, Chakwal-97, Margalla-99, Wafaq-2001, Bhakkar-2001 and G.A-2002 were grown under uniform agronomic practices under the Wheat Programme, National Agricultural Research Centre (NARC) Islamabad, Pakistan. At harvest (during mid of May), sample of about 20 kg wheat plants (whole) of each variety were cut and collected manually, weighed and separated the grains from leaves and stem called 'straw'. Grains and straw of each variety was weighed for grain to straw ratios calculation. Representative samples of grains and straw of each variety were ground through 1 mm screen in Wiley hammer mill (standard model 4) and stored for subsequent chemical analysis.

Chemical analysis

Grains and straw of each wheat variety were analyzed for proximate composition according to AOAC (1990) methods. Straw was also analyzed for neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) by Van Soest *et al.* (1991) methods. Acid insoluble ash (silica) content was estimated by the difference of total ash and soluble ash (AOAC, 1990). Concentrations of sodium (Na) and potassium (K) in grains and straw were determined by flame photometer (Biotech Engineering Management Co. Ltd., UK). Phosphorus (P) was determined by using UVD-2960 spectrophotometer while calcium (Ca) by titration (AOAC, 1990) methods.

In-Situ digestibility

The *in-situ* digestibility of wheat straw was studied by nylon bag technique (Orskov *et al*., 1980). Four grams of ground straw sample of each variety was weighed into dacron polyester bags (50 µm pore size and 7' x 4" dimension) in duplicate. Two mature male sheep of *lohi* breed fitted with permanent ruminal cannulas (40 mm diameter) were used. These sheep were adapted with wheat straw based diet (75% straw + 15% concentrate + 10% maize green fodder) for 10 days before and during the trial. Availability of clean water was assured round the clock. Nylon bags containing straw were placed in the dorsal sac of the rumen for 72 hours incubation and then taken out and washed with running tap water until the rinse was clear. The bags were then dried at 80^{o}C for 48 hours in a forced air oven. The disappearance of DM was calculated from the amount incubated and left in the bag after incubation. Digestibility of NDF and ADF was also calculated.

Statistical analysis

The data obtained were subjected to statistical analysis by using analysis of variance (Snedecor and Cochran, 1976). Means were compared by Duncan's Multiple Range test (Steel *et al*., 1997) at 5% level of probability.

RESULTS AND DISCUSSION

Wheat grains

Chemical composition of grains and straw from different wheat varieties is shown in Table 1 and 2, respectively. DM of different wheat varieties ranged from 88.37 to 89.98%. Highest DM (89.98%) was observed in Marvi-2000, however, statistically there was no difference among the varieties. CP in different varieties ranged from 9.32 to 14.83% and the difference was significant ($P<0.05$) among the varieties with maximum CP (14.83%) in Bhakkar 2001 variety. Values of CP were almost identical as reported by Shah *et al*. (1977) who analyzed 13 wheat varieties and found range of CP 9.29-13.36%, CF 2.15-2.36%, EE 0.98-1.48%, total ash 0.98-1.69% and NFE 71.83-76.41%. Hamilton and Trenholm, (1984) observed CP values of 12.10 to 16.80%, respectively, in different wheat varieties. Our results of CP are in agreement with the results of Kernan *et al*. (1984). Varietal differences in grains yield among wheat varieties were also reported by El-Metwally and Saudy (2009).

Table 1: Chemical composition (%, DM) of grains from 19 varieties of wheat

Varieties	DM	CP	CF	EE	ASH	NFE	Ca	P	Na	K
Local white	89.46	13.52^{abc}	3.00^{d}	1.70^{jk}	1.82^{a}	79.91^{efg}	-	0.41	0.01	0.48
Manthar	89.46	11.85^{abc}	3.45^{bc}	2.14^{fg}	1.61^{d}	81.12^{cde}	0.08	0.35	0.02	0.52
Tatara	89.29	10.53^{abc}	3.54^{b}	1.90^{hi}	1.63^{cd}	82.26^{bc}	0.080	0.41	0.01	0.59
Inqalab-91	89.17	9.86^{bc}	2.81^{e}	2.52^{bcd}	1.73^{abcd}	82.92^{ab}	0.10	0.49	0.02	0.52
Sariab-92	89.49	12.51^{abc}	3.16^{d}	2.41^{d}	1.62^{d}	80.62^{def}	0.09	0.45	0.01	0.48
Kohsar-95	89.36	11.60^{b}	3.09^{d}	1.84^{ij}	1.75^{abc}	81.84^{bcd}	-	0.40	0.03	0.51
M.H-97	89.63	14.70^{a}	3.14^{d}	1.61^{kl}	1.68^{bcd}	78.79^{g}	0.14	0.45	0.01	0.48
Chakwal-97	89.07	11.36^{abc}	3.62^{ab}	2.04^{gh}	1.64^{bcd}	81.04^{cde}	0.06	0.45	0.01	0.47
Margalla-99	89.29	13.32^{abc}	3.12^{d}	3.17^{a}	1.69^{bcd}	78.78^{g}	0.06	0.48	0.01	0.52
Zarlashta-99	88.70	9.32^{c}	3.23^{d}	1.48^{l}	1.72^{bcd}	83.91^{a}	-	0.38	0.01	0.52
Auqab-2000	89.55	10.66^{abc}	3.76^{a}	2.49^{cd}	1.71^{abcd}	80.74^{cde}	-	0.41	0.01	0.48
Chenab-2000	89.28	10.19^{bc}	3.76^{ef}	2.63^{bc}	1.65^{bcd}	82.86^{ab}	0.09	0.47	0.01	0.48
Marvi-2000	89.98	13.42^{abc}	3.28^{cd}	2.22^{ef}	1.75^{abc}	79.13^{fg}	-	0.54	0.01	0.50
Iqbal-2000	89.84	10.64^{abc}	3.27^{cd}	2.70^{b}	1.75^{abc}	81.04^{cde}	0.06	0.38	0.02	0.48
Wafaq-2001	89.23	11.86^{b}	3.11^{d}	2.54^{bcd}	1.70^{bcd}	81.08^{cde}	0.10	0.34	0.01	0.50
Bhakkar-2001	89.40	14.83^{a}	2.59^{f}	1.32^{m}	1.64^{bcd}	79.58^{efg}	0.10	0.45	0.02	0.51
G.A-2002	88.37	14.07^{ab}	3.45^{bc}	1.97^{ghi}	1.76^{ab}	78.94^{g}	-	0.52	0.01	0.51
S.H-2003	89.40	12.21^{abc}	3.17^{d}	2.53^{bcd}	1.66^{bcd}	80.50d^{ef}	0.07	0.45	0.01	0.49
A.S-2003	89.6	12.16^{abc}	3.17^{bc}	2.37^{de}	1.75^{abc}	80.55d^{ef}	-	0.55	0.01	0.52

a,b,…, k Columns means with different superscripts differ significantly ($P<0.05$); DM: dry matter; CP: crude protein; CF: crude fibre; EE: ether extract; NFE: nitrogen free extract; Ca: calcium; P: phosphorus; Na: sodium and K: potassium.

Table 2: Chemical composition (%, DM) of straw from 19 varieties of wheat

Varieties	DM	CP	CF	NFE	AIA	NDF	ADF	ADL	Ca	P	Na	K	Grains/ Straw
Local white	95.23	2.25^{i}	45.41^{cde}	45.89^{a}	3.08	75.70	47.10	7.00	0.25	0.08	0.13	1.60	1:1.61
Manthar	94.88	4.24^{c}	42.28^{I}	44.60^{b}	5.01	72.30	52.80	6.40	0.25	0.08	0.08	1.64	1:1.36
Tatara	95.29	4.06^{d}	44.73^{ef}	44.47^{b}	3.30	76.70	50.70	6.90	0.33	0.08	0.09	1.51	1:1.54
Inqalab-91	95.84	2.60^{h}	45.82^{bcd}	45.18^{ab}	4.03	76.10	52.30	6.70	0.42	0.08	0.49	1.88	1:1.49
Sariab-92	95.36	3.03^{g}	46.67^{b}	43.37^{cd}	2.95	76.20	52.20	7.90	0.25	0.06	0.12	1.47	1:1.90
Kohsar-95	95.13	3.59^{e}	45.03^{def}	44.47^{b}	3.31	78.00	50.50	6.80	0.25	0.05	0.05	1.51	1:1.54
M.H-97	95.10	1.30^{j}	46.20^{bc}	44.76^{b}	4.45	75.00	54.10	5.80	0.25	0.05	0.11	1.77	1:1.40
Chakwal-97	95.41	2.67^{h}	45.81^{bcd}	44.59^{b}	5.91	78.40	53.90	7.10	0.42	0.03	0.18	1.64	1:1.56
Margalla-99	95.59	4.40^{b}	44.27^{fg}	44.78^{b}	4.54	75.80	52.60	5.80	0.29	0.06	0.12	1.67	1:1.91
Zarlashta-99	95.31	2.21^{i}	48.19^{a}	40.52^{f}	5.73	79.50	51.10	6.10	0.50	0.06	0.06	1.51	1:1.78
Auqab-2000	95.25	3.56^{e}	45.98^{bc}	42.35^{de}	3.04	74.50	51.40	6.70	0.34	0.09	0.07	1.72	1:1.47
Chenab-2000	95.26	4.36^{b}	45.85^{bcd}	42.87^{de}	3.49	78.00	53.70	6.70	0.25	0.06	0.27	1.51	1:1.95
Marvi-2000	95.19	4.55^{a}	44.83^{ef}	43.30^{cd}	3.42	76.00	48.90	6.70	0.48	0.05	0.08	1.89	1:1.83
Iqbal-2000	95.18	3.62^{e}	43.16^{h}	45.87^{a}	4.03	77.10	48.51	7.10	0.29	0.06	0.12	1.64	1:1.70
Wafaq-2001	95.60	2.25^{i}	45.76^{cd}	44.69^{b}	4.20	77.60	51.80	5.60	0.42	0.03	0.05	1.59	1:1.50
Bhakkar-2001	95.34	2.18^{i}	47.88^{a}	41.93^{e}	5.44	78.00	54.30	6.90	0.38	0.07	0.13	1.85	1:1.37
G.A-2002	95.54	3.38^{f}	45.48^{cde}	44.02^{bc}	4.09	75.00	52.10	7.40	0.33	0.06	0.15	1.67	1:1.88
S.H-2003	94.56	3.57^{e}	41.88^{i}	45.99^{a}	4.56	75.50	49.30	6.50	0.34	0.06	0.14	2.07	1:1.64
A.S-2003	94.24	4.54^{a}	43.57^{gh}	44.65^{b}	3.26	76.80	53.30	6.80	0.17	0.05	0.18	1.95	1:1.18

a,b,…, j Columns means with different superscripts differ significantly (P<0.05); DM: dry matter; CP: crude protein; CF: crude fibre; NFE: nitrogen free extract; AIA: acid insoluble ash; NDF: neutral detergent fibre; ADF: acid detergent fibre; ADL: acid detergent lignin; Ca: calcium; P: phosphorus; Na: sodium and K: potassium.

Table 3: *In-situ* digestibility (%) of nutrients of straw from 19 varieties of wheat

Varieties	*In-situ* digestibility (%)		
	DM	NDF	ADF
Local white	49.36^{cd}	48.83^{d}	44.06^{h}
Manthar	50.03b^{cd}	49.29^{d}	52.05^{bc}
Tatara	52.43^{b}	51.85^{c}	48.66^{e}
Inqalab-91	51.27^{bc}	52.62^{c}	52.86^{b}
Sariab-92	40.09^{h}	36.75^{ij}	36.46^{l}
Kohsar-95	35.84^{j}	35.59^{j}	33.95^{m}
M.H-97	49.45^{cd}	46.37^{e}	51.14^{cd}
Chakwal-97	45.62^{fg}	44.17^{f}	47.73^{ef}
Margalla-99	38.35^{hi}	37.22^{i}	42.38^{i}
Zarlashta-99	45.86^{fg}	47.16^{e}	45.14^{g}
Auqab-2000	40.96^{h}	38.89^{h}	39.23^{k}
Chenab-2000	39.79^{h}	36.77^{ij}	41.33^{j}
Marvi-2000	35.31^{j}	35.74^{j}	32.40^{n}
Iqbal-2000	56.54^{a}	57.99^{b}	43.39^{h}
Wafaq-2001	57.26^{a}	59.68^{a}	53.86^{a}
Bhakkar-2001	46.91^{ef}	48.41^{d}	47.74^{ef}
G.A-2002	43.49^{g}	44.83^{f}	47.60^{f}
S.H-2003	37.32^{ij}	41.37^{g}	40.71^{j}
A.S-2003	48.57^{d}	49.29^{d}	50.88^{d}

*Means with different superscript with in column differ significantly (P<0.05); DM: dry matter; NDF: neutral detergent fibre; ADF: acid detergent fibre

Grains contained CF, EE, total ash and NFE contents varied from 2.60 to 3.76%, 1.32 to 3.17%, 1.61 to 1.82% and 78.72 to 84.24% in different wheat varieties. However, no differences were observed in concentrations of minerals (Na, K, Ca and P) in grains of different varieties. Our results are substantially supported by the findings of El-Metwally and Saudy (2009).

Wheat straw

DM of straw of different wheat varieties ranged from 94.24 to 95.84% with maximum DM (95.84%) of Inqalab-91 and lowest (94.24%) in A.S-2003 (Table 2) but the differences were non-significant (P>0.05). Moreover, straws CP (1.30 to 4.55%) range was comparatively wide among the 19 varieties. Straw from Marvi-2000 contained the highest CP (4.55%) followed by A.S-2003 (4.54%) whereas; lowest CP (1.30%) was in M.H-97. CP of wheat straw might be affected by environmental factors including location, soil fertility, and soil type. Zhiliang *et al*. (1996) reported significant difference in chemical composition and digestibility of crop residues especially grown on different types of soil. Our results are in agreement with the findings of Kernan *et al*., 1984. Our results are also in alignment with the findings of Ghorbani and Hoseini, (2002) who observed CP content range of 1.4 to 3.9% in straws of 20 winter and 20 spring wheat varieties. Tuah *et al.* (1986) and Ramanzin *el al.* (1991) observed variations in CP content in straws of different varieties. CF ranged from 41.88 to 48.19% and the differences were significant (P<0.05) among the varieties. Maximum CF (48.19%) was observed in Zarlashta-99 and minimum in S.H-2003 (41.88%). Similar trend of ether extract (EE) in wheat straw from all varieties was observed.

The total ash content of straw of different wheat varieties ranged from 5.76 to 8.58% with maximum (8.58%) total ash found in Zarlashta-99 followed by Manthar (8.33%). Our results of total ash from straw are in agreement with the findings of Kernan *et al*. (1984) who reported total ash ranging from 4.9 to 8.7% in different wheat varieties.

NFE of different varieties of wheat straw was found different from each other ranging from 40.53 to 46.00%. However, highest percentage (46.0%) of NFE was observed in S.H-2003 followed by local wheat variety (45.91%) and lowest value was observed in Zarlashta-99. Na, K, Ca and P concentrations did not vary statistically among the straw of 19 wheat varieties (Table 2).

In wheat straw values of NDF, ADF, lignin and acid insoluble ash ranged from 72.3-79.5; 47.1-54.3; 5.6-7.9%; and 2.95-5.91%, respectively. There is non-significant (P>0.05) difference in NDF and ADF in straw from 18 wheat varieties. However, small differences were observed in lignin and insoluble ash contents. Highest NDF (79.5%) was observed in Zarlashta-99 and ADF in

Bhakkar-2001(54.3%). Local wheat variety contained lowest values of ADF (47.1%) than Iqbal-2000 wheat varieties. Highest content of lignin (7.9%) was observed in Sariab and highest content of AIA (5.91%) was found in Chakwal-97. Results of NDF, ADF and lignin contents are in agreement with the findings of previous workers (Zhiliang *et al*, 1996; Ghorbani and Huseini, 2002). These differences in CP, CF, and EE among straws of various wheat varieties may be due to the environmental as well as varietal differences (Tolera, *et al.*, 2008). Grains to straw ratios were found to be highest in Chenab-2000 (1:1.95) and lowest in A.S 2003 (1:1.18) variety; that clearly indicated that straw production was highest in Chenab -2000 while grains in A.S-2003 variety compared to the remaining varieties.

***In-situ* digestibility**

In-situ digestibility of DM, NDF and ADF of straw from 19 different wheat varieties are presented in Table 4. Results indicated that Wafaq-2001 has the highest digestibility of DM, NDF and ADF which were 57.26, 59.68 and 53.86% and in Marvi-2000 digestibility of DM, NDF and ADF were 35.31%, 35.74% and 32.4%. Similarly, Kohsar-95 straw has very poor digestibility of DM (35.84%), NDF (35.59%) and ADF (33.93%). *In-situ* digestibility of DM, NDF, and ADF among various varieties of wheat straws significantly differed with each other. Wafaq-2001 variety has the lowest content of lignin compared to other varieties, therefore; *in-situ* digestibility of DM, NDF, and ADF is higher in wafaq-2001, while Marvi-2000 and Kohsar-95 varieties have highest contents of lignin so the digestibility of DM, NDF and ADF is lowest. From these results we conclude that lignin is the only factor that is most significantly correlated to straw degradability. Our results are in line with Ramanzin *et al*. (1991) who reported that lignin is positively correlated to straw degradability. Lignin content can be used as an indicator of straw quality. Capper *et al*. (1989) stated that straw quality may be substantially affected by leaf and stem proportions when compared with different varieties characterized by diverse genetic and morphological traits. Generally leaves of wheat contain higher CP content than the stems portion (Orskov *et al*., 1990). Ghorbani and Hoseini, (2002) studied the in vitro DM digestibility of straw from 20 winter and 20 spring cultivars which ranged from 33 to 54%. From these results it can be concluded that Zarlashta-99 variety straw is nutritionally very poor because of the highest lignin content whereas Wafaq-2001 variety straw is best in terms of digestibility of DM, NDF and ADF in sheep when compared to other varieties.

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