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THE EFFECTS OF CULTIVAR AND LOCATION ON COMPOSITION AND *IN VITRO* DIGESTIBILITY OF WINTER AND SPRING WHEAT STRAW

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ABSTRACT

Straw from 20 winter and 20 spring cultivars of wheat collected from 6 experimental stations were evaluated chemically to determine if the feeding value of straw differed among cultivars and if straw nutritional quality components were associated with desirable agronomic characteristics such as grain yield, heading date and plant height. No significant differences were observed for crude protein (CP) content among winter and spring cultivars but there were significant differences for location, cultivars and cultivar × location interaction for the spring cultivars. A combined analysis for spring cultivars showed a significant difference between location, cultivar, and cultivar × location interaction effects for all the components tested except for hemicellulose. Average CP, neutral detergent fiber, acid detergent fiber, hemicellulose and *in vitro* dry matter digestibility percentage of all cultivars ranged from 1.4 to 3.9%, 73 to 79%, 45 to 50%, 24 to 29% and 33 to 54%, respectively. Agronomic characteristics were unrelated to most straw quality components. The data indicated that genotypic selection can be made for feed quality components without affecting agronomic characteristics.

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Key words: Feeding value, *In vitro* digestibility, Wheat cultivars.

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تاثیر ژنوتیپ و محل بر ترکیب و ارزش غذایی کاه گندم زمستانه و بهاره

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به ترتیب، دانشیار گروه علوم دامی دانشگاه صنعتی اصفهان و مربی گروه علوم دامی دانشگاه شهید باهنرکرمان، کرمان، جمهوری اسلامی ایران.

چکیده

این بررسی برای مقایسه شیمیایی ارزش غذایی کاه ۲۰ رقم گندم زمستانه و ۲۰ رقم گندم بهاره جمع آوری شده از ٦ ایستگاه تحقیقاتی و نیز تعیین همبستگی اجزای کیفیت غذایی با ویژگی های زراعی مانند تولید دانه، تاریخ خوشه دهی و ارتفاع گیاه انجام شد. اختلاف معنی داری بین درصد پروتئین ارقام زمستانه مشاهده نشد ولی اختلاف معنی داری برای محل، رقم و برهمکنش رقم × محل بین ارقام بهاره برای درصد پروتئین خام مشاهده شد. تجزیه مرکب داده ها برای ارقام بهاره نشان داد که اثر رقم، محل، و برهمکنش محل × رقم، بجز برای همی سلولز، برای دیگر اجزا، معنی داربود. درصد پروتئین خام، دیواره سلولی، دیواره سلولی بدون همی سلولز و قابلیت هضم برای همه رقم ها به ترتیب از ۱/٤ تا ۳/۹٪ ، ۷۳ تا ۷۹٪ ، ٤٥ تا ٥۰٪، ۲٤ تا۲۹٪ و ۳۳ تا ٥٤٪ بود. ویژگی های زراعی با بیشتر اجزای

ترکیبی کیفیت کاه همبستگی معنی داری نداشتند. این نتایج نشان داد که انتخاب ژنوتیپ می تواند بر پایه اجزای کیفی کاه انجام شود، بدون این که تاثیری بر ویژگی های زراعی داشته باشد.

INTRODUCTION

Straw from small grains is one of the largest potential sources of feed for maintenance of ruminant animals. Iran produces about 16 million metric tons of wheat straw annually. These estimates are based on the assumption that on the average 1.3 kg of straw are produced per kg of grain (2). If the 8 million cows in Iran were fed 2 kg day^{-1} for 3 mo each year (i.e. during winter) they would consume only 9.2% of the straw produced annually. Wheat straw is generally the least digestible, barley straw is intermediate and oat straw is the most digestible by ruminants (14). Limited comparative research has been conducted on digestibility of straw from small grain cultivars. Gupta *et al.* (10) observed no significant differences in digestibility of whole plants of 11 cultivars of oats in India. However, Palmer (15), Rao (16) and White *et al.* (19) found differences in straw digestibility of spring barley, wheat and oat cultivars. Kernan *et al.* (12) and White *et al.* (19) reported that variations in cereal straw digestibility among crop cultivars were as great as some researchers had achieved by chemically treating the straw to improve its digestibility.

Our first objective was to evaluate differences in straw digestibility and composition among winter and spring wheat cultivars grown at six experimental stations. Our second objective was to determine if straw digestibility was associated with its crude protein and fiber content.

MATERIALS AND METHODS

Samples of winter and spring wheat straw were collected from Karaj, Zarghan, Darab, Zabol, Gorgan and Khorram Abad experimental stations. Ten winter wheat straws collected from Karaj were: 'Navid', 'Azd/Inia', 'Son64', 'Omid', 'Wwp', 'Nir', 'Al cedo', 'Orefl', 'Lni', and 'Tjb841-10' and ten winter wheat straws collected from Zarghan were: 'Ghods', 'Omid', 'Van's', 'K2340', 'Cnn', 'Torim', 'Hys', 'F13471', 'Qts4', and '1-32-1540'.

Spring wheat straw collected from Zabol, Darab, Gorgan, and Khorram Abad were: 'Falat', 'Altar84', 'Arvand', '71/3/Fn/Th', 'Crow's' 'Maya's', 'Trt's', 'Vee's', '1158-5714', 'Mn-72131', 'Hanh's', 'Sara's', 'Vec/Nac', 'Metatails', 'Kaus's', 'Carpentro', 'Vcm-Cno's', 'Bow's', 'Dga-cno's' and 'Veery'

Each location (Darab, Gorgan, Karaj, Zarghan, Zabol and Khorram Abad) consisted of four plots, and one sample was collected from each plot (four samples for each location). Spring wheat cultivars were grown at four locations. Heading date was described as the days when 50% of heads in the plot were flowering. Twenty plants were randomly selected from each plot and were cut at the soil surface and plant height was measured to the nearest cm. Six square meters from middle of each plot were harvested to obtain the grain yield when all cultivars were completely dry.

Plants were grown using the same procedures at the individual locations. Straw samples were dried in a forced-air oven at 60°C for 72 h and ground to pass through a 1-mm screen. Samples were analyzed for dry matter (DM) (1), and for neutral detergent fiber (NDF), acid detergent fiber (ADF) and hemicellulose by the procedure of Goering and Van Soest (9),

crude protein (CP) by the Kjeldahl method and *in-vitro* dry matter digestibility (IVDMD) by the Tilley and Terry method (18).

Standard statistical analysis for a completely randomized design was conducted for winter cultivars. Since the same cultivars were not tested on the same location, location was not included in the statistical model. For spring cultivars, a completely randomized design with factorial arrangement was used for each quality component (7). The Tukey test at the 5% probability level was used to evaluate differences among genotype means when the F test was significant. Simple correlation coefficients were computed between straw quality components and agronomic characteristics. All statistical analyses were performed using SPSS (17).

RESULTS AND DISCUSSION

The straw quality components of the wheat straw grown at Karaj, Zarghan, Darab, Gorgan, Zabol and Khorram Abad are presented in Tables 1 and 2. Significant differences were found for each straw quality component measured except for CP. Straw CP ranged from 2.3 to 2.9% at Karaj, and 1.4 to 2.3% at Zarghan (Table 1). No significant differences were observed among the winter cultivars grown at Karaj and Zarghan (Table 1). Straw CP ranged from 2.5 to 3.9% for spring cultivars (Table 2). There were significant differences for location, cultivars and cultivar × location interaction between the spring cultivars (Table 2). Average CP content of spring cultivars at Darab, Gorgan, Zabol and Khorram Abad were 3.97, 3.72, 1.94 and 2.99%, respectively (Table 2); $P<0.05$.

Table 1. Straw quality components (% DM) of 20 winter wheat cultivars grown at Karaj and Zarghan.

Cultivar[1]	CP		NDF		ADF		Hemicellulose		IVDMD	
	Karaj	Zarghan	Karaj	Zarghan	Karaj	Zarghan	Karaj	Zarghan	Karaj	Zarghan
1	2.58	1.66	76.4	78.5	47.2 ^{ab†}	50.1 ^{ab}	29.2	28.9	53.6 ^{a}	39.0
2	2.45	1.74	75.2	75.9	49.8 ^{a}	47.9 ^{ab}	25.4	27.9	48.4 ^{ab}	38.9
3	2.54	2.28	75.2	73.3	47.5 ^{ab}	46.6 ^{b}	27.5	26.7	49.9 ^{ab}	49.0
4	2.9	2.14	75.2	73.1	46.4 ^{ab}	47.9 ^{ab}	26.0	25.1	45.5 ^{ab}	36.6
5	2.94	2.24	73.4	75.6	47.5 ^{ab}	48.2 ^{ab}	27.0	27.4	48.2 ^{ab}	43.6
6	2.49	1.38	74.8	74.8	46.2 ^{ab}	47.3 ^{b}	28.3	27.3	49.9 ^{ab}	35.0
7	2.34	1.66	74.6	77.4	47.6 ^{ab}	48.8 ^{ab}	27.0	28.6	49.6 ^{ab}	35.6
8	2.87	1.89	72.6	75.5	47.3 ^{ab}	49.1 ^{ab}	25.3	25.8	46.8 ^{ab}	32.8
9	2.64	2.05	73.9	73.7	47.1 ^{ab}	48.3 ^{ab}	26.4	25.7	48.7 ^{ab}	44.0
10	2.72	2.17	73.4	77.6	45.3 ^{b}	52.6 ^{a}	27.7	25.0	42.3 ^{b}	37.4
Mean	2.65	2.04	74.5	75.5	47.2	48.7	27.0	26.7	48.3	39.3

† Means in the same column with different letter differ (P<0.05).

Karaj cultivars: 1) 'Navid', 2)'Azd/lnia', 3) 'Son 64', 4) 'Omid', 5) 'Wwp', 6) 'Nir', 7) 'Alcedo', 8) 'Orefl', 9) 'Lni'. 10) 'Tjb841'.

Zarghan cultivars: 1) 'Ghods', 2) 'Omid', 3) 'Van's', 4) 'K2340', 5) 'Cnn', 6) 'Torim', 7) 'Hys', 8) 'F13471', 9) 'Qt54', 10) '1-32-540'.

Cultivar 'Crow's' of spring wheat straw had the highest CP content (3.95%) but 'Torim' a winter cultivar, had the lowest (1.4%) (Tables 1 and 2). Similar findings were reported by Givens (8) for 62 wheat, 52 barley and 5 oat cultivars. However, some investigators (5, 16) have reported an effect of cultivar on CP content.

Table 2. Straw quality components (%DM) of spring cultivars at Darab, Gorgan, Zabol and Khorram Abad.

	CP	NDF	ADF	HEMI	IVDMD
Cultivar					
'Falat'	3.01	77.0	50.0	27.1	48.7
'Altar 84'	2.52	76.8	49.3	26.5	50.6
'Arvand'	3.23	75.9	50.1	25.8	43.1
'71/3/Fn/Th'	3.19	74.5	49.1	25.2	45.5
'Crow's'	3.85	75.1	48.0	27.1	50.6
'Trt''s'	3.10	72.9	49.6	23.6	47.2
'1158-5714'	2.99	74.4	50.4	24.0	50.1
'MN 72131'	3.54	73.3	48.1	25.1	50.1
'Hanhn's'	3.38	74.0	49.4	24.6	48.0
'Sara's'	3.24	74.7	49.5	25.2	44.3
'Bow's'	3.33	73.3	47.9	25.3	44.6
'Veel/Nac'	3.25	74.2	47.7	24.0	46.7
'Metaltails'	3.68	73.6	47.7	25.7	50.0
'Kaus's'	2.98	74.8	49.3	25.5	43.4
'Vee's'	3.1	73.4	48.5	25.9	46.8
'Carpentro'	3.2	73.8	47.8	26.1	42.3
'Vem-cno's'	2.5	76.0	51.6	24.4	41.6
'Dga cno's'	3.3	73.2	48.5	24.6	48.1
'Veery'	2.7	75.3	49.9	25.4	42.4
Locations					
Darab	$3.97^{a\dagger}$	71.0^{c}	42.2^{b}	25.4^{a}	52.6^{a}
Gorgan	3.72^{a}	76.5^{a}	53.4^{a}	22.7^{c}	38.62^{c}
Khorram Abad	2.99^{b}	73.7^{b}	47.6^{c}	26.0^{b}	47.55^{b}
Zabol	1.94^{c}	78.2^{a}	49.1^{b}	27.1^{a}	46.35^{b}
			Mean squares		
Cultivar	0.9^{***}	11.8^{**}	8.9^{***}	7.5	1.2^{***}
Location	33.4^{***}	188.6^{**}	383.1^{***}	140.0^{***}	1930.0^{***}
Cutivar × location	0.8^{**}	7.2^{**}	5.95^{***}	4.6	80.0^{***}

$^{*}P<0.05$ $^{**}P<0.01$ $^{***}P<0.001$

† Means in the same column with different letter differ significantly ($P<0.05$).

None of the straw cultivars contained the recommended CP level (5.9%) for maintaining a mature beef cow during the middle third of

pregnancy (13). The straw CP content, averaged across all six locations, was lower than the 4.1% CP listed by the National Research Council (13).

Fibrous Components

Means of NDF, ADF and hemicellulose across cultivars for each location are presented in Tables 1 and 2. The differences among the winter cultivars grown at Karaj and Zarghan for ADF was significant ($P<0.05$), and the effects of cultivar, location and location × cultivar interaction were significant among the spring cultivars (Tables 1 and 2). Straw NDF ranged from 72.6 to 76.4% at Karaj, 73.1 to 78.5% at Zarghan, and 73 to 77% for spring wheat cultivars. Wheat straw produced at Darab had significantly ($P<0.05$) lower NDF (71%) compared to straw produced at Khorram Abad (73.7%) and Gorgan (76.5%). Among the cultivars grown in all six locations, 'Navid' grown at Karaj had the highest (78.5%) and 'F13471' grown at Zarghan had the lowest (72.6%) NDF content (Table 1).

Similar findings were reported by Capper (3) and Dias-Da-Silva and Guedes (5) for barley and wheat straw. However, Erickson *et al.* (6), Givens and Adamson (8), and Rao (16) reported that cultivars had no effect on NDF.

Straw ADF and hemicellulose percentages varied among the cultivars and ADF ranged from 45% for 'Tjb841 to 53% for '1-32-1540' and hemicellulose from 24% for 'Trt "S" ' to 29% for 'Navid' (Tables 1 and 2). The differences among the winter cultivars for ADF was significant ($P<0.05$) and in spring cultivars the effect of cultivars, location and location × cultivar interaction were significant (Tables 1 and 2; $P<0.05$).

Straw Digestibility

In vitro dry matter digestibility of winter cultivars ranged from 42 to 53%, (Karaj location), 32 to 49%, (Zarghan location) and for spring cultivars from 42 to 51% (Table 1). Average straw DM digestibility from all six locations were as follows; Karaj (48%), Zarghan (39%), Darab (52%), Gorgan (38%), Zabol (49%), and Khorram Abad (47%). Significant differences ($P<0.05$) were observed among the winter cultivars (Table 1). The difference in digestibility between the lowest and the highest cultivars at Karaj, Zarghan and spring cultivars were 11, 17 and 9 units, respectively (Table 1). There was a significant difference between locations, cultivar and location × cultivar interaction effects for spring cultivars (Table 2). Winter cultivars 'Navid' and 'F13471' had the highest (53.6%) and the lowest (32.8%) IVDMD in their straw (Table 1).

Differences in straw digestibility among the cultivars were as great as some researchers have achieved by chemically treating the straw to improve its digestibility. Horton and Steacy (11) found that treating oat, barley, and wheat straw with 3.5% anhydrous ammonia improved the *in vitro* digestibility by 2.2, 3.7, and 6.3 percentage units, respectively. Coxworth *et al.* (4) found that treating oat, barley and wheat straw with 5% ammonia improved the *in-vivo* digestibility by 8, 12, and 14 percentage units, respectively.

The potential feeding value of wheat straw grown at Darab was higher; mean values for CP and IVDMD were higher, and for NDF and ADF were lower. Among the Darab cultivars, 'Crow's' had the highest potential feeding value of all wheat cultivars tested. Wheat straw grown at Gorgan

location produced straw with the highest concentration of NDF and ADF and the lowest concentration of hemicellulose (Table 2).

The relationship between straw quality components and agronomic characteristics of wheat cultivars were calculated to determine if desirable agronomic characteristics were affected by changes in straw quality components (Table 3). The correlation between agronomic characteristics and feeding quality components was low. In fact, there were no significant correlations for winter cultivars. Some of the correlation coefficients for spring cultivars were highly significant but numerical values were low (Table 3).

Table 3. Simple correlation coefficients between straw quality components and agronomic characteristics of winter and spring wheat cultivars.

Agronomic Characteristics	Starw quality components				
	CP	NDF	ADF	HEMI	IVDMD
Spring cultivars					
Grain Yield	0.05	-0.28†	-0.29†	0.02	0.0
Heading Date	0.37†	-0.10	-0.13	-0.37§	-0.32†
Plant Height	0.15	-0.29†	-0.13	-0.23	-0.10
Winter cultivars (Zarghan)					
Grain Yield	-0.15	-0.13	0.0	-0.17	0.07
Heading Date	0.14	0.12	-0.33	-0.17	0.03
Plant Height	0.27	0.08	-0.30	0.21	0.16
Winter cultivars (Karaj)					
Grain Yield	0.0	-0.13	0.23	-0.35	0.06
Heading Date	-0.12	0.05	0.20	0.32	0.06
Plant Height	0.07	0.07	0.05	0.12	0.01

† P<0.01 § P<0.001

Heading date had a positive correlation with CP (P<0.001) and negative correlation with hemicellulose (P<0.001) and IVDMD (P<0.01). Grain yield had a negative correlation (P<0.01) with NDF and ADF. These data which agree with the result of White *et al.* (19) and Erickson *et al.* (6), suggest that the most important agronomic characteristics are not closely associated with wheat straw quality components and that it may be possible

to improve the feeding value of the straw without sacrificing the desirable agronomic characteristics.

LITERATURE CITED

1. Association of Official Analytical Chemists. 1990. Official Methods of Analysis. 15th ed., AOAC, Washington, D.C., U.S.A. 69-90.
2. Bauer, A. and J.C. Zubriski. 1978. Hard red spring wheat straw yield in relation to grain yields. Soil Sci. Soc. Amer. J. 42:777-781.
3. Capper, B.C. 1989. Genetic variation in the feeding value of cereal straw. Anim. Feed Sci. Technol. 21:125-140.
4. Coxworth, E.J., H. Kernan, H. Nicholson and R. Chaplin. 1977. Improving the feeding value of straw for ruminant animals. Saskatchewan Res. Council Rep. 77:11-20.
5. Dias-Da-Silva, A.A. and C.V.M. Guedes. 1990. Variability in the nutritive value of straw wheat, rye and triticale and response to urea treatment. Anim. Feed Sci. Technol. 28:79-89.
6. Erickson, D.O., D.W. Meger and A.F. Faster. 1982. The effect of genotypes on the feed value of barley straws. J. Anim. Sci. 55:1015-1026.
7. Gill, J.L. 1978. Design and Analysis of Experiments in the Animal and Medical Sciences. Ames, Iowa, U.S.A. 156-169.
8. Givens, D.I. and A.H. Adamson. 1990. Chemical composition, *in vitro* digestibility and energy values *in vivo* of untreated cereal straws produced on farms throughout England. Anim. Feed Sci. Technol. 26:323-335.
9. Goering, H.K. and P.J. Van Soest. 1970. Forage Fiber Analysis. ARS, USDA Agric. Handbook. No. 379, Washington, D.C., U.S.A. 8-9.

10. Gupta, P., C. Singh and K. Pradhan. 1976. Variability in protein, cell wall constituents and *in vitro* nutrient digestibility in some important strains of fodder oat harvested at different stages of growth. Ind. J. Agric. Sci. 46:329-393.

11. Horton, G.M.J. and G.M. Steacy. 1979. Effect of anhydrous ammonia treatment on the intake and digestibility of cereal straws by steer. J. Anim. Sci. 48:1239-1249.

12. Kernan, J.A., W.L. Crowle, D.T. Spurr and E.C. Coxworth. 1979. Straw quality of cereal cultivars before and after treatment with anhydrous ammonia. Can. J. Anim. Sci. 59:511-517.

13. National Research Council. 1989. Nutrient Requirements of Dairy Cattle. 6th. ed., Nat. Acad. Sci., Washington, D.C., U.S.A. 78-115.

14. Morrison, F.B. 1958. Feeds and Feeding, Abridged. The Morrison Publishing Co., Ithaca, New York, U.S.A. 538-607.

15. Palmer, T.G. 1976. The feeding value of straw for ruminants. ADAS Q. Rev. 21:220-234.

16. Rao, S.C. 1989. Regional environment and cultivar effects on the quality of wheat straw. Agron. J. 81:939-943.

17. SPSS for Windows. 1993. Release 6.0 Edition., SPSS Inc.

18. Tilly, J.M.A. and R.A. Terry. 1963. A two stage technique for the *in vitro* digestion of forage crops. J. B. Grassl. Soc. 18:104-111.

19. White, L.W., G.P. Hartman and J.W. Bergman. 1981. *In-vitro* digestibility, crude protein and phosphorous content of straw of winter wheat, barley and oat cultivars in the eastern Montana. Agron. J. 73:111-121.