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Original Article

Nutritional characteristics of some wheat varieties and evaluation for grain feed

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Abstract. The experiment was conducted to determine nutritional composition, macro-micro mineral content, phytic acid, β-glucan, total pentosans, soluble pentosans, viscosity and metabolizable energy values for poultry and ruminant in some wheat varieties growed Turkey. Ten wheat varieties were used and five samples were analyzed each variety for all parameters. Wheat varieties were ground through a 1 mm sieve for chemical analysis. Except for the differences among the acid detergent fiber (ADF) values and β-glucan values of wheat varietes, the difference among analyzed all other nutrient results was statistically significant ($P<0.01$). As a result, although these wheat varieties have significantly different nutrient contents, Ege-88 for poultry and Salihli-92 for ruminant animals may show better feeding performance in terms of energy.

Key words: wheat, variety, nutritional composition

Introduction

More than two-thirds of wheat grain produced worldwide is used as human consumption, 20% as animal feed, while the remaining 3-5% is used for seed, industrial and other purposes (1). Especially in countries where the cereals production is high and prices is low, it is a very common application to include wheat grain into broilers' diets at the rates of 60-65%. The use of wheat as feed for animal production is projected to rise, while the wheat used for biofuel production only accounts for 1.2% of global use in 2025 (2).

Wheat as food or feed is often taken into consideration primarily as a source of energy which consists mainly carbohydrate such as starch and it is certainly important in this respect. However, it also contains significant quantity of other important nutrient such as proteins, fiber, lipids, vitamins, minerals, and phytochemicals. Generally, wheat contains carbohydrate 78.10%, protein 14.70%, lipid 2.10%, minerals 2.10% and considerable proportions of vitamins (thiamine and vitamin B complex). Also wheat is a valuable source of trace elements such as selenium and magnesium (3,4).

The chemical composition of wheat grain can be highly variable especially its starch and crude protein content according to seed type, growing location, climate, fertilization. (5,6). For instance, generally wheat contains 9% protein and 50% starch, but some literatures has reported its protein and starch content rising up to 23% and 80% respectivelly on dry matter bases of starch (6). Obviously, considerable amount of work is designed to evaluate variability in nutritive value of wheat. Some studies have indicated that variety, growing location, and storage time had a signicant effect on metabolizable energy and nutrients digestibility (7), and also on gut flora, structure and function (8). Other researchers have studied nutritive value of various type wheat as effected by their chemical composition parameters such as dry matter, crude protein, ether extract, starch (9) and non-starch polysaccharides content and structure (10). Its physical and nutritional chemical composition can vary widely, depending on variety (11) even the energy value may be differ in same varieties (12).

In wheat production in Turkey, is one of the major grain products. Therefore current knowledge of the nutrients composition of wheat grain needs to be investigated. The aim of this study was to determine nutrient composition and energy levels of some wheat grain varieties produced in Turkey. And also, looking at these explanations, the main purpose of this study is to evaluate the potential of using the nutritional content of wheat varieties in terms of feed value in the nutrition of poultry and ruminant animals.

Materials and Methods

Materials

Wheat samples were supplied from Ege University, Faculty of Agriculture, Department of Fields Crops, Bornova-İzmir, Ege Agricultural Research Institute, Menemen-İzmir and Bahri Daİdaİ International Agricultural Research Institute, Karatay-Konya. Wheat varieties used in the experiment are grown in Turkey, commonly. Ten wheat varieties were used in total and for each variety five samples were analyzed including all parameters. All selected experimental wheat grain samples from each variety were ground through a 1 mm screen in preparation for chemical analysis.

Chemical analysis

Nutrient contents of wheat samples were analyzed according to the methods reported in (13), and all data were presented on a dry matter basis. All samples were analyzed for dry mater (DM) (method 934.01), ash (method 942.05), crude protein (CP) (method 990.03), ether extract (EE) (method 920.39), crude fiber (CF) (method 962.09). The sugar content of the materials was determined by the Luff-Scroll method and the starch determination by polarimetric method. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents were determined using the methods by (14). Nitrogen-free extracts (NFE) were calculated as 100 - % (moisture + Ash + CP + EE + CF). Estimates for ME_P for poultry, MJ/kg were based on CP, EE, starch and sugar levels determined from the samples using a prediction equation (15);

$ME_{P,}$ Mcal/kg^{-1}= (3.69 x CP + 8.18 x EE + 3.99 x Starch + 3.11 x Sugar)

Estimates for crude nutrition metabolizable energy (ME_R) as MJ/kg^{-1} in DM for ruminant were based on crude nutrients (protein, fiber, and fat levels) determined from the samples using a prediction equation (15);

ME_R Mcal/kg^{-1}= ((3260 + (0.455 x CP + 3.517 x EE - 4.037 x CF)) and CP, EE, CF quantities in OM (g kg^{-1}). All nutritional parameters, mineral contents, and energy values of the samples are given on a dry matter basis.

Atomic Absorption Spectroscopy (Ultrospec 2100 pro UV/visible spectrophotometer) was used determined for potassium (K), magnesium (Mg), calcium (Ca), phosphorus (P), sodium (Na), zinc (Zn), iron (Fe), manganese (Mn), coper (Cu) concentrations. The colorimetric method was used for the analysis of total phytic acid content (16). İ-glucan content was determined enzymatically following the wheat grains procedures of commercial kits from Megazyme (Megazyme International Ireland Ltd. Wicklow, Ireland); the β-glucan protocol was AACC method 32-23. The total pentosans and soluble pentosans were analyzed according to the colorimetric methods of (17). Viscosity of grains was determined according to (18) using a Brookfield Digital Viscometer (Model DV - II + PRO, Brookfield Engineering Laboratories, Stoughton, MA) maintained at 40 °C.

Statistical analysis

The statistical analysis of the results included a one-way analysis of variance ANOVA using General Linear Models and Duncan's multiple range test, which were applied to the results using the SPSS 25 (19). The model included varieties as main effects.

Results

Results show that the differences among varieties in terms of DM, CP, EE, CF, NFE, NDF, sugar, starch contents of wheat grain were significant ($P<0.05$) except for ADF contents ($P>0.05$) in Table 1. In this study, the DM content of wheat varieties ranged from 882 to 916 g kg^{-1} (average 900), the CP contents ranged from 1.64 to 132 mg kg^{-1} (average 106), EE contents ranged from 18.6 to 13.0 g kg^{-1} (average 16.1), the CF contents ranged from 9.0 to 24.2 g kg^{-1} (mean, 16.2), the EE contents ranged from 18.6 to 13.0 g kg^{-1} (mean, 16.1), the NFE contents ranged from 706 to 801 g kg^{-1} (mean, 747), the starch contents ranged from 557 to 628 g kg^{-1} (mean, 597), the sugar contents ranged from 67.6 to 106.3 g kg^{-1} (mean, 83.5), the NDF contents ranged from 102 to 147 g kg^{-1} (mean, 117), the ADF contents ranged from 22.2 to 34.2 g kg^{-1} (mean, 30.1), ME_P value ranged from 2.84 to 3.38 Mcal/kg (mean, 3.16) and ME_R values ranged from 3.18 to 3.27 Mcal/kg (mean, 3.24).

The effect of variety on the ash and mineral contents of wheat grains are presented in Table 2. The variety had a significant effect on the ash and mineral contents of wheat grains (P<0.01). The ash content of wheat grains ranged from 14.2 to 17.5 g kg^{-1} (avera-

Table 1. Nutritional composition and metabolizable energy of some wheat varieties (g kg^{-1}, in DM)

Varieties	DM	CP	EE	CF	NFE	NDF	ADF	Sugar	Starch	ME_P	ME_R
Menemen-88	882^{d}	116^{a}	18.6^{a}	24.2^{a}	706^{e}	124^{b}	33.2	67.6^{f}	610^{b}	3.23^{bcd}	3.22^{d}
Ege-88	900^{b}	132^{a}	14.9^{cd}	18.5^{abc}	718^{e}	121^{bc}	22.2	88.7^{bcd}	626^{a}	3.38^{a}	3.24^{bcd}
Ziya Bey	896^{bc}	127^{a}	16.8^{abc}	16.4^{bc}	725de	102^{e}	22.3	90.4^{bc}	605^{b}	3.30^{abc}	3.26^{abc}
Kalif Bey	890^{c}	88^{bc}	13.1^{d}	13.0^{cd}	761^{bc}	115^{bcd}	33.0	77.7^{def}	576^{cd}	2.97^{f}	3.24^{bcd}
Cumhuriyet-75	893^{bc}	124^{a}	17.6^{ab}	16.0^{bc}	721de	112^{cde}	32.2	77.9^{def}	585^{c}	3.18^{de}	3.26^{abc}
İzmir-85	893^{c}	64^{d}	16.6^{abc}	20.3^{ab}	772^{b}	113^{cd}	34.2	106.3^{a}	628^{a}	3.20^{cd}	3.18^{e}
Basri Bey	912^{a}	93^{b}	16.6^{abc}	18.3^{abc}	769^{b}	121^{bc}	29.3	75.4^{ef}	588^{c}	3.06^{f}	3.23^{cd}
Gönen	911^{a}	70^{cd}	13.0^{d}	12.7^{cd}	801^{a}	147^{a}	32.1	70.8^{f}	570de	2.84^{g}	3.23^{cd}
Gediz-75	911^{a}	121^{a}	18.0^{ab}	14.0^{cd}	742^{cd}	111^{cde}	29.4	83.0^{cde}	626^{a}	3.34^{ab}	3.27^{ab}
Salihli-92	916^{a}	115^{a}	16.1^{bc}	9.0^{d}	759^{bc}	107de	31.1	97.2^{ab}	557^{e}	3.08^{ef}	3.28^{a}
Means	900	106	16.1	16.2	747	117	30.1	83.5	597	3.16	3.24
SEM	1.6	3.9	0.3	0.8	4.7	2.0	1.1	1.9	3.7	1.0	0.2
Probability	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.213	<0.001	<0.001	<0.001	<0.001

$^{a,b,..,f}$ *Means within a column in each variable with no common superscript differ significantly (P<0.05), SEM Standard error of means (Pooled), DM dry matter, CP crude protein, EE ether extract, CF crude fiber, NFE nitrogen free extract, Sug sugar, Stc starch, NDF neutral detergent fiber, ADF acid detergent fiber, ME_P metabolizable energy poultry (Mcal/kg) , ME_R metabolizable energy ruminant (Mcal/kg).*

Table 2. Ash and mineral content of some wheat varieties

Varieties	Ash^{1}	Ca^{1}	P^{1}	K^{1}	Na^{1}	Mg^{1}	Fe^{2}	Cu^{2}	Mn^{2}	Zn^{2}
Menemen-88	16.5^{abc}	0.47^{b}	2.68^{b}	6.56^{ab}	0.11^{c}	0.71^{c}	66.64^{ab}	4.45^{a}	13.58^{c}	25.29^{a}
Ege-88	15.3^{bcd}	0.44^{b}	2.74^{b}	5.79^{d}	0.19^{b}	0.49^{de}	65.44^{abc}	4.05^{ab}	11.09^{de}	10.47^{de}
Ziya Bey	14.5^{cd}	0.52^{a}	2.77^{b}	6.03^{bcd}	0.36^{a}	1.04^{a}	69.47^{a}	4.60^{a}	22.46^{a}	6.39^{f}
Kalif Bey	14.2^{d}	0.37^{c}	2.42^{d}	5.82^{d}	0.11^{c}	0.62^{cd}	56.51^{bcd}	2.59^{cd}	14.50^{bc}	9.93^{e}
Cumhuriyet-75	17.0^{ab}	0.30^{d}	3.12^{a}	6.65^{a}	0.10^{c}	0.87^{b}	59.92^{abcd}	3.33^{abc}	16.11^{b}	17.03^{b}
İzmir-85	17.5^{a}	0.27^{de}	3.03^{a}	6.54^{ab}	0.09^{c}	0.71^{c}	54.06^{cd}	1.70^{d}	12.09^{cd}	13.04^{cd}
Basri Bey	14.5^{cd}	0.26^{de}	2.42^{d}	6.00^{cd}	0.09^{c}	0.48^{e}	52.54^{d}	2.25^{cd}	9.71^{de}	8.73^{ef}
Gönen	14.7^{cd}	0.19^{f}	2.55^{c}	6.43^{abc}	0.10^{c}	0.52^{de}	35.93^{e}	3.10^{bc}	10.23^{de}	8.56^{ef}
Gediz-75	15.6^{abcd}	0.24^{ef}	2.76^{b}	5.93^{cd}	0.10^{c}	0.49^{de}	32.95^{e}	2.62^{cd}	8.67^{e}	14.32^{c}
Salihli-92	16.2^{abcd}	0.31^{d}	3.14^{a}	5.98^{cd}	0.11^{c}	0.55^{de}	40.63^{e}	2.34^{cd}	13.89^{bc}	6.07^{f}
Means	15.6	0.34	2.76	6.17	0.14	0.65	53.16	3.07	13.45	12.12
SEM	0.2	0.2	0.4	0.7	0.1	0.03	2.10	0.17	0.60	0.86
Probability	0.004	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

$^{a,b,..,f}$ *Means within a column in each variable with no common superscript differ significantly (P<0.05), SEM Standard error of means (Pooled). ^{1}:g kg^{-1}, in dry matter; 2: mg kg^{-1}, in dry matter.*

ge 15.6), Ca content varied from 0.19 to 0.52 g kg^{-1} (mean 0.34), P content varied from 2.42 to 3.14 g kg^{-1} (average 2.76), the K content of wheat varieties varied from 5.79 to 6.65 g kg^{-1} (average 6.17), Na content varied from 0.09 to 0.36 g kg^{-1} (average 0.14), Mg content varied from 0.48 to 1.04 g kg^{-1} (average 0.65), Fe content ranged from 32.95 to 69.47 mg kg^{-1} (average 53.16), Cu content ranged from 1.70 to 4.60 mg kg^{-1} (mean 3.07), Mn content varied from 8.67 to 22.46 mg kg^{-1} (average 13.45), Zn content varied from 6.07 to 25.29 mg kg^{-1} (average 12.12).

There were no differences among varieties in terms of İ-glucan contents of wheat grains (P>0.05) in Table 3. In the present study, among varieties in total pentosans, soluble pentosans and viscosity of wheat grain were significant (P<0.05). Phytic acid contents ranged from 0.728 to 0.933% in DM respectively (means, 0.832). Total pentosans, soluble pentosans contents and viscosity ranged from 2.57 to 5.16, 0.78 to1.22 and 0.97 to 1.14 respectively.

Discussion

The DM determined in this study are compatable with the results of relevant studies (20-24). However, the range reported by (25) was 96% with an exceptionally high value. The CP contents of wheat grains agree with the findings of (20,22-24,26-28), while it is lower than the value found by (21,25,29-31). Lipids are present only in a small extent in cereals but the have a significant effect on the quality and the texture of foods because of their ability to associate with starch and especially proteins specific amphipatic nature that having both hydrophilic and hydrophobic parts, forming a complex structure (32). The findings about EE content of wheat are consistent with the findings of relevant studies (22,24,25) but it is lower than the value found by (20,26,27,31). Findings about NFE of some wheat varieties are largely conform with results of relevant studies (20,22,25,27). However, some researchers have reported that lower (21,23,24,30). Starch is the main storage carbohydrate and rich source of energy and influence the level of glycaemia in wheat kernels (33). Results of starch content agree with findings of (31,34,35). Contrary, it is lower than (25). However, sugar contents in our study were higher than (25). Findings the CF determined in this study are consistent with the findings of relevant studies (22-24,20,26-28,31). Contrary (25), observed similar values for CF in different wheat varieties. (22) and (23) reported that with similar NDF content in this study. However, the range reported by (30) was 16% with a high value. Findings the ADF determined in

Table 3. Phytic acid, β-glucan, pentosane, soluble pentosane concantration and viscosity of some wheat varieties

Varieties	Phytic acid[1]	β-glucan[2]	Total pentosans[2]	Soluble pentosans	Viscosity[3]
Menemen-88	0.802[ab]	0.23	3.13[cd]	0.89[cd]	1.09[abc]
Ege-88	0.820[ab]	1.97	3.84[bc]	1.02[bc]	1.06[c]
Ziya Bey	0.866[a]	0.52	2.57[d]	0.78[d]	1.06[c]
Kaİif Bey	0.785[b]	0.59	5.16[a]	1.22[a]	1.12[ab]
Cumhuriyet-75	0.933[a]	1.24	4.50[ab]	1.12[ab]	0.99[d]
İzmir-85	0.879[a]	0.65	2.98[cd]	0.86[cd]	0.99[d]
Basri Bey	0.728[b]	1.27	4.43[ab]	1.10[ab]	1.08[bc]
Gönen	0.775[b]	0.98	3.47[bcd]	0.95[bc]	1.14[a]
Gediz-75	0.852[a]	0.51	3.15[cd]	0.89[cd]	0.97[d]
Salihli-92	0.882[a]	0.57	4.44[ab]	1.10[ab]	1.12[ab]
Means	0.832	0.85	3.77	0.99	1.06
SEM	0.02	0.14	0.14	0.02	0.01
Probability	<0.001	0.198	<0.001	<0.001	<0.001

[a, b, c, d] Means within a column in each variable with no common superscript differ significantly (P<0.05), SEM Standard error of means (Pooled). [1]:%, in DM; [2]:%, w/w in DM; [3]: cP in DM.

this study are consistent with the findings of relevant studies (22,23,30). ME_P values are consistent with the results of (25,36), also ME_R values are consistent with the results of (20,23).

Mineral contents of some wheat varieties obtained in the current study are similar with those obtained by (22,37). (38) also found significant varietal differences in the accession of Ca, P, K, Na, Mg, Mn, B, and Sr in twelve varieties of wheat. (39) found important va riation among the 175 wheat lines, exist with Fe, Zn, and Se concentrations in grain.

İ-glucans has low solubility properties, approximately total 10-15% of them in whole wheat grain can soluble in hot water (40). There is increasing evidence that İ-glucans are able to regulate the immune responses that are involved in fighting infection and attackig tumors in a variety of inflammatory conditions. While a high İ-glucan content in human food may be advantageous, a lower İ-glucan content in animal feed may be recommended. There were no differences among varieties in terms of İ-glucan contents of wheat grains (P>0.05) in Table 3. In the present study, İ-glucan contents of wheat grains ranged from 0.23 to 1.97 and agree with previous studies (24,25,31,34,37,41-43). (44) reported that einkorn, emmer, and durum wheat types contained about half the level of mixed-linkage beta-glucan (0.25-0.45% of DM) present in winter, spring, and spelt wheats (0.50-0.95% of DM). In the study with wheat wholemeal, 166 samples were analysed and the İ-glucan content was determined that 0.81 (0.29-1.10) as mean.

Viscosity content of cereals is a notable indicator concerning feed value for poultry and single stomach farm animals except with ruminants. Researchers have determined the high correlations between viscosity of whole grains measured *in vitro* and nutritional value (45). On the other hand, water-soluble pentosans form highly viscous solutions and viscosity of different cereal grain fraction was closely relevant to the content of water-soluble pentosans (46). Since polysaccharides make up 80% of the wheat grain, any change in their composition has a significant effect on the nutritional value of whole wheat (47). Differences among varieties in total pentosans, soluble pentosans and viscosity of wheat grain were significant (P<0.05) in Table 3. Total pentosans, soluble pentosans contents and viscosity ranged from 2.57 to 5.16, 0.78 to1.22 and 0.97 to 1.14 respectively. These results agree with those obtained by (25, 34, 48). Also (48) who reported that viscosity of wheat grain was influenced by variety.

Phytic acid is the major phosphorous storage compound in plant seed and can account for up to 80% of seed in total phosphorous (49). Also, phytic acid has a strong potential to chelate complex with multivalent metal ions, expecially zinc, calcium, and iron. These chelate bond with metal ions can show in very insoluble salts with poor bioavailability of minerals (50). Phytic acid is also easily able to form complexes with proteins at high pH levels in digestive system, and thus significintly decrease digestibility, absorbsition, and bioavailability of cereal proteins (51). Besides well known negative properties of the phytich acid with complexing iron, may cause a notable reduction in the structure of hydroxyl radicals in the gut (52). But also positive effect against carcinogenesis have been shown with in vitro cell culture systems such as mice, rats and guinea pigs, but the mechanism of action is not understood (53). Generally, in the present study total phytic acid contents (0.775-0.933%) agree with in a limited number of previous studies. (54) reported that phytic acid contents were obtained 0.62-1.33% for wheat. (55) reported that phytic acid content (mg/kg) were obtained 20 mg/kg for hard wheat, 9.80 mg/kg for hard wheat flour.

Conclusion

In conclusion, the study presents an addition to chemical composition database for some wheat varieties. Additional information on these grains is need such as amino acids, vitamins, nutraceutical and bioprotective substances and also digestibility should be obtained in future study. In addition to the economic importance of wheat, its contribution to humans as food and to animals as feed is indisputable. The results could be a guide for consumption of these cereals by animals.

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