Nutritional Value of Cottonseeds and It's Derived Products : I. Physical Fractionations and Proximate Composition

A. Mujahid, M. Abdullah*, A. R. Barque and A. H. Gilani
Department of Animal Nutrition, University of Agriculture, Faisalabad, Pakistan

ABSTRACT : The study was conducted to determine physicochemical parameters in various physical fractions (linter, hull, kernel, oil and meal) of cottonseed of different varieties (MNH 147, CIM 240, NIAB 78, FH 87, CIM 109, MNH 93, FH 682, GOHAR 87, SLS 1 and B 557). Average components of linter, hull, and kernel in different varieties of cotton were 12.21, 28.24 and 70.42%, respectively. Average percentage of meal and oil was 48.97 and 22.09% in seed, and 69.28 and 30.72% in kernel, respectively. Maximum percentage of meal was recovered from variety CIM 240 and lowest in variety CIM 109. Statistical analysis revealed variety differences ($p<0.05$) in seed and it's components. Average contents of crude protein, crude fiber and ash was 22.31, 17.74 and 4.27% in seed, 2.85, 56.50 and 2.61% in hull; 32.62, 3.45 and 4.01% in kernel; 47.15, 5.00 and 5.78% in meal, respectively. Average contents of Ca, p, Mg, K, Na and Cl were 0.09, 0.22, 0.26, 0.65, 0.009 and 0.035% in seed; 0.12, 0.07, 0.09, 0.51, 0.020 and 0.034% in hull and 0.16, 0.59, 0.32, 1.01, 0.03 and 0.07% in meal of different varieties of cotton, respectively. Fe, Zn, Cu and Mn were 141.35, 24.55, 186.50 and 27.12 mg/kg in seed; 158.48, 2.06, 74.60, and 22.17 mg/kg in hulls; and 167.62, 20.30, 185.83 and 20.67 mg/kg in meal, respectively. Significant varietal differences were observed in proximate composition and mineral contents of cottonseeds and derived products. Cottonseeds and their products of varieties FH 87, CIM 109 and MNH 93 showed higher nutrient density while lower was observed in varieties CIM 240, SLS I and FH 682. *(Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 3 : 348-355)*

Key Words : Cottonseed, Cottonseed Meal, Proximate Composition

INTRODUCTION

Cotton is one of the high priority crop for Pakistan second only to wheat in acreage (Anonymous, 1984) It not only provides fiber for domestic textile industry and export (Anonymous, 1996a) but also accounts for about 60% of the vegetable oil (Anonymous, 1990) and about 90% of the high protein cakes and meals. This makes it by far the most important domestic oilseed (Anonymous, 1984; Khan and Mian, 1986).

Pakistan is one of the principal producers of cotton in the world. Cotton crop is grown on 3,149 thousand hectares with an annual yield of 15,965 metric ton (Anonymous, 1997). Cottonseed meal (CSM) is a by-product left after extraction of oil from the cottonseed (CS). From each ton of CS crushed approximately 421.83 to 435.45 kg CSM is available after removal of oil, hulls and linter (Morrison, 1957; Aliener, 1980; Almashouley and Khan, 1990).

Percentage of linter varies with different varieties (Thomas and Gerdes, 1945; Majid and Khan, 1963; Sitaram et al., 1988) and by pressing methods (Bailey, 1948). Cottonseed oil is of great commercial importance and its percentage differs in different varieties, localities and under different environmental conditions (Hancock, 1942; Pope and Ware, 1945; Memon et al., 1962).

CS is one of the best sources of most essential amino acids, phosphatides like lecithin, lipase, phytase (Olcott and Fountains, 1941) and protein (Almashouley and Khan, 1990). CSM has fairly high protein and fiber contents depending on processing method (Anonymous, 1996). There are considerable variations in fat, fiber and protein quality of CSM and thus significant differences in energy contents can be expected. The CSM has been suggested as an attractive protein source for animal feeds (Kuiken, 1952) and has potential as a protein source for human and other animals (Martinez, 1977). Chemical composition of CS varies with variety, locality and environmental conditions (Bailey, 1948; Majid and Khan, 1963; Wahab, 1960).

Cottonseed meal (CSM) is a rich source of phosphorus, containing about 1.0% or more. Mineral constituents of the cottonseed (CS) are known to vary with variety and location of growth. Different conditions of growth and soil fertility causes considerable variation in mineral contents Malik and Khan (1964) reported different mineral content of four cotton varieties. Wahab (1960) reported great variation in mineral contents of CS collected from different localities. The information about proximate composition and mineral constituents of different varieties of cottonseed and it's derived products is scanty in the country. In view of local availability and adequate nutrients there is a need to explore the proximate and mineral contents of different available varieties of

* Corresponding Author: M. Abdullah. Dept. of Livestock Management, University of Agriculture, Faisalabad, Pakistan. E-mail: uathsan@fsd.comsats.net.pk.
Received August 7, 1998; Accepted May 10, 1999

cottonseed and it's derived products.

MATERIALS AND METHODS

Certified cottonseeds of different varieties (MNH 147, CIM 240, NIAB 78, FH 87, CIM 109, MNH 93. FH 682, GOHAR 87, SLS I and B 557) recommended for cultivation in different areas of Punjab for the year 1996, were collected from Directorate of Cotton (Research), Ayub Agriculture Research Institute, Faisalabad. Various physical fractions of cottonseed were separated and subjected to analysis for proximate and mineral (Ca, Mg, P, Na, Cl and K) constituents (AOAC, 1990). Ether extract was determined following AOAC (1990). Fe, Zn, Cu and Mn were analyzed using atomic absorption spectrophotometer (Varian Model AA-n75). The data on each parameter were subjected to statistical analysis using analysis of valiance technique according to completely randomized design (Steel and Torrie, 1980). The variation associated with varieties was determined. Duncan's multiple range test (Duncan, 1955) was applied to compare the means, with probability level of 0.05.

Table 1. Physical fractions as percentage of the seed of different varieties of cotton

Variety	Linter	Hull*	Kernel*
MNH 147	13.74 ± 0.31^{c}	29.57 ± 0.23^{c}	69.27 ± 0.15^{e}
CIM 240	12.53 ± 0.23^{d}	22.55 ± 0.17^{g}	76.73 ± 0.13^{a}
NIAB 78	15.24 ± 0.10^{b}	27.47 ± 0.20^{d}	70.53 ± 0.12^{cde}
FH 87	16.58 ± 0.07^{a}	26.40 ± 0.24^{e}	72.15 ± 0.20^{cd}
CIM 109	15.57 ± 0.02^{b}	33.41 ± 0.08^{a}	65.43 ± 0.16^{f}
MNH 93	9.15 ± 0.16^{f}	24.48 ± 0.19^{f}	74.30 ± 0.24^{b}
FH 682	11.58 ± 0.15^{e}	32.60 ± 0.31^{b}	66.07 ± 0.52^{f}
GOHAR 87	4.50 ± 0.20^{h}	28.38 ± 0.30^{d}	70.27 ± 0.18^{de}
SLS I	15.55 ± 0.10^{b}	30.12 ± 0.29^{c}	67.15 ± 1.93^{f}
B 557	7.69 ± 0.07^{g}	26.44 ± 0.30^{e}	72.30 ± 0.30^{c}
Mean ± SEM	12.21 ± 0.49	28.24 ± 0.43	70.42 ± 0.49

Same letters on means in a column show non-significant differences.

* Hull and kernel of delinted seeds.

RESULTS AND DISCUSSION

Physical fraction

Average weight of linter as percentage of undelinted seed of different varieties of cotton was 12.21. Variable amount of linter was obtained from undelinted seed of different varieties highest being in the case of variety FH 87 (16.58%) and lowest in the case of variety GOHAR 87 (4.50%). The statistical analysis of the data showed varietal differences ($p<0.01$) in linter percentages.

Thomas and Gerdes (1945) also observed differences between varieties with regard to linter percentage and reported that it ranged between 11.0 to 17.8% Similar values were reported by Bailey (1948) for linter percentage in moisture free fuzzy cottonseed obtained from commercial processing (12.71%) and acid delinted (14.4%).

Majid and Khan (1963) reported linter percentage of 12 varieties of cottonseed to range between 4.0 to 14.4%. Average weight of hull and kernel as percentage of delinted seed in different varieties of cotton were 28.24 and 70.42%, respectively. Variable amount of hull was obtained from seed of different varieties of cotton, highest being in case of CIM 109 (33.41%) and lowest in case of CIM 240 (22.55%). The statistical analysis of the data showed significant ($p<0.01$) varietal differences. Seeds of CIM 109 variety had significantly higher contents than all other varieties. Next in descending order were the hull contents in varieties FH 682, SLS I and MNH 147, the difference in the later two being non-significant. The differences in hull content between NIAB 78 and GOHAR 87; B 557 and FH 87 were also non-significant. Significantly lowest amount of hulls were recovered from seeds of variety CIM 240.

After removal of hulls conversely highest amount of kernel was observed in variety CIM 240 (76.73%) and the lowest in case of CIM 109 (65.43%). The statistical analysis of the data revealed significant ($p<0.01$) varietal differences.

Average percentage of seed and kernel meal in different varieties of cotton was 38.97 and 69.28%, respectively. Variable amounts of meal were obtained from seeds of different varieties of cotton highest being in CIM 240 (54.17%) and lowest in CIM 109 (42.61%). The meal percentage from seed ranged 40.63-54.75% in cottonseed varieties. Statistical analysis of the data showed varietal differences ($p<0.01$). Comparison of means revealed higher values in CIM 240 and B 557 while no differences among B 557, NIAB 78, MNH 93 and GOHAR 87 and among GOHAR, 87, MNH 147, SLS I and FH 87. Means of FH 682 and CIM 109 were lower than all other varieties.

Meals obtained from kernels of cotton showed considerable variation highest being in the case of NIAB 78 (72.17%) and lowest in the case of FH 682 (64.68%). The meal percentage from kernel ranged between 61.50-73.96% in CS varieties under study. The statistical analysis of the data showed varietal differences ($p<0.01$). Comparison of means revealed higher value in NIAB 78 and no differences among means of B 557, GOHAR 87, SLS I, MNH 147 and CIM 240, MNH 93, FH 87 and CIM 109 and among FH 87, CIM 109 and FH 682.

The meal percentage of seed of different varieties of cotton was higher than the value (35.65-44.35%) reported by Bailey (1948) and that (42.18-43.55%) reported by Morrison (1957). The difference was due to different processing method. Both of these workers reported values for meals obtained by the screw press expeller while the meal in present study has been obtained by solvent extraction method.

Proximate composition

Proximate composition of seed of different varieties of cotton is presented in table 2. Average CP content of seeds of cotton was 22.31%. CP contents were highest in FH 87 and lowest in FH 682. The statistical analysis of the data showed significant ($p<0.05$) varietal differences.

Zakirov et al. (1982) showed considerable variation in CP contents of CS of different varieties. Majid and Khan (1963) and Almashouley and Khan (1990) reported lower protein content of cottonseed. Pandey and Thejappa (1976) reported much higher crude protein content. Similar was the case of Nigerian commercial cottonseeds (Ikurior and Fetuga, 1987) and Zhemian variety (Yu et al., 1990). The variation may be attributed to variety and location.

Average CF content of seeds of different cotton varieties was 17.74%. CF was highest in the case of NIAB 78 and lowest in case of MNH 93. The variation in CF content of cottonseeds have been attributed to environmental conditions in addition to that of varieties (Pope and Ware, 1945; Wahab, 1960). Average crude ash (CA) contents of seeds of different cotton varieties were 4.27%, Ash contents were highest in case of SLS I and lowest in case of CIM 240.

Average content of EE in different varieties of CS was 22.09%. Variable amount of EE was obtained from seed of different varieties, highest being in FH 87 (24.42%) and lowest in NIAB 78 (20.06%) Statistical analysis of the data revealed significant ($p<0.5$) varietal differences.

EE contents in CS vary with variety, season, locality and ecological factors (Pope and Ware, 1945; Thomas and Gerdes, 1945; Memon et al., 1962). There was no correlation between oil content and fiber quality (Dani, 1991). Rakhimov (1980) reported differences in EE of CS and attributed to variety and fertilization. Ikurior and FetuBa (1987) showed higher oil content in three Nigerian commercial CS varieties than composite cottonseed from three location. Khan and Mian (1989) reported that seed oil content of MNH 93 and NIAB 78 showed marked effect as compared to B 557 for location and season. Rahim Yar Khan gave best oil content irrespective of variety. The oil contents of varieties B 557, MNH 93 and NIAB 78 from different locations ranged between 22.33-22.55, 19.40-21.24 and 17.39-18.99%, respectively. The values for variety B 557 were higher and those of MNH 93 and NIAB 78 were lower than those of present study. The variation may be attributed to location and season. Almashouley and Khan (1990) reported that oil content in lintered and delintered seed ranged between 13.2-21.7 and 14.54-24.15% respectively, in commercial processing plants, which was little lower than the findings of the present study The differences might be due to efficient oil extraction in the present study than that of commercial processes. Yu et al. (1990) reported 33.75% seed oil content in low gossypol cultivar Zhemian 9, which was sufficiently higher than the findings of present study. The variation was due to varietal differences.

The proximate contents of hulls of seeds of different varieties of cotton are presented in table 2. Average contents of CP, CF and CA in hulls of different varieties of CS were 2.85, 56.50, and 2.6%, respectively. Variable contents of CP, CF, and CA were observed in hulls of different varieties of CS highest in the case of FH 87 (3.47%), NIAB 78 (64.82%), and CIM 240 (2.87%) and lowest in the case of FH 682 (2.26%), MNH 93 (46.11%) and MNH 93 (2.23%), respectively The CP, CF and CA contents ranged between 1.31-4.87, 41.1-69.16, and 1.44-3.86%, respectively, in hull of CS varieties under study. Statistical analysis of the data revealed varietal differences in CP ($p<0.05$) and CF ($p<0.01$) but no differences in CA.

Average of CP, CF and CA contents in kernels of CS of different varieties were 32.62, 3.45, and 4.01%, respectively. Variable contents of CP, CF and CA were observed in kernels of CS of different varieties, highest in the case of FH 87 (37.13%), NIAB 78 (5.88%) and B 557 (5.23%) and lowest in the case of FH 682 (27.15%), B 557 (2.61%) and FH 682 (3.37%), respectively The CP, CF and CA contents ranged between 23.54-41.13, 1.36-7.78, and 2.27-6.87%, respectively, in kernel of CS. Statistical analysis of the data showed varietal differences ($p<0.05$).

Average EE content of kernel in different varieties of CS was 30.72%. Variable amount of oil was obtained from different cottonseed varieties highest in case of FH 682 (35.32%) and lowest in the case of NIAB 78 (27.83%). Comparison of means revealed no differences between FH 682, CIM 109 and FH 87; CIM 109, FH 87 and MNH 93; B 557 and NIAB 78 and between CIM 240, MNH 147, SLS I GOHAR 87 and B 557.

Akdemir et al. (1986) reported higher oil contents of CS. The values obtained in the present study were lower than reported values (Sattarov and Mikrani, 1986; Pulatov and Gubanova, 1986). This might be due to different varieties, localities, seasons (Hancock, 1942; Khan and Mian, 1989), cultivar (Dani, 1989) or ecological factors (Memon et al., 1962; Malik and Khan, 1964; Rakhimov, 1980).

Table 2. Proximate composition (%) of seed and derived products of different cotton varieties (on dry matter basis)

Variety		CP	CF	EE	CA
MNH 147	Seed	23.10 ± 1.45^{cd}	19.54 ± 0.65^{b}	20.71 ± 0.69^{bc}	4.85 ± 0.17^{ab}
	Hull	3.07 ± 0.17^{abcd}	58.91 ± 1.11^{b}	-	2.75 ± 0.25
	Kernel	32.93 ± 0.75^{ab}	4.20 ± 0.22^{b}	29.23 ± 1.02^{cd}	4.06 ± 0.11^{b}
	Meal	46.54 ± 1.06^{bc}	5.93 ± 0.32^{b}	1.16 ± 0.17^{bc}	5.73 ± 0.15
CIM 240	Seed	19.66 ± 0.64^{fe}	14.96 ± 0.32^{de}	22.89 ± 0.41^{ab}	3.94 ± 0.32^{c}
	Hull	2.52 ± 0.25^{bcd}	57.14 ± 4.81^{bc}	-	2.87 ± 0.18
	Kernel	30.87 ± 0.81^{bc}	27.79 ± 0.36^{d}	29.40 ± 0.44^{cd}	3.61 ± 0.27^{b}
	Meal	43.73 ± 1.15^{c}	3.95 ± 0.50^{cde}	1.70 ± 0.43^{abc}	5.11 ± 0.37
NIAB 78	Seed	19.78 ± 0.93^{fe}	22.12 ± 0.92^{a}	20.06 ± 0.19^{c}	4.18 ± 0.15^{bc}
	Hull	2.57 ± 0.17^{bcd}	64.82 ± 2.08^{a}	-	2.70 ± 0.19
	Kernel	31.82 ± 1.72^{b}	5.88 ± 0.52^{a}	27.83 ± 0.28^{d}	4.14 ± 0.22^{b}
	Meal	44.10 ± 2.38^{c}	8.14 ± 0.72^{a}	1.02 ± 0.01^{c}	5.73 ± 0.31
FH 87	Seed	28.57 ± 0.67^{a}	16.89 ± 0.97^{cd}	24.42 ± 0.30^{a}	4.03 ± 0.15^{c}
	Hull	3.47 ± 0.44^{a}	63.64 ± 0.92^{a}	-	2.67 ± 0.27
	Kernel	37.13 ± 1.07^{a}	3.36 ± 0.20^{bcd}	33.27 ± 0.51^{ab}	3.75 ± 0.44^{b}
	Meal	55.65 ± 1.60^{a}	5.03 ± 0.30^{bcde}	1.85 ± 0.26^{ab}	5.63 ± 0.66
CIM 109	Seed	26.16 ± 0.88^{ab}	16.98 ± 0.93^{cd}	23.29 ± 0.63^{a}	4.20 ± 0.09^{bc}
	Hull	3.25 ± 0.36^{ab}	46.77 ± 1.23^{d}	-	2.62 ± 0.35
	Kernel	34.76 ± 0.94^{ab}	3.44 ± 0.22^{bcd}	34.88 ± 1.05^{b}	3.60 ± 0.25^{b}
	Meal	53.37 ± 4.15^{a}	5.28 ± 0.33^{bcd}	2.07 ± 0.30^{a}	5.54 ± 0.38
MNH 93	Seed	25.40 ± 0.44^{bc}	13.03 ± 0.65^{e}	23.97 ± 0.43^{a}	4.20 ± 0.15^{bc}
	Hull	3.17 ± 0.29^{abc}	46.11 ± 2.47^{d}	-	2.23 ± 0.21
	Kernel	34.52 ± 1.28^{ab}	2.65 ± 0.40^{d}	31.55 ± 0.45^{bc}	4.13 ± 0.51^{b}
	Meal	50.43 ± 1.87^{ab}	3.87 ± 0.58^{de}	1.72 ± 0.18^{abc}	6.03 ± 0.74
FH 682	Seed	18.19 ± 0.31^{f}	19.66 ± 1.13^{b}	23.79 ± 0.43^{a}	4.03 ± 0.13^{c}
	Hull	2.26 ± 0.22^{d}	55.12 ± 1.16^{bc}	-	2.46 ± 0.19
	Kernel	27.15 ± 0.80^{c}	3.11 ± 0.27^{cd}	35.32 ± 1.79^{a}	3.37 ± 0.14^{b}
	Meal	41.97 ± 1.24^{c}	4.81 ± 0.42^{bcde}	2.11 ± 0.13^{a}	5.21 ± 0.22
GOHAR 87	Seed	21.96 ± 0.58^{de}	16.53 ± 0.97^{cd}	20.64 ± 0.67^{bc}	4.25 ± 0.09^{abc}
	Hull	2.99 ± 0.33^{abcd}	55.63 ± 2.04^{bc}	-	2.47 ± 0.13
	Kernel	33.13 ± 2.34^{ab}	2.82 ± 0.27^{d}	28.64 ± 0.88^{cd}	4.29 ± 0.39^{b}
	Meal	46.43 ± 3.27^{bc}	3.95 ± 0.38^{cde}	1.00 ± 0.25^{c}	6.02 ± 0.54
SLS I	Seed	18.75 ± 1.26^{f}	18.63 ± 0.72^{bc}	20.54 ± 1.41^{bc}	4.87 ± 0.28^{a}
	Hull	2.34 ± 0.22^{cd}	52.42 ± 1.34^{c}	-	2.61 ± 0.15
	Kernel	30.71 ± 1.26^{bc}	3.84 ± 0.38^{bc}	29.12 ± 2.12^{cd}	3.90 ± 0.21^{b}
	Meal	43.33 ± 1.77^{c}	5.42 ± 0.53^{bc}	1.14 ± 0.10^{bc}	5.51 ± 0.30
B 557	Seed	21.56 ± 0.80^{de}	19.01 ± 0.70^{bc}	20.64 ± 0.54^{bc}	4.18 ± 0.36^{bc}
	Hull	2.89 ± 0.16^{abcd}	64.45 ± 1.31^{a}	-	2.69 ± 0.13
	Kernel	33.17 ± 1.94^{ab}	2.61 ± 0.23^{d}	27.94 ± 0.90^{cd}	5.23 ± 0.36^{a}
	Meal	46.03 ± 2.69^{bc}	3.62 ± 0.32^{e}	1.01 ± 0.12^{c}	7.26 ± 0.30
Mean	Seed	22.31 ± 0.50	17.74 ± 0.40	22.09 ± 0.37	4.27 ± 0.07
	Hull	2.85 ± 0.09	56.50 ± 1.00	-	2.61 ± 0.07
	Kernel	32.62 ± 0.53	3.45 ± 0.15	30.72 ± 0.58	4.01 ± 0.11
	Meal	47.15 ± 0.80	5.00 ± 0.21	1.48 ± 0.10	5.78 ± 0.15

Different superscripts on mean values of a proximate component within seed, hull, kernel or meal show significant differences.

Average contents of CP, CF, EE and CA in meal of different varieties of CS were 47.15, 5.00, 1.48, and 5.78%, respectively. Variable contents of CP, CF, EE and CA was observed in meal of different verities of CS, highest in case of FH 87 (55.65%), NIAB 78 (8.14%), FH 682 (2.11%) and B 557 (7.26%) and lowest in case of FH 682 (41.97%), B 557 (3.62%), GOHAR 87 (1.00%) and CIM 240 (5.11%), respectively. The CP, CF, EE and CA contents ranged between 36.32-61.64, 10.82-24.81, 0.53-2.56 and 3.41-9.53%, respectively, in meal of cottonseed varieties under study. Statistical analysis of the data showed varietal differences ($p<0.01$) in CP, CF and EE while no differences in CA content.

Mineral composition

Average percentage of macrominerals in seed of different varieties of cotton is presented in table 3. Average contents of Ca, P, Mg, K, Na and Cl in seed of different varieties of cotton were 0.090, 0.216, 0.258, 0.652, 0.0089 and 0.035%, respectively. Variable contents of Ca, P, Mg, K, Na and Cl were observed in seed of different cotton varieties, highest in case of FH 87 (0.128%), FH 87 (0.405%), FH 87 (0.322%), CIM 240 and FH 87 (0.783%), SLS I and B 557 (0.01%) and GOHAR 87 (0.047%), respectively. The Ca, P, Mg, K, Na, and Cl ranged between 0.032-0.176, 0.062-0.436, 0.115-0.413, 0.400-0.900, 0.0070-0.0111, and 0.0071-0.0710%, respectively in seed. The statistical analysis of the data revealed varietal differences ($p<0.01$) in Ca, P, Mg and K while no differences in Na and Cl.

Guthrie et al. (1944) reported higher values for Ca (0.25%), P (1.27%), Mg (0.55%), K (1.17%), Na (0.20%) and Cl (0.05%) in CS than those of the present study. Malik and Khan (1964) reported considerable varietal differences in macromineral contents of CS. Their values for Ca (0.212-0.452%), P (0.154-1.412%) and upper range (1.269%) of K were higher while the lower level (0.287%) of K was less than the findings of present study. Ikurior and Fetuga (1987) reported higher value (1.21%) of P than that of present study. Similarly higher values were reported by NRC (1984). The contradiction between reported and studied values might be due to varieties (Pandey and Thejappa, 1976), location (Ikurior and Fetuga, 1987) or environmental conditions (Pope and Ware 1945; Wahab, 1960).

Average contents of Fe, Zn, Cu and Mn in seed of different varieties of cotton were 141.35, 24.55, 186.50 and 27.12 mg/kg, respectively (table 4). Variable contents of Fe, Zn Cu and Mn were observed in seed of different cotton varieties, highest in case of SLS I (157.17 mg/kg), NIAB 78 (27.50 mg/kg) NIAB 78 (236.67 mg/kg) and GOHAR 87 (41.33 mg/kg) and lowest in case of MNH 147 (122.83 mg/kg), FH 682 (23.50 mg/kg), GOHAR 87 (156.67 mg/kg) and MNH 147 (22.17 mg/kg), respectively. The Fe, Zn, Cu and Mn ranged between 108-183, 16-32, 110-300, and 19-52 mg/kg, respectively, in seed of cotton varieties under study. Statistical analysis revealed varietal differences ($p<0.01$) in Fe and Mn while no differences in Zn and Cu. The iron contents of present study were higher than those reported by NRC (1984) while sufficiently lower than those reported by Guthrie et al. (1944).

Average contents of Ca, P, Mg, K, Na and Cl in hull were 0.1246, 0.0703, 0.9070, 0.5050, 0.0196 and 0.0343%, respectively. Variable contents of Ca, P, Mg, K, Na and Cl were observed in hull, highest in case of MNH 147 (0.2967%), FH 87 (0.0796%), FH 87 (0.1168%), NIAB 78 and FH 682 (0.5500%), SLS I and B 557 (0.0200%), and NIAB 78 and GOHAR 87 (0.0426%), and lowest in case of FH 682 (0.0960%), B 557 (0.0633%), GOHAR 87 (0.0592%), CIM 109 (0.4500%), FH 87 (0.0189%) and SLS I (0.0267%), respectively. The Ca, P, Mg, K, Na and Cl ranged between 0.0320-0.1760, 0.0208-0.1247, 0.0288, 0.4000-0600, 0.0177-0.0218 and 0.0072-0.0710%, respectively, in seed hull of cotton varieties under study. Statistical analysis of data revealed no varietal differences. The Ca, Na, and Cl contents observed in the study were in agreement while K, Mg and P were sufficiently lower than the values reported by Guthrie et al. (1944) and NRC (1984).

Average contents of Fe, Zn, Cu and Mn in hull were 158.48, 2.06, 74.60 and 22.17 mg/kg, respectively. Variable contents of Fe, Zn, Cu and Mn were found in hull, highest in case of MNH 93 (171.50 mg/kg), NIAB 78 (2.25 mg/kg), NIAB 78 (94.67 mg/kg), and GOHAR 87 (139.00 mg/kg), CIM 240 (1.92 mg/kg), GOHAR 87 (62.67 mg/kg) and FH 87 (18.67 mg/kg), respectively. The Fe, Zn, Cu and Mn ranged between 127-204, 1.40-2.80, 44-120 and 12-37 mg/kg, respectively, in hull of CS varieties under study. Statistical analysis revealed varietal differences ($p<0.01$) in Fe and Mn while no differences in Zn and Cu. Guthrie et al. (1944) reported sufficiently higher values for Fe (300 mg/kg), Zn (20 mg/kg), and Mn (140 mg/kg) while the lower value for Cu (14 mg/kg) than the findings of present study. The reported values of NRC (1984) for Fe and Cu were lower while for Zn and Mn were higher than those of present study.

Average contents of Ca, P, Mg, K and Cl in kernel were 0.1075, 0.4056, 0.2243, 0.7567, and 0.0465%, respectively. Variable contents of Ca, P, Mg, K and Cl were observed in kernel, highest in case of FH 87 (0.1360%), FH 87 (0.5957%), MNH 147 (0.2560%), GOHAR 87 (0.9167%) and MNH 147 (0.0556%), and lowest in case of FH 682 (0.1227%), FH 682 (0.2078%), CIM 240 (0.1888%), MNH 147 (0.4550%) and CIM 109 (0.308%), respectively. The Ca, P, Mg, K and Cl ranged between 0.0640-0.1039, 0.0960-0.3936, 0.4000-1.0000 and 0.0071-0.0923%, respectively, in seed kernel of cotton varieties. Statistical analysis of the data revealed varietal differences ($p<0.05$) in Ca, P and K while no differences in Mg and Cl contents. Guthrie et al. (1944) reported higher values for P (1.73%), Mg (0.78%), K (1.14%) and Cl (0.5%) while the value for Ca (0.16%) was lower than the findings of present study.

Average contents of macrominerals in meal of different cottonseed varieties are presented in table 3. Average contents of Ca, P, Mg, K, Na and Cl in meal were 0.1557, 0.5876, 0.3246, 1.1017, 0.0267 and 0.0671%, respectively. Variable contents of Ca, P, Mg, K, Na and Cl were observed in meal, highest in case of FH 87 (0.2038%). FH 87 (0.8928%), CIM 109 (0.3858%), FH 87 (1.3500%), B 557 (0.0283%) and FH 87 (0.0834%), and lowest in case of NIAB 78 (0.1293%), FH 682 (0.3213%), CIM 240 (0.2675%), MNH 147 (0.6500%), MNH 147 (0.0259%) and CIM 109 (0.0472%), respectively. The Ca, P, Mg K, Na and Cl ranged between 0.0887-0.2877, 0.1606-1.3506, 0.1484-0.5462, 0.6000-1.5000, 0.0214-0.0297 and 0.0109-

Table 3. Macromineral contents (%) in seed and derived products of different cotton varieties

Variety		Calcium	Phosphorus	Magnesium	Potassium	Sodium	Chloride
MNH 147	Seed	0.107^{abc}	0.194^{c}	0.299^{ab}	0.750^{a}	0.0091	0.033
	Hull	0.2967	0.0658	0.0880	0.5333	0.0199	0.0355
	Kernel	0.1067^{abc}	0.4953^{ab}	0.2560	0.4500^{e}	-	0.0556
	Meal	0.1507^{bc}	0.6998^{abc}	0.3617	0.6500^{e}	0.0259	0.0786
CIM 240	Seed	0.069^{cde}	0.156^{cd}	0.227^{bc}	0.783^{a}	0.0088	0.033
	Hull	0.0987	0.0727	0.1008	0.4833	0.0196	0.0296
	Kernel	0.0987^{cde}	0.2736^{bc}	0.1888	0.8000^{bc}	-	0.0343
	Meal	0.1398^{c}	0.3876^{cd}	0.2675	1.1333^{bc}	0.0270	0.0486
NIAB 78	Seed	0.075^{bcde}	0.177^{cd}	0.222^{bc}	0.750^{a}	0.0087	0.032
	Hull	0.0960	0.0658	0.0944	0.5500	0.0192	0.0426
	Kernel	0.0933^{bcde}	0.2736^{bc}	0.2000	0.6670^{d}	-	0.0355
	Meal	0.1293^{c}	0.3791^{cd}	0.2771	0.9167^{d}	0.0276	0.0492
FH 87	Seed	0.128^{a}	0.405^{a}	0.322^{a}	0.783^{a}	0.0090	0.028
	Hull	0.1253	0.0796	0.1168	0.5333	0.0189	0.0343
	Kernel	0.1360^{a}	0.5957^{a}	0.2544	0.8833^{ab}	-	0.0556
	Meal	0.2038^{a}	0.8928^{a}	0.3813	1.3500^{a}	0.0267	0.0834
CIM 109	Seed	0.112^{ab}	0.312^{b}	0.302^{ab}	0.600^{b}	0.0088	0.043
	Hull	0.1227	0.0762	0.1136	0.4500	0.0196	0.0331
	Kernel	0.1227^{ab}	0.5161^{a}	0.2512	0.8667^{ab}	-	0.0308
	Meal	0.1884^{ab}	0.7925^{ab}	0.3858	1.3167^{a}	0.0272	0.0472
MNH 93	Seed	0.099^{abcd}	0.291^{b}	0.286^{abc}	0.800^{a}	0.0086	0.031
	Hull	0.1093	0.0658	0.0880	0.4833	0.0199	0.0331
	Kernel	0.1173^{abcd}	0.5437^{a}	0.2528	0.9000^{ab}	-	0.0556
	Meal	0.1714^{abc}	0.7944^{ab}	0.3693	1.333^{a}	0.0266	0.0813
FH 682	Seed	0.059^{e}	0.114^{d}	0.283^{abc}	0.583^{bc}	0.0086	0.038
	Hull	0.0960	0.0693	0.0736	0.5500	0.0193	0.0320
	Kernel	0.0907^{e}	0.2078^{c}	0.1920	0.8333^{abc}	-	0.0426
	Meal	0.1402^{c}	0.3213^{d}	0.2968	1.2667^{ab}	0.0267	0.0659
Gohar 87	Seed	0.096^{abcde}	0.180^{c}	0.206^{c}	0.550^{bcd}	0.0092	0.047
	Hull	0.1067	0.0693	0.0592	0.4667	0.0194	0.0426
	Kernel	0.1067^{abcde}	0.5022^{ab}	0.2384	0.9167^{a}	-	0.0462
	Meal	0.1495^{bc}	0.7038^{abc}	0.3341	0.2833^{ab}	0.0268	0.0647
SLS I	Seed	0.063^{de}	0.132^{cd}	0.213^{c}	0.467^{cd}	0.0100	0.028
	Hull	0.1000	0.0700	0.0850	0.5167	0.0200	0.0267
	Kernel	0.0967^{de}	0.2800^{bc}	0.1900	0.7333^{cd}	-	0.0533
	Meal	0.1367^{c}	0.3950^{cd}	0.2683	1.0500^{cd}	0.0267	0.075
B 557	Seed	0.095^{abcde}	0.197^{c}	0.215^{c}	0.450^{d}	0.0100	0.038
	Hull	0.0983	0.0633	0.0933	0.4833	0.0200	0.0350
	Kernel	0.1083^{abcde}	0.3683^{abc}	0.2167	0.5167^{e}	-	0.0550
	Meal	0.1483^{bc}	0.5083^{bcd}	0.3033	0.7167^{e}	0.0283	0.0783
Mean	Seed	0.090	0.216	0.258	0.652	0.0089	0.035
	Hull	0.1246	0.0703	0.0907	0.5050	0.0196	0.0343
	Kernel	0.1075	0.4056	0.2243	0.7567	-	0.0465
	Meal	0.1557	0.5876	0.3246	1.1017	0.0267	0.0671

Different superscript on mean values of a particular mineral within seed, hull, kernel or meal show significant differences.

0.1383%, respectively, in meal of CS varieties under study. Statistical analysis of the data showed varietal differences ($p<0.01$) in Ca, P and K while no differences in Mg, Na and Cl. Guthrie et al. (1944) reported significantly higher values in cottonseed meal for Ca (0.43%), P (2.88%), Mg (0.95%) and K (1.77%). Similarly higher values of Ca, P, Mg, K and Na, and lower value for Cl were reported by NRC (1994), while the value (Guthrie et al., 1944) for Na (0.29%) was in agreement with that of present study. The condtradiction in the findings of previous and present study might be due to different varieties (Pandey and Thajappa, 1976), location (Ikurlor and Fetuga, 1987), and environmental conditions (Pope and Ware, 1945; Wahab, 1960).

Average contents of microminerals in meals of different varieties of cottonseed are presented in table 4. Average contents of Fe, Zn, Cu and Mn in meal were 167.62, 20.30, 185.83 and 20.67 mg/kg, respectively. Variable contents of Fe, Zn, Cu and Mn were observed in meal, highest in case of B 557 (195.67 mg/kg), FH 682 (21.67 mg/kg) B 557 (198.33 mg/kg) and NIAB 78 (22.67 mg/kg), and lowest in case of CIM 240 (140 mg/kg), CIM 240 (19 mg/kg), CIM 240 (173.33 mg/kg) and FH 87 (18.83 mg/kg), respectively. The Fe, Zn, Cu and Mn ranged between 135-210, 14-25, 130-240 and 14-27 mg/kg, respectively in meal of cottonseed varieties under study which were in agreement with the findings of Guthrie et al. (1944). Statistical analysis of the data revealed varietal differences ($p<0.01$) in iron content while no differences in Zn, Cu and Mn contents. The values of

Table 4. Micromineral contents (mg/kg) in seed and it's derived products of different cotton varieties (on dry matter basis)

Variety		Iron	Zinc	Copper	Manganese
MNH 147	Seed	122.83^{d}	25.83	185.00	22.17^{c}
	Hull	139.00^{d}	2.05	74.00	20.33^{cd}
	Meal	158.50^{d}	20.00	178.33	21.00
CIM 240	Seed	127.17^{ca}	23.67	195.00	33.83^{b}
	Hull	145.00^{cd}	1.92	78.00	20.67^{cd}
	Meal	140.001^{e}	19.00	173.33	19.50
NIAB 78	Seed	131.50^{ca}	27.50	236.67	25.17^{c}
	Hull	149.33^{bcd}	2.25	94.67	25.50^{cd}
	Meal	174.67^{b}	20.83	195.00	22.67
FH 87	Seed	136.33^{bca}	23.67	168.33	23.50^{c}
	Hull	155.33^{abcd}	1.95	67.33	18.67^{d}
	Meal	172.00^{b}	19.50	180.00	18.83
CIM 109	Seed	144.00^{abc}	24.00	200.00	26.33^{c}
	Hull	159.67^{abc}	2.12	80.00	23.33^{bc}
	Meal	159.33^{d}	19.67	180.00	21.67
MNH 93	Seed	155.33^{a}	24.50	205.00	26.83^{c}
	Hull	171.50^{a}	2.22	82.00	20.33^{cd}
	Meal	160.33^{cd}	20.33	185.00	21.83
FH 682	Seed	143.33^{abc}	23.50	171.67	23.50^{c}
	Hull	163.17^{ab}	1.97	68.67	19.67^{cd}
	Meal	168.00^{bc}	21.67	196.67	20.33
Gohar 87	Seed	152.00^{ab}	23.67	156..67	41.33^{a}
	Hull	170.83^{a}	2.00	62.67	33.33^{a}
	Meal	188.67^{a}	20.83	188.33	20.17
SLS I	Seed	157.17^{a}	25.17	171.67	24.67^{c}
	Hull	169.17^{a}	2.03	68.67	20.17^{cd}
	Meal	159.00^{d}	20.17	188.33	21.00
B 557	Seed	143.83^{abc}	24.00	175.00	23.83^{c}
	Hull	161.83^{abc}	2.12	70.00	19.67^{cd}
	Meal	195.67^{a}	21.00	198.33	19.67
Mean	Seed	141.35	24.55	186.50	27.12
	Hull	158.48	2.06	74.60	22.17
	Meal	167.62	20.30	185.83	20.67

Different superscript on mean values of a particular mineral within seed, hull, kernel or meal show significant differences.

NRC (1994) for Fe and Cu were lower while for Zn and Mn were higher than the findings of present study.

REFERENCES

Akdemir, H., I. Demir, S. Emiroglu and R. Marquard. 1986. Investigation into the heritability of quality characteristics of cottonseeds using breeding material of Turkish provenance. Pl. Res. Dev. 24:79-84.

Almashouley, A. H. and A. Khan. 1990. Quality survey of cottonseed oil industry of Pakistan. Pak. Cott. 34:45-53.

Anonymous. 1984. Pakistan's editable oilseeds industry. USDA, Washington DC. pp. 215.

Anonymous. 1990. Role of cotton in edible oil production. World Oil Seed Situation and Market. Sept. 1990.

Anonymous. 1996a. Cotton development in Punjab and future strategies. AARI, Faisalabad.

Anonymous. 1996b. Cottonseed meal. Pak. Poul pp. 7

Anonymous. 1997. Economic Survey 1996-97. Government of Pakistan, Finance Division, Economic Advirser's Wing, Islamabad, Pakistan.

AOAC. 1990. Official Methods of Analysis. Association of Official and Analytical Chemists 15th Ed. Arlington, Virginia-22201.

Bailey, A. E. 1948. Cottonseed and cottonseed products. Wiley Interscience, New York.

Dani, R. G. 1989. Genotype × environmental interactions for seed oil and protein content in cotton (*Gossypium hirsutum* L.). Ind. J. Gen. 49:227-240.

Dani, R. G. 1991. Oil content and fibre quality traits in some cultivars of *Gossypium arboreum*. Ann. Agri. Res. 12(1):95-97.

Duncan, D. B. 1955. Multiple range and multiple F tests. Biometerics. 11:1-42.

Guthrie, J. D., C. L. Hoffpair, E. T. Steiner and M. Stansbury. 1944. Survey of the chemical composition of cotton fibres, cottonseed, peanuts and sweat potatoes. A Rev. Processed Release, AIC-61, Southern Regional Research Laboratory, USDA. 20.

Hancock, N. I. 1942. Factors in the breeding of cotton for increased oil and nitrogen content. Tenn. Agri. Expt. St. Cir. 79:7.

Ikurior, S. A. and B. L. A. Fetuga. 1987. Composition of some recommended Nigerian commercial cottonseed varieties. Food Chem. 26:307-314.

Khan, A. and M. A. Mian. 1986. Possibility in increase of cottonseed oil recovery on screw press expeller. Pak. Cott. 30:21-24.

Khan, A. and M. A. Mian. 1989. Studies on oil content of cottonseed with respect to season and place. Pak. Cotton. 33:120-130.

Kuiken, K. A. 1952. Availability of essential amino acids in cottonseed meal. J. Nutr. 46:13-25.

Liener, I. E. 1980 Toxic Constituents of lilant Feedstuffs. Academic Press. New York.

Majid, S. A. and G. A. Khan. 1963. A note on the production utilization physical and chemical properties of cottonseed varieties commercially grown in Pakistan Pak. Cott. 7: 137-147

Malik, D. M. and A. H. Khan. 1964. Effect of season and location on oil protein and gossypol content of cottonseed of new long staple varieties. Pak. Cott. 8:163-173.

Malik, D. M. and A. H. Khan. 1964. Studies on inorganic constituents of cottonseed. Pak. Cott. 8:137-147.

Martinez, W. H. 1977. Other antinutritional factors of practical importance. Evaluation of Proteins for Humans. C. E. Bodwell (Ed.) AVI. Publ. Co. Westport, CT.

Memon, A. M., Q. H. Kazi, M. Ahmad, A. Baluch and M. B. A. Baig, 1962. Oil content studies on some of the commercial cotton varieties of West Pakistan. Pak. Cott. 6:160-166.

Morrison, F. B. 1957. Feeds and Feeding (22nd Ed.). The Morrison Publishing Company Ithaca, New York. pp. 545-56.

National Research Council. 1984. Nutrient Requirements of Beef Cattle. (6th Rev. Ed.). Natl. Acad. Sci. Washington, DC.

National Research Council. 1994. Nutrient Requirements of Poultry (9th Rev. Ed.). Natl. Acad. Sci. Washington, DC.

Olcott, H. S. and T. D. Fountains. 1941. Composition of cottonseed lipase of germinated seed. JACS. 63:825-827.

Pandey, S. N. and N. Thejappa. 1976. Chemical analysis of seeds of new glandless cotton varieties. Ind. J. Agri. Sci. 46:15-18.

Pope, O. A. and J. O. Ware. 1945. Effect of variety location and season on oil, protein and fuzz of cottonseed and on fiber properties of lint. USDA Bull. No. 903, Washington, DC.

Pulatov, M. and N. Gubanova. 1986. Combining ability of fine fibred cotton varieties for oil content. Khlopkovodstvo. 2:23-24.

Rakhimov, A. 1980. Oil content of cotton seeds in relation to variety and fertilizer regime on newly irrigated light serozem soil. Referativnyi Zhurnal. 8:495.

Sattarov, B. K. and A. R. Mikrani. 1986. Oil content of hybrids of the cotton species (*Gossypium barbadense* L). Genofond. Tekhicheskikh Kultur. 69-76.

Sitaram, M., I. Bhatt, P. Varadarajan and V. Sundaram. 1988. Better utilization of cottonseed. IS CIJ., March:5.

Steel, R. G. D. and J. H. Torrie. 1980. Principles and Procedures of Statistics. McGraw-Hill Book Company, Inc. New York.

Thomas, H. L. and F. L. Geodes. 1945. Cotton quality test results of interest to cottonseed oil mill superintendents, mimeographed released by USDA Marketing: Service, Cotton Branch. 1-9.

Wahab, A. 1960. Composition of Cottonseed. Fifty Years of Research at the Punjab Agriculture College, Layallpur.

Ware, J. O. 1936. Plant breeding and the cotton industry. USDA Year book. pp. 657.

Yu, B., R. Xia, X. Wang, O. Zhu and X. Qiu. 1990. A new cotton variety of low gossypol cotton Zhemian 9. China Cott. 5:23.

Zakirov, A., A. N. Nuritdinov and M. M. Kiktev. 1982. Biochemical characteristics of new cotton varieties in the collection. USSR Fanlar Akad. Dokl. 5:57-58.