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Studies on Detoxification of Feeds and Feed Ingredients

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Different feed ingredients i.e. wheat, sorghum, maize, corn gluten meal, rice bran, cotton seed meal, mustard seed meal, sunflower meal, soy bean meal, sesame meal, peanut meal and broiler feeds were procured from local market and analyzed for chemical composition and toxic factors. The oilseed cakes and rice bran meal were treated to eliminate the toxic factors. Detoxification of feed ingredients resulted in decrease in gossypol from 0.31 to 0.05% in cotton seed meal, allylisothiocyanate from 1.55 to traces in mustard seed meal, chlorogenic acid from 3.20 to 0.95% in sunflower meal and trypsin inhibitor from 72.10 to 17.20 mg/g in soy bean meal. Phytic acid contents in oilseed cakes i.e. cotton seed, mustard seed, sunflower, soybean, and rice bran meals before and after treatments were reduced from 2.91 to 0.43, 3.54 to 0.40, 2.84 to 0.52, 3.22 to 0.64 and 2.60 to 0.42%, respectively.

Key words: Feed ingredients. Toxic factors, Cereals, Phytic acid.

Introduction

Pakistan produce around 20844 thousands metric tonnes of cereals which are used as food and feed products (Economic Survey 1999-2000). Only a small fraction of low quality broken cereals or their useless byproducts i.e. wheat bran, rice bran, rice polishing etc. are used as poultry or animal feed ingredients. Similarly 2016 thousands tonnes oilseeds are produced annually (Economic Survey 1999-2000). The cake left after extraction of edible oil, is a potential source of protein, carbohydrates, minerals, etc (Aherne and Kennelly 1983) but has limited use in poultry feed (Christian 1958; Bernard and Goloblatt 1980; Aherne and Kennelly 1983; Shah and Mahmood 1986) due to the presence of toxic and antinutritive factors such as gossypol (cotton seed) glucosinolate (mustard rapeseed), trypsin inhibitor (soybean) and chlorogenic acid (sunflower seed). The left over cakes of these oil seeds and cereals also contain antinutritive factors like phytic acid. Phytic acid is myo-insoitol - 1,2,3,4,5,6 hexanis-dihydrogen phosphate. In most seeds it serves as primary phosphorus and myo-inositol reserve. Phytic acid forms chelating compounds with proteins and minerals and decrease their solubility, functionality, digestibility and physiological availability, while appropriate treatments have been suggested to reduce or eliminate toxic and antinutritional compounds of various feed ingredients (Maga 1982; Cosgrove 1980; Rodriguez *et al* 1985).

Present investigations were carried out to determine toxic and antinutritive factors in oil seed meals and efforts were made to reduce or eliminate these factors from the meals to be used in poultry feed and to produce a toxin-free poultry feed.

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Materials and Methods

Four broilers feed samples and different feed ingredients i.e. oilseed cakes, cereals, rice bran, etc were produced from local market.

Processing. Cotton, mustard, sunflower, soybean, sesame, peanut seed cakes and rice bran were ground to fine powder (60 mesh) and placed in soxhlet extractor (Quickfit England) for 20 hr with *n*-hexane for reducing oil contents to the minimum (1 ± 0.5%). The meals so obtained were dried, by placing them in open air and finally in an oven at 60 ± 2˚C followed by grinding to fine powder.

Detoxification procedure. 1. *Cotton seed meal*: Five hundred grams cotton seed meal were mixed with a solution containing 1.0% $Ca(OH)_2$ + 0.15% $FeSO_4$ to eliminate free gossypol (Saqib *et al* 1997) and 3.0% NaCl (w/w of meal) was also added later on to help in leaching out phytic acid (Niazi *et al* 1988). The cotton seed meal mix was boiled for 30 min and filtered. The residue was dried in an oven at 80 ± 2˚C and ground to 80 mesh size.

2. *Mustard seed meal*: Five hundred grams mustard seed meal were dipped in water (1:5 w/v) at 55˚C for 45 min followed by steam stripping to remove toxic factor allylisothiocyanate (Mustakas *et al* 1965). Then 3.0% NaCl (w/w of meal) was added to the mixture and its pH was adjusted to 5. The mixture was kept at the same temperature for one hour, followed by filtration (Niazi *et al* 1988). The residue was dried in an oven at 80 ± 2˚C and grounded to 80 mesh size.

3. *Sunflower meal*. Five hundred grams sunflower meal seed were soaked in 0.2% sodium bisulphate for 20 min and kept for

one hour at ambient temperature (Bau *et al* 1983) followed by leaching with 3.0% NaCl solution (1500 ml) at 55°C. The pH was adjusted to 5 and kept for one hour. The slurry was filtered and the residue was dried and powdered as mentioned above.

4. *Soybean meal*. Soybean meal was treated for reduction of trypsin inhibitor and phytic acid contents (Sathe and Salunkhe 1981). It was processed as described for sunflower meal except that 0.25% $NaHCO_3$ was used instead of 0.20% $NaHSO_3$.

5. *Rice bran meal*. The rice bran meal was wetted with deionised water (1:2 w/w basis). Its pH was adjusted to 5 with 1N HCl and autoclaved at 1 kg/cm (120°C) for 30 min to inactivate the enzyme lipase and also dephosphorylase present in it, followed by drying at 80°C and grinding to 80 mesh size (Niazi *et al* 1997).

6. *Analytical methods*. Standard procedures previously described were used to determine concentration of gossypol (AOAC 1990), allyisothiocyanate (Wetter 1955), chlorogeneric acid (Bau *et al* 1983), trypsin inhibitor (Eskin *et al* 1978) and phytic acid (Wheeler and Ferrel 1971). Proximate composition (moisture, fat, crude protein, crude fibre, ash and nitrogen free extract) were determined according to standard procedures of AOAC (1990).

Results and Discussion

Proximate composition of oilseed meals and rice bran meal (Table 1) indicated that high protein (39.21 to 53.22%), nitrogen free extract-NFE (31.22% to 42.77%) and ash (6.40% to 8.12%) contents are essential ingredients to be added into feeds. As these ingredients are potential source of energy and minerals, required for animal and poultry feed preparation. Furthermore, elimination or reduction of toxic and antinutritive factors of these would also improve the nutritive value of feeds.

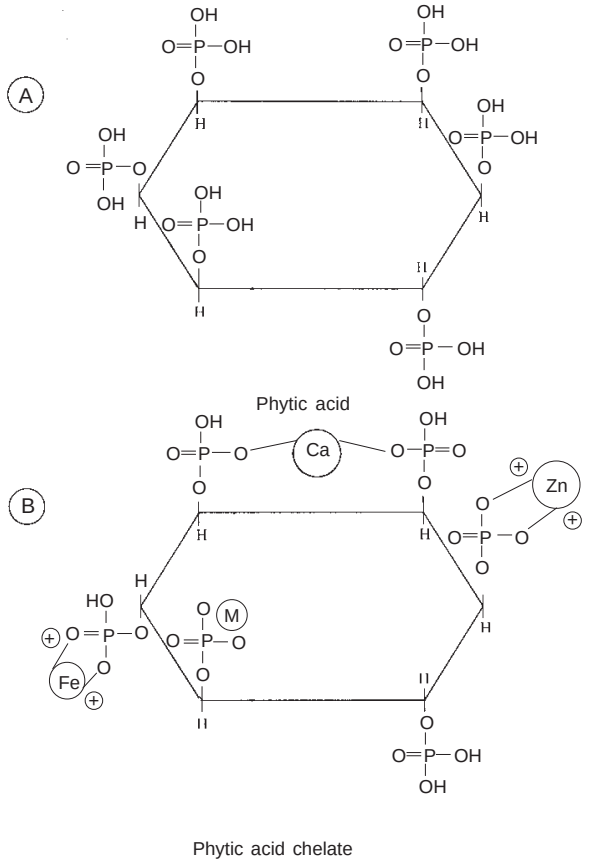

Fig 1. Structures of phytic acid (A) and phytic acid chelate (B) at neutral pH

Table 1
Proximate composition* of oil seed meals and cereals

Oilseed Meals	Moisture (%)	Crude protein (%)	Fat (%)	Crude Fibre (%)	Ash (%)	NFE (%)
Cotton seed meal**	7.75	39.21	1.91	7.11	6.40	35.37
Mustard seed meal	5.80	41.11	1.50	10.90	6.81	39.68
Sunflower seed meal**	6.23	51.54	2.12	6.92	8.11	31.22
Soybean seed meal	8.84	40.50	1.90	6.71	8.12	42.77
Sesame seed meal	9.15	53.22	1.41	10.83	5.80	38.74
Wheat	8.50	12.50	2.58	2.70	1.90	71.52
Sorgham	9.10	11.75	2.05	2.50	2.10	72.50
Maize	9.00	8.80	3.00	2.40	2.15	74.65
Corn gluten meal 60%	8.15	59.50	3.50	1.00	1.50	26.35
Rice bran	7.00	15.50	3.00	14.90	13.50	46.10
Broiler feed	10.50	20.70	3.00	2.80	8.10	54.90

* On dry matter basis; ** Decorticated/dehulled; NFE: Nitrogen free extract.

Amount of different toxic material such as gossypol, allylisothiocyanate, chlorogenic acid, trypsin inhibitor and antinutritive factors i.e. phytic acid in oil seed meal and creals are shown in Table 2. Toxic and antinutritive factors determined in different feed ingredients showed that cotton, mustard, sunflower, soybean meals contained 0.31% gossypol, 1.55% allylisothiocyanate, 3.20% chlorogenic acid, 72.10 mg/g trypsin inhibitor, respectively. Incorporation of these ingredients in poultry feed at higher level would certainly exert adverse effect on the nutritional value of feeds. Thus, it is essential to detoxify these feed ingredients.

Detoxification of oil seed meals and rice bran meals did show losses in proteins but overall recovery of detoxified oil seed meals (81.83 to 85.70%) and rice bran meal seemed economically, acceptable (Table 2). Detoxification effectively reduced gossypol (0.05%). allylisothiocyanate (traces), chlorogenic acid (0.95%). trypsin inhibitor (17.20 mg/g), and phytic acid contents (0.40% to 0.64%) to safer limits. Losses in weight of protein which occurred during different treatments appeared to be much less as compared to the nutritional improvement in oilseed meals. But the other feed ingredients when supplemented in poultry feed, increased over-all performance.

All the oil seed meals and rice bran meal contained 2.60 to 3.54% phytic acid, maximum being in mustard and minimum in rice bran (Table 2). Cereals i.e. wheat, sorghum and maize grains contained 1.08 to 1.24% phytic acid, whereas cereal by products i.e. rice bran meal and corn gluten meal which are used as poultry feed ingredients contained 1.52% to 1.94% phytic acid, respectively. The results are in agreement with the findings of Eardman (1979) and Niazi *et al* (1997). Broiler feeds available in local market showed on an average 1.81% phytic acid (Table 2).

The structure of phytic acid and phytic acid chelate at neutral pH is shown in Fig 1. It is apparent that various cations could strongly chelate between two phosphate groups depending upon the strength of various metal ions. Similarly, proteins form loose complexes with phytic acid which affect their bioavailability as indicated by Eardman (1979).

Table 2
Antinutritive factors in oil seeds and cereals and detoxified oil seed meals

Sr. No.	Oil seed meals untreated/treated	Crude Protein (%)	Gossypol (%)	Allyliso-thiocyanate (%)	Chlorogenic acid (%)	Trypsin inhibitor (gm/g)	Phytic acid (%)	Recovery (%)
1.	Cotton seed meal	39.12	0.31	-	-	-	2.91	-
2.	(i) 1% $Ca(OH_2)$ + 0.15% $FeSO_4$ (ii) 3% NaCl	36.40	0.05	-	-	-	0.43	85.70
3.	Mustard seed meal	41.12	-	1.55	-	-	3.54	-
4.	(i) Enzymic.Detoxified (ii) 3% NaCl	38.52	-	Traces	-	-	0.40	81.83
5.	Sunflower seed meal	51.44	-	-	3.20	-	2.84	-
6.	(i) 0.2% $NaHSO_3$ (ii) 3% NaCl	45.81	-	-	0.95	-	0.52	82.64
7.	Soybean seed meal	40.52	-	-	-	72.20	3.22	-
8.	(i) 0.25% $NaHCO_3$ (ii) 3% NaCl	38.24	-	-	-	17.20	0.64	81.85
9.	Rice bran meal	12.20	-	-	-	-	2.60	-
10.	(i) Meal water (1:2), pH:5 (ii) Autoclaving 38 min. 1 kg/cm_2 (iii) 3% NaCl	12.05	-	-	-	-	0.42	-
11.	Wheat	12.50	-	-	-	-	1.24	-
12.	Sorghum	11.75	-	-	-	-	1.08	-
13.	Maize	8.80	-	-	-	-	1.15	-
14.	Corn gluten meal	59.50	-	-	-	-	1.94	-
15.	Rice bran	15.50	-	-	-	-	1.52	-
16.	Broiler feed	20.70	0.009	0.075	-	1.70	1.81	-

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