SOME ANTI-NUTRITIONAL COMPONENTS IN NIGERIA COTTONSEED AND COTTONSEED MEALS

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SUMMARY

Cottonseed of three Nigerian commercial varieties of cotton, three locational composite seed cotton and cottonseed meals were investigated with respect to their content of gossypol (free and total), tannins, phytin and phytin phosphorus. Free and total gossypol ranged from 1.14 to 1.34% and 1.21 to 1.59%, respectively in cottonseed kernels, and 0.028 to 0.064% and 0.413 to 0.831%, respectively in cotton seed meals. Varietal and environmental factors appeared to influence the gossypol content of cottonseed while the variability in the meals was due to the effects of conditions under which the seed was processed. Tannins ranged from 26.25 to 38.50 mg/100g in the seed kernels and 3.13 to 6.75 mg/100g in the meals. From all indications varietal, locational and processing factors appeared to influence the tannin content of the seed and meals in a similar manner as they influenced the gossypol content. Phytin and phytin phosphorus did not vary appreciably between or within seed type, neither did processing of seed appear to affect their contents in the meals.

INTRODUCTION

Cellular components other than nutrients occur in nearly all types of foods. While some of such components seem harmless, a good many of them have been found to interfere in one respect or another, with the utilization of foods by animals and man. This latter group constitutes what is referred to as anti-nutritional factors or components. They vary widely in chemical nature and in the manifestation of their anti-nutritional effects. Prominent among the anti-nutritional food components are protease inhibators, substances which have the ability to inhibit the proteolytic activity of certain enzymes, which are found throughout the plant kingdom, particularly among the legumes, (Liener and Kakade, 1969). Phyto-haemagglutinins, or Lecithins, which have the property to agglutinate red blood cells, occur in seeds of members of the families *Leguminosea* and *Euphorbiaceae* (Jaffe, 1969). Cyanogenic glucosides have been reported in fruits, sorghum, lima beans and cassava (Montgomery, 1969). Phytin which occurs in grains (Young and Grieves, 1940), beans, (Lolas and Markakis, 1975), cottonseed products (Wozenski and Woodburn, 1975) has adverse effects on availability of some essential mineral elements (Nwokolo and Bragg, 1977). Tannis are polyphenolic compounds which occur in a wide variety of plants used for foods and feeds (Jambunathan and Mertz, 1973; Radderkrishnan and Sivaprassad, 1980), where they interact with food proteins altering the digestibility of the protein and consequently causing retardation in animal growth (McGinty, 1969).

Cottonseed and its products contain a naturally occuring polyphenolic compound known as gossypol, which because of its nutritional importance, has been studied more than any other factor in cottonseed products. The nutritional importance of gossypol lies in its toxic and physiological effects on especially monogastric animals, which include

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anorexia, dyspnea, hydrothorax and oedema of lungs, hydroperitoneum, hepatic degeneration, hypertrophy and dilation of the heart (Smith, 1957), and changes in the electrocardiogram (Albrecht *et al.* 1968). Further to these effects, during the processing of cottonseed for oil, gossypol combines with the reactive epsilon-amino groups of lysine, and to a lesser extent, with other cellular components of the seed, to form insoluble, indigestible complexes, thereby reducing the nutritive value of the resultant cottonseed meal protein (Damaty and Hudson, 1975, 1979; Martinez *et al.*, 1967; Clawson *et al.*, 1961; Buitrago *et al.*, 1970).

Cotton is an important commercial crop in Nigeria and in recent years cottonseed and the oil-processed by-product, cottonseed meal, have become increasingly important in human and animal feeding. There has been no documentation of the contained levels of gossypol and other anti-nutritional components in Nigerian cottonseed and cottonseed meals. The present investigation was therefore undertaken to provide this vital information on some of the anti-nutritional components in the commercial varieties and composite cottonseed, and in cottonseed meals produced in Nigeria.

MATERIALS AND METHODS

The cottonseed samples were of three Nigerian commercial varieties of cotton, Samaru 71 (S71), Samaru 72 (S72) and Samaru 77 (S77), which were supplied by the Fibre Breeding Section, Institute for Agricultural Research, Ahmadu Bello University, Samaru, Zaria. The seedcotton for each pure variety was separately ginned and approximately 30kg cottonseed sampled in a labelled satchet. Composite cottonseed samples were also collected from ginneries located at Funtua (CSF), Mallufashi (CSM) and Chalawa, Kano (CSK). These are areas from where a greater portion of Nigerian cotton is produced. The cottonseed samples were brought to our laboratory, cracked in a mortar and the kernels mannually separately from the hulls and linters. The cleansed kernels were stored in screw-top Kilner Dual Purpose Jars, from which a portion was ground using a Gulatti Grinder, Type DFH 48 and also stored in the screw-top jars. All samples were kept in an air cooled room until used.

Samples of cottonseed meals were obtained from four oilseed mills which process most of the cottonseed produced in Nigeria: Funtua Cottonseed Crushing Co. Limited, Funtua, Kaduna State (FCCC), Gombe Oil Seed Processors Limited, Gombe, Bauchi State (GOSP), Gusua Oil Mill Limited, Gusua, Sokoto State (GUOM) and Kano State Oil and Allied Products Limited, Kano (KOSAP). Five batch samples were collected from each mill during the seasons 1979/80 and 1980/81, except from GOSP where due to production difficulties, only one batch was obtained. The ground samples were stored in the same way as were the kernels.

The anti-nutritional components which were determined in the cottonseed kernels and meal samples included total gossypol, using the method of Pons and Hoffpauir (1957); free gossypol, by the A.O.C.S. (1969) method. Preparation of standard graphs for both forms of gossypol involved the use of primary standard gossypol acetic acid in place of pure gossypol. The tannin content of the samples was determined by the method described by Hagerman and Butler (1978). Standard calibration graph was prepared using 0.2 to 1.0mg/ml concentrations of tannis acid and their corresponding optical densities at 510nm. Phytin phosphorus was determined according to the method outlined by Young and Greaves (1940); the values were converted into phytin after multiplying by the factor 3.55.

RESULTS AND DISCUSSION

The data contained in Table 1 show the anti-nutritional components in Nigerian commercial varieties and composite cot-

TABLE 1

Anti-Nutritional components in Nigerian Commercial Cottonseed Varietis and Composite Cottonseed

	Varieties							*Composites*						
	S71	S73	S77	Mean	±	SD	CV%	CSF	CSK	CSM	Mean	±	SD	CV%
Free gossypol (%)	1.18	1.14	1.28	1.20	±	0.07	6.01	1.26	1.34	1.20	1.27	±	0.07	5.53
Total gossypol (%)	1.21	1.25	1.59	1.35	±	0.21	15.47	1.34	1.51	1.35	1.40	±	0.10	6.81
Tannins (mg/100g)	26.25	27.00	38.50	30.58	±	6.87	22.45	33.25	38.50	37.75	36.50	±	2.84	7.78
Phytin (%)	0.56	0.62	0.61	0.60	±	0.03	5.36	0.55	0.58	0.58	0.57	±	0.02	3.04
Phytin phosphorus (%)	0.16	0.18	0.17	0.17	±	0.01	5.88	0.16	0.16	0.16	0.16	±	0	0
Phytin phosphorus (%) of total phosphorus)	13.13	14.83	12.04	12.67	±	1.43	15.22	12.92	15.14	10.38	12.81	±	2.38	18.59

tonseed. Average values of free gossypol ranged from 1.14% for S72 to 1.28% for S77, that latter value was one standard deviation above the varietal mean of 1.20%. Total gossypol value of 1.59% for S77 was considerably higher than the 1.21% and 1.25% obtained for S71 and S72 varieties respectively. Generally higher values of both free and total gossypol were obtained in the composite than in the varieties of cottonseed. Among the composite seed of the various locations, higher levels of both forms of gossypol were found in CSK seed while identical levels were obtained in CSF and CSM. These varietal and locational variations in gossypol content of Nigerian cottonseed are consistent with previous findings. Stansbury *et al* (1956) reported a wide range in free gossypol content of 8 commercial cottonseed varieties in the United States, and concluded that both variety of seed and environment had a highly significant influence on the gossypol content of cottonseed kernels. Others (Pons *et al.*, 1953; Frampton *et al.*, 1960) have similarly found that the factors of variety of seed and environment both influenced the gossypol content of cottonseed. Variability in gossypol content of cottonseed has been attributed to genetical characteristics (Goldovskii, 1956). In fact, according to Berardi and Goldblatt (1969), nearly all the factors which tend to influence the content of gossypol pigments in cottonseed belong to one of two principal factors namely, inherent genetic and environmental. The locational variability may be consequential to the fact (Pons *et al.*, 1953) that gossypol content in cottonseed is positively correlated with rainfall and negatively correlated with temperature.

Inter-species differences in gossypol content of cottonseed also exist. Boatner *et al* (1949) have reported that the seed of *G. barbadense L.* contain more gossypol than the seed of *G. hirsutum L.;* and within the *G. barbadense* species, the seed of the Sea Island contains more gossypol than the Egyptian seed. The Nigerian varieties are hybrids of the staple types of *G. hirsutum* and local material (Faulkner, 1974).

The data reported in the present investigation indicate that 80 to 98% of the

gossypol in cottonseed kernels exists in the free state, the finding which also agrees with previous reports by Pons *et al* (1953) and Stansbury *et al* (1956).

Average free gossypol levels of 0.050, 0.039, 0.041 and 0.028% were obtained for KSOAP, FCCC, GuOM and GOSP meals respectively (Table 2). These values indicate that 96 to 98% of the free gossypol contained in cottonseed kernels was bound to other seed components and, or was destroyed during seed processing. One of the objectives during the processing of cottonseed is to bind free gossypol pigments in the meal so that they are not extracted in the oil since gossypol complicates oil refining (Thurber *et al.*, 1954); Berardi and Frampton, 1957). During the cooking of cottonseed kernels in order to "loosen" the oil for easy extraction, free gossypol combines with the *epsilon*amino groups of lysine to form insoluble complexes. The magnitude of this reaction is directly related to the temperature and length of cooking period, and to the amount of moisture in contact with the kernels (King *et al.*, 1962). The reaction is also dependent upon the pH of the medium (Lyman *et al.*, 1959) and is further complicated by the presence of carbohydrates and phospholipids (Martinez *et al.*, 1967). Processing conditions therefore are primary determinants of the free gossypol content of cottonseed

TABLE 2

Anti-Nutritional Components in Nigerian Cottonseed Meals

	KSOAP Kano	*FCCC Funtua*	*GuOM Gusau*	*GOSP* Gombe*
Free gossypol (%)				
Mean ± SD	0.05 ± 0.02	0.038 ± 0.01	0.041 ± 0.02	0.029
Range	0.035 — 0.064	0.028 — 0.047	0.028 — 0.054	
CV %	41.01	35.36	44.84	
Total gossypol (%)				
Mean ± SD	0.789 ± 0.06	0.572 ± 0.02	0.564 ± 0.001	0.623
Range	0.747 — 0.831	0.413 — 0.697	0.564 — 0.564	
CV %	7.53	35.11	0.13	
Tannins (mg/100g)				
Mean ± SD	3.69 ± 0.79	5.75 ± 1.41	3.32 ± 0.26	3.50
Range	3.13 — 4.25	4.75 — 6.75	3.13 — 3.50	
CV %	31.46	24.60	7.88	
Phytin (%)				
Mean ± SD	0.74 ± 0.007	0.57 ± 0.01	0.62 ± 0.02	0.72
Range	0.73 — 0.74	0.56 — 0.58	0.60 — 0.63	
CV %	0.96	2.48	3.42	
Phytin phophorus (%)				
Mean ± SD	0.21	0.61	0.18 ± 0.007	0.20
Range	0.21 — 0.21	0.16 — 0.16	0.17 — 0.18	
CV %	—	—	3.93	
Phytin phosphorus (% total P)				
Mean ± SD	16.37 ± 0.39	13.17 ± 1.95	16.41 ± 1.20	17.06
Range	16.09 — 16.64	11.79 — 14.55	15.56 — 17.25	
CV %	2.38	14.82	7.28	

*Only one batch sample was collected from this source.

meals, and would tend to form the basis for explaining the variability in free gossypol analysed in the four Nigerian cottonseed meals.

The average values of total gossypol ranged from 0.564% for GuOM to 0.789% for KSOAP meals, indicating that a portion of the total gossypol may have been lost during seed processing. Such losses are to be expected since a small portion of gossypol usually gets extracted in the crude cottonseed oil, while a quantity is also destroyed during processing especially for hydraulic or screw-processed seed (Pons *et al.*, 1953).

The tannin content of Nigerian cottonseed varieties ranged from 26.25mg/100g for S71 to 38.50mg/100g. Within the composite seed, CSK contained a higher tannin level than either CSF or CSM seed, and the overall locational composite seed average value of 36.50mg/100g was appreciably higher than the varietal average tannin value. These data show a similarity of occurence in cottonseed kernels between tannins and gossypol and would tend to suggest the probability that the varietal and environmental factors influence the tannin content of cottonseed in a similar manner as they affect the gossypol content.

The levels of tannins which were analysed in cottonseed meals were considerably lower than those obtained in the seed kernels, indicating processing influence. Tannins are known to react with proteins to form insoluble tannin-protein complexes (Swain, 1965; Jambunathan and Mertz, 1973). Athough the mechanism of this reaction is not readily definable, it is likely to occur during certain stages in the processing of cottonseed. It is also likely that the same processing conditions that influence the gossypol content of cottonseed meal may influence the tannin content similarly since both anti-nutritional factors are polyphenolic compounds.

Phytin and phytin phosphorus content of the cottonseed samples being assayed did not vary appreciably according to variety or location of seed. Contrary to this finding, Stansbury *et al* (1953) reported highly significant influence of environmental, but not varietal factors, on phytin phosphorus content of cottonseed kernels. These workers reported a wide range (0.43 to 1.07%) of phytin in cottonseed. The phytin levels obtained in Nigerian cottonseed lie within this range, however the mean value of 2.49% which Wozenski and Woodburn (1975) reported in cottonseed appears to be considerably higher than either the values in Nigerian seed or the range reported by Stansbury *et al* (1953).

Unlike gossypol and tannins, the levels of phytin and phytin phosphorus were not reduced in cottonseed meals, suggesting that processing of seed does not affect these components, at least not in the same way as gossypol and tannins are affected. If anything the levels of both phytin and phytin phosphorus were some-what elevated especially in KSOAP and GOSP meals. However, the values reported in the meals being investigated appeared to be generally low when compared with values reported by other workers in cottonseed meals.

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