causes were examined for any presence of aflatoxins. Results from this study will be reported elsewhere.

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Nutritive Assessment of Guar Oil (*Cyanopsis tetra conoloba* L. Taub)

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It has been reported that guar seed meal contains a high proportion of protein (45–55%) and lipid (5–7%). It has also been reported that the guar lipid profile is very comparable with that of the popular edible oils. The feeding trials with guar oil were carried on the rats, and the accumulation of total lipid in liver, heart, and blood was compared with that of mustard oil and groundnut oil fed rats. It was observed that the guar oil fed rats developed a fatty liver. Moreover, this oil has a atherogenic effect on the heart. These results indicated the guar oil should not be recommended for the human consumption.

In recent years the production of guar meal has increased considerably, since it is the main source of gum. Presently utilization of guar seed meal is 0.6 ton and expected to be more, as the demand for guar gum in the world market has increased. It has been reported that guar seed meal contains a high proportion of protein (45–55%) and lipids (5–7%). It has been shown that the guar lipid profile is comparable with that of popular edible oils. Singh and Misra (1981) have recommended the guar oil for human consumption after carrying out nutritional trials. In the present paper the nutritive aspect of guar oil was studied on rats, after feeding them guar oil diets, their lipid content in liver, heart, and blood was examined, and the results, were compared with those from rats maintained on mustard and groundnut oil diets. The rats maintained on groundnut oil diets were treated as controls.

EXPERIMENTAL SECTION

Albino male rats of 3–4 months old were divided into three groups. One group was maintained on a guar oil diet and the other two were maintained on groundnut and mustard oil diets, respectively.

Preparation of Guar Oil. Guar oil was prepared according to the method described by Kartha and Sethi (1957), as follows. The sun-dried guar seed meal was first ground with the help of a mill, 100 g of powdered guar seed meal was mixed with 10 g of clean glass powder and 20 g of anhydrous sodium sulfate in a glass mortor, and the mixture was further ground to a fine powder. The entire powdered meal was transferred to a glass percolator (30 cm × 5 cm in diameter) fixed to a wooden stand containing 10 g of anhydrous sodium sulfate with a cotton plug at the bottom. Again a cotton plug over the guar meal powder in the percolator was placed and above that sodium sulfate was layered. The entire column was extracted with petroleum ether (40–60 °C). The oil extracted in this way was collected in a weighted conical flask. Approximately 200 mL of petroleum ether was used for one extraction. The ether was distilled off, and the oil in the flask was weighed to a constant weight by evaporating the last traces of solvent on a water bath.

The market samples of mustard oil and groundnut oil were dissolved in petroleum ether solvent and passed through the column of sodium sulfate and glass powder. The solvent was distilled off and the remaining oil was used for the experimental purpose.

One kilogram of diet contained wheat (800 g), oil (100 g), USP XVII salt mixture (40 g), vitaminous starch (10 g), and starch (50 g). Vitaminous starch was prepared according to the procedure described by Mamma and Hauge (1953).

The USP XVII salt mixture was prepared by grinding 439.3 g of NaCl (from 1 kg of NaCl) with 0.79 g of KI. Similarly, the remaining NaCl was ground together with $K_2H_2PO_4$ (389.0 g), $MgSO_4 \cdot 7H_2O$ (57.3 g), $CaCO_3$ (381.4 g), $FeSO_4 \cdot 7H_2O$ (27.0 g), $MnSO_4 \cdot H_2O$ (4.01 g), $ZnSO_4$ (0.518 g), $CuSO_4 \cdot 5H_2O$ (0.4777 g), and $CoCl2 \cdot 6H_2 \cdot 6H_2O$ (0.023 g). This mixture was mixed with the KI mixture, and then the entire mixture was reduced to a fine powder and was stored in a cool and dry place for further use.

The groundnut oil used was of Postman brand and mustard oil used was of Kanodia brand, procured from the local market.

Previously weighed male albino rats of three groups were maintained on guar oil, groundnut oil, and mustared oil feed for a period of 28 days. Water was provided ad libitum and periodic weights of the rats were noted.

The rats were sacrificed by guillotine after 28 days of the experiment. The blood was collected, the liver and the heart were removed, weighed, and immediately immersed in a chloroform–methanol (2:1 v/v) mixture, the serum was separated from the blood, and a known amount of serum was transferred to the tubes containing the chloroform–

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Table I. Fatty Acid Composition (Percent) of Oil from Groundnut Oil, Mustard, Oil, and Guar Oil

source of oil	fatty acid composition, %, of oil[a]									
	C14	C16	C18	C18:1	C18:2	C18:3	C20	C20:1	C22	C24
groundnut oil	0.5	8.0	4.4	53.0	26.3		2.4		3.1	1.1
mustard oil	0.4	1.5	3.0	22.0	14.2	6.0	7.0	44.2	<0.5	<0.5
guar oil	tr	17.9	5.8	29.0	47.2	nil				

[a] C represents chain length; tr represents trace amount.

Table II. Protein Intake, Weight Gain, and Protein Efficiency Ratio (PER) in Rats Maintained on Different Oil Diets for 28 Days[a]

sample no.	source of oil	protein intake, g, during 28 days	wt gain, g, during 28 days	PER
1	groundnut	9.59 ± 0.43 (5)	12.88 ± 1.10 (5)	0.76 ± 0.05 (5)
2	mustard	11.06 ± 1.14 (6); $p < 0.05$	15.12 ± 1.23 (6); NS	0.74 ± 0.05 (6); NS
3	guar	12.24 ± 0.97 (4); $p < 0.05$	16.88 ± 0.87 (4); $p < 0.22$	0.66 ± 0.01 (4); NS

[a] Values represent mean ± SE, and numbers in parentheses indicate the animals used in each experiment. Rats fed with the groundnut oil diet have been treated as the control. p denotes the level of significance, and NS means nonsignificant.

Table III. Total Lipid Content of Liver, Heart, and Blood in Rats Maintained on Different Oil Diets for 28 Days[a]

sample no.	source of oil	lipid content in liver, mg/g wet wt of liver	lipid content in heart, mg/g wet wt of heart	lipid content of blood, mg/100 mL of blood
1	groundnut	162.10 ± 19.03 (5)	51.19 ± 5.51 (5)	626.00 ± 135.00 (5)
2	mustard	130.06 ± 11.02 (6); NS	72.66 ± 1.96 (6); $p < 0.02$	610.00 ± 62.0 (6); NS
3	guar	388.66 ± 89.52 (4); $p < 0.05$	292.53 ± 83.11 (4); $p < 0.05$	544.00 ± 44.00 (4); NS

[a] Values represent mean ± SE and numbers in parentheses indicate the animals used in each experiment. Rats fed with the groundnut oil diet have been treated as the control. p denotes the level of significance, and NS means nonsignificant.

methenol mixture (2:1 v/v).

Lipids from the heart, liver, and blood serum were extracted by using the method described by Folch et al. (1957). Lipids thus extracted were dissolved in a known amount of chloroform, and suitable aliquots were transferred in the previously weighed planchets. These lipid-containing planchets were dried under infrared light at 55 °C. These planchets were then cooled and weighed. This procedure was repeated until a constant weight was obtained.

RESULTS AND DISCUSSION

Table I shows the fatty acid composition of all the three oils used in the experiment. It was observed that mustard oil fed rats gained weight, though not significant, but weight gained by rats fed with the guar oil diet was significant as compared to that of the rats maintained on the groundnut oil diet. It appears that guar oil fed rats followed the growth pattern like that of mustard oil fed rats. The protein intake in rats fed on the mustard oil and guar oil diet was marginally increased as compared to that in rats maintained on the groundnut oil diet (Table II). However, PER in all the rats fed with three different oil diets remained unchanged because, for all groups of rats, the protein source fed was the common, i.e., the protein content of wheat.

The liver plays a central role in regulating lipid metabolism. the liver has an active enzyme system for synthesizing and oxidizing free fatty acids and for synthesizing triglyserides, phospholipids, cholesterol, and lipoproteins. Table III shows the lipid content of liver of rats fed on different oil diets. There was a significant accumulation of lipid in the liver of rats fed with the guar oil diet as compared to the rats fed with the groundnut oil diet. There was no accumulation of lipids in liver of the mustard oil fed rats. Such extensive accumulation of lipid in the liver of guar oil fed rats is regarded as a pathogenic condition, which in turn may cause liver damage and impair the liver function. It can be concluded that guar oil caused the development of a fatty liver. This was further supported by the fact that guar oil fed rats had a significant liver enlargement as compared to the groundnut oil fed rats, when the results were expressed as liver weight/body weight ratio (Table IV). The total lipid content of the blood was not significantly altered in the guar oil fed rats as well as the mustard oil fed rats (Table III). It seems that guar oil contained some toxic substances that cannot be removed in the process of extraction of oil from guar seed meal. These toxic substances could be responsible for the production of fatty liver; hence, it needs further investigation.

Table IV. Liver Weight to Body Weight Ratio in Rats Maintained on Different Oil Diets for 28 Days[a]

sample no.	source of oil	liver weight/body weight ratio
1	groundnut	0.02942 ± 0.00128 (5)
2	mustard	0.03296 ± 0.00097 (6); $p < 0.02$
3	guar	0.03998 ± 0.00320 (4); $p < 0.02$

[a] Values represent mean ± SE and numbers in parentheses indicate the animals used in each experiment. Rats fed with the ground nut oil diet have been treated as the control. p denotes the level of significance.

In the present investigation, the circulatory lipids were not significantly altered in the guar as well as mustard oil fed rats as compared to those in the groundnut oil fed rats (Table III). Since studies were performed for a short duration (28 days), the elevation of blood lipid was not noticeable. But under the circumstances of the high lipid content of liver, in guar oil fed rats, the circulating lipid level is sure to rise in due course, and even a modest elevation of blood lipid over many years could be a major contributing factor to the development of heart disease and diabetes (Simpson et al., 1980). There was a significant accumulation of lipids in the heart of guar oil and mustard oil fed rats. In the present investigation it was observed that the circulating lipids of guar oil and mustard oil fed rats had more of a tendency to get deposited in the heart, which suggested that circulating lipids in these two oils fed rats could be more saturated fatty acids containing

lipids. Kobayashi and Kanoh (1979) have reported that there is a marked increase in the deposition of fat in the heart with more circulating saturated fatty acids. The present study clearly indicates that feeding guar oil to rats leads to the development of atherorosclerosis.

During the present study it was observed that guar oil feeding caused the high fat deposition leading to liver enlargement that could be due to the presence of some toxic substances. The circulating lipids in guar oil fed rats had an accumulation in the heart, suggesting the development of atherosclerosis. Hence, the guar oil cannot be recommended for human consumption.

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Improving the Biological Value of Guar Meal by Detoxification

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Guar seed meal is a byproduct of guar gum industry. It contains 45–55% of proteins along with several toxic substances like polyphenols, lignins, trypsin inhibitor, and saponins. It also contains some foul-smelling substances like organic acids, aldehydes, and cyanogens. The presence of the above toxic substances and foul-smelling compounds lowers the nutritive value of guar meal. Several solvent systems were tried for the detoxification of raw meal so as to make it good for consumption and to improve its biological value. Among several extracting systems, ethanol–HCl (100:1 v/v) was found to be suitable for removing most of the above toxic and foul-smelling components. The nutritional studies carried out on rats with such detoxified meal showed significant improvement in the biological value of the meal.

Guar seed meal, a byproduct of guar gum industry, contains 45–55% protein (Subramanian and Parpia, 1975) and 7% oil (Singh and Misra, 1980). A large portion of this meal remains unutilized owing to the presence of several toxic substances like polyphenols, lignins (Bajaj et al., 1978), trypsin inhibitor (Sumathi and Pattabiraman, 1976; Couch et al., 1966, 1967) and saponins (Arora and Joshi, 1980; Coxon and Wells, 1980) as well as some foul-smelling components, possibly organic acids, aldehydes, and cyanogens (Harborne, 1967). Presently 0.6 million ton of guar meal is available annually in India alone, and in years to come, the production is expected to be fairly high because of enormous demand of guar gum in world markets. Ingestion of guar meal is reported to have caused anorexia, diarrhoea, and decreased milk production in cattle (*Natl. Dairy Res. Inst.*, 1960). Lower feed efficiency and depression in growth (Sathe and Bose, 1962) and mortality in animals (Kawatra et al., 1969) have been described as symptoms of guar meal toxicity. Attempts made for the detoxification of meal, earlier, have not been proven beneficial (Subramanian and Parpia, 1975). Toasted guar meal, however, has been reported to be a suitable replacement for up to half of the peanut cake as an ingredient poultry feed (Brahma and Siddiqui, 1978). This limited use of the meal will not keep pace with the increased production of guar. In the present paper the details of a procedure for the detoxification of guar meal and the improvement in the biological value are described.

EXPERIMENTAL SECTION

Guar seed meal was purchased from a stockist (Delhi area) of guar gum industry in two lots. Endosperm splits were removed by sieving and finally by hand picking. Both the lots were mixed, ground to 80 mesh, and made moisture free. Lipids were extracted with ether by using the Soxhlet extraction procedure. The meal cake was dried and used for further experiments.

In order to arrive at a conclusion for the choice of an efficient detoxification method as finally applied on the meal, several other solvent(s)/extracting mediums were tried on a small quantity of the material. The main emphasis, during the course of these experiments, was placed on the minimum loss of the solids with concomitant removal of foul-smelling components. Since the condensed tannins contribute maximum to the toxic principle of guar, it was of interest to estimate them in the raw meal as well as in the processed meal. The tannins were estimated following the method of Burns (1971).

Extraction with Water. One-hundred grams of defatted guar meal flour was stirred with 400 mL of water in a Waring blender for 2 h at 1000 rpm. The contents were centrifuged at 4000 rpm for 15 min. The process was repeated 3 times for 1 h each. The residue was dried at 100 °C for 6 h. The water treatment failed to remove the foul smell but caused a loss of solids to the extent of 28%. It was able to remove tannins only to the extent of 32%.

Extraction with 70% Ethanol, Methanol, Ethanol, and Ethanol–HCl (100:1 v/v). Defatted guar meal was treated with these solvent systems, separately, following the procedure as described under Extraction with Water. Finally, the resultant cake was dried at 100 °C in the case of 70% ethanol and 60 °C in the other cases for 6 h. The estimated loss in flour weight was 30%, 9%, 6.5%, and 7.8%, respectively. To a certain extent, even after extraction, the foul smell persisted in all the dried residues except the one obtained after the ethanol–HCl solvent system. The removal of the condensed tannins, by the

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