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STUDIES ON DESIGNING A PILOT PLANT FOR THE PRODUCTION OF DETOXIFIED GUAR MEAL AND GUAR GUM FROM GUAR SEEDS (*C. PSORALIOIDES*): PHYSICO-CHEMICAL CONSTANTS

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Guar gum and guar meal produced by five industrial concenrs of Pakistan, from guar seeds goes waste due to presence of toxic substance saponin that makes it unfit for human/animal use. The experiments conducted on the extraction of gum and detoxified guar meal were on a small laboratory scale. In the present study some useful parameters. for designing and fabrication of pilot plant have been investigaged fo large scale production of guar gum and detoxified guar meal for human consumption.

Key words: Detoxified guar meal and guar gum.

INTRODUCTION

Guar is botanically known as *Cyamopsis psoralioides.* Annual production of guar seeds in Pakistan is about 250,000 tons [1]. The guar plant is adaptable for semi-arid regions [2]. Guar seeds contain gum, chemically known as galactomannan.

Guar is used in mining, cosmetics, Pharmaceuticals, oil drilling, printing, textile sizing, paper manufacturing, butter soap making, milk, food and cheese industries [3,4,5].

In Pakistan guar gum from guar seeds is made by five manufacturing concerns in Karachi and Nawabshah, based on foreign formula. The residue know as guar meal is a by product and contains about 45% protein. The guar meal protein contains toxicity [6] and detoxification enhances it nutritional qualities [7]. In a process [8] developed by the Karachi Laboratories of PCSIR, guar gum and detoxified guar meal flour can be produced simultaneoulsy from guar seeds.

In view of the commercial importance of the process, it was through important to plan a large scale production unit of guar gum and detoxified guar protein flour [9]

EXPERIMENTAL

Equipments. (a) Vibrating screen; (b) Dehuller; (c) Ball grinder; (d) Washing tanks; (e) Acid treatment vessel.

For an affective design and fabrication of pilot plant production units of guar gum and the detoxified guar protein flour, the physico-chemical data helpful for engineers have been collected for fabrication of the pilot plant

Procedure

(a) *Preparation of gum.* (1). Separating the impurities from the seeds. (2) Subjecting the seeds to a process of differential grinding. (3) Separating the kernel (meal) from the gum splits. (4) Grinding the gum splits to a 100 mesh size (0, 150 mm) to get crude guar gum.

(b) *Preparation of detoxified guar meal.* The guar meal obtained as at a-3, is subjected to washing (3 times) at 60^{O} for 30 minutes. (with solid to water w/v ratio 1:8) heating the washed material at pH 3 at 100^{O} for 60 minutes, subsequently adjusting the pH to neutral by washing, finally drying the wet material by hot air blowing upto 5% moisture, to get detoxified guar protein flour (30 mesh). Table 3 indicates the chemical composition.

RESULTS AND DISCUSSIONS

In order to assess the toxicity in the treated guar meal, experimental rats were fed in the Laboratories on the detoxified meal at 20% protein level in a semi-ayathetic diet for a period of 31 days. There were no deaths amongst the group of rats which were fed on the test diet while the whole group fed on raw guar meal diet within a period of 11 days. The initial and final weights of the animals were as follows:-

Initial weight per rat fed on.

Detoxified meal	=	44 g
Final weight per rat	=	83 g
Wt. gain per rat	=	39 g

However a rapid chemical test can be done for the quantitative determination of saponin in a product of a production plant [10].

Since the process developed by PCSIR Karachi Laboratories for the production of guar gum and detoxified guar

meal was used only on laboratory scale. It was thought important to run this process on pilot plant scale.

For designing and fabricating pilot plant operational units for the production of guar gum and detoxified guar meal from guar seeds; some important and effective parameters have been studied and necessary data was collected.

1. Builk density of guar seed and its allied product (Table 1).

Table 1. Bulk denisty and mesh analysis of guar seed whole and crushed.

Ingredients	Density g/cm^3	Sieve no.	Retained (%)	Passed through (%)
Guar seed (commercial with foreign matter)	0.80	–	–	–
Guar seed (commercial without foreign matter)	0.81	No. 4 (4.75 mm)	–	100
		No. 6 (3.35 mm)	28	72
		No. 8 (2.388 mm)	72	–
Crushed guar seeds (meal and split combined)	0.61	No. 10 (2.000 mm)	40	60
		No. 20 (0.850 mm)	34.5	25.5
		No. 30 (0.600 mm)	14.2	11.3
Guar gum splits (crude)	0.67	–	–	–
Guar meal (crude)	0.66	–	–	–
Guar meal (detoxified)	0.57	–	–	–

2. Size range analysis of guar seeds, gum splits and kernel for the purpose of effective designing of vibrating screens other equipment like dehuller, ball grinder (temperature controlled). (Table 1).

3. Solid to water ratio required during the washing process for detoxification. Temperature in washing tanks, duration of washing, RPM of the agitator during washing and time of filtration of each washing. Viscosity and density of washings of crude guar meal (Table 2).

4. Volume increase during soaking or washing of the guar meal (Table 2).

5. Material balance of guar seeds, kernel and splits (Table 3).

6. Solubility of gum present in residual form in the meal and water extract of meal during detoxification process and chemical composition of detoxified guar meal product (Table 3).

For determining the exact mesh size of guar seed, standard endocot sieves (UK), were used. In the first instance sieves No. 4, 6 and 8 mesh, were used in sequence. (Table 1) shows that guar seeds, as such could pass 100% through mesh No. 4 while mesh No. 6 retained 28% and mesh No. 8 retained more than 70% of seeds Therefore, it may be concluded that the size of guar seed is about 4 mesh (or 4.75 mm).

For an effective separation of gum splits and seed kernel from guar seed a QUADROMAT Brabender Junior mill: DUISBURG and endocot standard test sieves UK were used. The crushed material from the mill was subjected to a sieving process. The material retained on 10 mesh sieve was found to be mostly gum splits containing more than 80% gum (Table 1) whereas the material retained on 20 mesh sieve, consists of mostly kernel, which is called guar meal, rich in protein. A toxic material saponin [11] (15%) is found in the kernel fraction which renders the meal unfit for consumption even as cattle feed.

Table 2. Description of washing and soaking of guar meal (crude).

No. of washing at 60° meal/water 1:8 (w/v)	Density at (28°)	Viscosity (28°C)	Rate of filteration with (Coarse cloth)	Effect on volume during saoking	
				Solid increase	Liquid increase
1st wash	1.01	2.30	1.98 sec/100 ml	363.0% Vol	8.0% Vol
IInd wash	1.00	1.50	2.0 sec/100 ml	300.0% "	28.0% "
IIIrd wash	1.00	1.36	1.33 sec/100 ml	294.0% "	28.0% "

Table 3. Material balance and chemical composition of various fractions obtained from guar seeds.

Parameters	Seeds (1000G)	Kernel (600 g) (60%)	Splits (400 g) (40%)	Detoxified guar meal (%)
1. Moisutre at 105°C	90.9 (9.1%)	49.92 (8.3%)	38.96 (9.7%)	5.86
2. Protein (ex 6.25)	276.1 (27.6%)	247.5 (41.3%)	33.36 (8.3%)	47.05
3. Fat ($CHCl_3$ extracted)	38.5 (3.8%)	33.12 (5.5%)	5.44 (1.4%)	8.09
4. Ash at 600°C	33.3 (3.3%)	26.28 (4.4%)	6.48 (1.6%)	1.18
5. N-free extract	462.2 (46.2%)	147.18 (14.7%)	311.76 (31.2%)	28.11
6. Fibre	99.0 (9.9%)	96.0 (16.0%)	4.0 (1.0%)	9.71

Kernel could pass through mesh No. 10 and the 40% material which consisted of mostly gum splits, was retained in the sieve. However, the 60% material (kernel) was further subjected to sieving and concluded that the particle size of the crushed material was between 20 and 30 mesh. (Table 1).

The bulk density of guar meal before and after the application of detoxification was determined and results are given (Tabel 1) Similarly material balance in respect of guar seeds, kernel and gum splits were estimated and total chemical, composition such as protein, moisture, fat, ash, fibre and nitrogen free extract determined for estimation of the material balance (Table 3). Insignificant difference was noticed in respect of almost all chemical components with the help of the above acquired data, and effective pilot plant for the simultaneous production of guar gum and detoxified guar meal from guar seeds could be designed and fabricated.

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