*Processing of Prepressed Solvent Extracted Oil from Indian Soybean-Refining Loss Studies

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ABSTRACT

Degumming of soybean oil considerably reduces the free fatty acid (FFA) content of the oil. Lowering of refining loss when oil is degummed prior to caustic treatment is attributed to this reduction in FFA and the excess carry over of neutral oil, because gums are excellent emulsifiers. Pretreatment of solvent extracted soybean oil with phosphoric acid followed by water degumming and caustic refining results in a lower refining loss and considerable reduction in caustic requirement in comparison to the conventional process based on water degumming followed by gum conditioning with phosphoric acid and caustic refining. The process gives sharp and fast separation of gums from the oil.

INTRODUCTION

A considerable quantity of solvent extracted soybean oil is being produced in India today, from extraction of soybeans as well as expeller cake. This production is increasing every year and is expected to reach 120,000 metric tons (MT) in 1985. With this increased production of soybean oil in India a better method for refining of solvent extracted soybean oil is desired.

Crude oil from solvent extraction plants contains variable amounts of non-glyceride impurities such as free fatty acids, color and pigment bodies, moisture and some amount of suspended impurities, mainly soybean particles and phosphatides. Most of these impurities are undesirable in the finished products and need to be removed.

In the first phase of oil processing the suspended impurities are removed by filtration. Phosphatides are known to be excellent emulsifying agents and cause a high refining loss due to carry over of neutral oil with gums/soapstock. Hence, removal of phosphatides before caustic refining is of the utmost importance. Phosphatides in their hydrated form separate out from the oil and are removed as gums by gravity or centrifugal separation. Lower refining loss when oil is degummed prior to alkali treatment is reported in literature (1-3). Use of various degumming agents such as water, phosphoric acid, citric acid, acetic anhydride, boric acid, etc., has been reported in the literature (4). The most commonly followed method of degumming is water/steam treatment of oil to remove hydratable phosphatides. The water degummed oil is then either refined directly with caustic or treated with 0.05-0.2% phosphoric acid prior to caustic refining. In the latter case, phosphoric acid helps convert non-hydratable phosphatides into hydratable phosphatides. In the recently developed physical refining processes for soybean oil, acid degumming is preferred over water/steam degumming. In this acid degumming process acid treatment of oil is followed by water degumming. Oil is then bleached and physically refined (1-6).

The present work has been carried out to investigate possible reasons, apart from the well known emulsification, for lower refining loss when water degummed oil is subjected to caustic refining. It also is intended to examine the possibility of using the phosphoric acid degumming method prior to caustic treatment to reduce the refining loss to a minimum level in the case of prepressed solvent extracted soybean oil. In these studies filtered oil is pretreated with a known quantity of phosphoric acid at a particular temperature, followed by water degumming and conventional caustic refining.

In the conventional method, i.e., water degumming and phosphoric acid treatment, followed by caustic refining, additional amount of caustic is required due to treatment with phosphoric acid after water degumming step. In the acid degumming process the caustic consumption will be reduced as the phosphoric acid added in the first step is removed during water degumming prior to caustic refining. The gums obtained in the acid degumming process are reported to be darker and hence produce inferior quality lecithin (4). In India, most of the soybean gums are not used for producing lecithin, but for soapstock. Under these circumstances, it is worthwhile to examine the acid degumming process and its effect on the caustic refining step.

EXPERIMENTAL

Materials

Filtered soybean oil was taken from expeller cake processing solvent extraction plant of 150 tons/day capacity, Troika make. In general, there was no specific control of the quality and quantity of lecithin extracted by the solvent hexane along with oil. The residual oil in the meal was controlled between 0.6-0.8%. Distilled water was used throughout the experimental work. The phosphoric acid used was of 85% concentration and reagent grade. The caustic soda used was reagent grade. FFA and phosphatide content of the oil samples were estimated by standard procedures (7, 8). Batch process was used throughout the experimental work. Loss was obtained by weighing the oil before and after the treatments. As a preliminary step, for confirmation of subsequent experimental work, crude oil and oil obtained at each processing step were analyzed to work out complete material balance for the free fatty acids in the oil. This indicated that an average of 98% of the free fatty acids could be accounted for in various fractions, for example, degummed oil, gums and acetone soluble and insoluble fractions of gums obtained from crude oil. This ascertained the reliability of the experimental work. All experiments were conducted in duplicate, and average values of the results are reported in this paper.

PROCEDURES

Conventional Process (Process 1)

Four kg filtered, crude solvent soybean oil was heated to 65-75 C; 100 ml hot water was then added to the oil under stirring and the mixture was stirred for 30 min at 65-75 C to hydrate the phosphatides. The hydrated phosphatides were separated from the oil by settling and filtration. A known quantity of water degummed oil was treated with phosphoric acid (0.2% on the weight of the oil) at 75-85 C for 30 min under stirring. Then a calculated quantity of 16° Be caustic solution (including 15% excess on FFA) was slowly added to the oil with low speed stirring. The mixture was stirred for 10 min and allowed to settle. The oil was decanted to remove soapstock and washed with hot water at 90-95 C (15% on weight of the oil) repeatedly until soap content was less than 100 ppm. Washed oil was dried at 90 C under 150 mm Hg pressure and weighed to calculate the refining loss.

Acid Degumming-Caustic Refining Process (Process 2)

Four kg filtered oil was heated to 75-85 C and mixed with

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[1] This work was completed while the authors were with the Mansingka Research Centre, Pachora, India.

0.2% phosphoric acid, under stirring, based on the weight of the oil, and stirring was continued further. After 30 min, 100 ml water at 65-75 C was added and the mixture was stirred 30 min longer and allowed to settle. The gums were removed by filtration. Filtered oil was then treated with 16° Be caustic solution as usual, soapstock was separated and the oil was washed and dried as given in Process 1.

RESULTS AND DISCUSSION

Soybean oil obtained from extraction of expeller cake contains more phosphatides than soybean oil obtained from extraction of full soybeans. Normally soybean oil extracted from soybeans contains 2-3% phosphatides. When the oil seed (18-22% oil) is prepressed in expeller to recover oil, the majority of the phosphatides remain in the oil cake. These phosphatides in the cake come along with 6-7% oil recovered in the solvent extraction step. One can expect such solvent extracted oil to have 5-6% phosphatides.

It is well known that the degumming of oil with water/acid reduces the overall refining loss. This reduction in refining loss is attributed mainly to the removal of phosphatides from the oil prior to caustic refining. Phosphatides have excellent emulsifying characteristics and cause carry over of large quantities of neutral oil in the soapstock. However, in the present investigation it was found that the reduction in refining loss by following the degumming step prior to caustic refining is due not only to the emulsifying nature of gums but also to the reduced FFA content of the degummed oil. As there is a direct correlation between FFA and loss, this reasoning for the reduction in loss on refining of degummed oil is justifiable. The reduction in FFA probably is due to the affinity of FFA's to phosphatides, which causes gums to carry some amount of FFA during settling. As is seen from Table I, in different sets of experiments on water degumming of solvent soybean oil, FFA contents of oil are reduced by 0.25-0.8% on degumming. It was checked in the present investigation that this reduction in acidity on degumming of oil is not due to the acidity of the gums but for the most part to free fatty acids.

Processing Loss Data

In view of the above, it is obvious that the phosphatides should be removed to the maximum extent before caustic treatment of the oil. In the conventional process oil after degumming with water still contains non-hydratable phosphatides. These need to be removed, particularly when the oil subsequently is to be processed by a physical refining method or subjected to hydrogenation. This requires treatment of oil with phosphoric acid to convert non-hydratable phosphatides to hydratable phosphatides. These converted phosphatides are removed during subsequent caustic refining of the oil. In the present studies, we have given phosphoric acid treatment to the oil prior to water degumming. The logic behind this is that phosphoric acid treatment converts the non-hydratable phosphatides to hydratable phosphatides. On the addition of water, the maximum amount of phosphatides of different nature are removed from the oil. Water also dissolves the added phosphoric acid from the oil and settles along with gums. Thus, addition of water after phosphoric acid treatment to the oil gives an additional advantage of reducing the alkali consumption needed for caustic refining. As is clear from Table I, FFA is reduced to a considerable extent in case of Process 2 also, but this reduction is slightly less than that obtained in Process 1. This probably is due to the small amount of phosphoric acid retained by the oil. This also may be possible in case the gums are not properly settled.

Though there is considerable reduction in the consumption of caustic in Process 2, there is a little increase in the

TABLE I

Processing Loss Data[a]

Lot no.	FFA of crude oil (%)	Phosphatide content (%)	FFA after degumming (%)		Reduction of FFA (%)		Degumming loss (%)		Loss in caustic refining (%)		Refining factor for caustic refining		Total loss (%)		Reduction in refining loss (Process 1) – (Process 2) (%)
			Process 1	Process 2	Process 1	Process 2	Process 1	Process 2	Process 1	Process 2	Process 1	Process 2	Process 1	Process 2	
1	1.0	1.6	0.75	0.8	0.25	0.2	3.9	3.5	2.3	2.0	3.1	2.5	6.2	5.5	0.7
2	2.1	2.6	1.5	1.6	0.6	0.5	7.4	7.7	4.7	3.8	3.1	2.4	12.1	11.5	0.6
3	2.9	3.3	2.4	3.0	0.5	b	8.1	6.5	5.4	5.1	2.3	1.7	13.5	11.6	1.9
4	3.2	4.2	2.4	2.7	0.8	0.5	7.7	7.2	6.5	5.7	2.7	2.1	14.2	12.9	1.3
5	3.7	0.5	3.4	4.0	0.3	b	0.8	0.7	8.5	8.1	2.5	2.0	9.2	8.8	0.4

[a] All losses are based on initial, well filtered solvent soybean oil.

[b] Acid removal incomplete.

TABLE II

Requirement of Process Chemicals[a]

Lot no.	Phosphoric acid[b] (85%) (Kg)		Caustic[c] 100% basis (Kg)		Change in chemical consumption in Process 2		Net saving in Process 2 per ton of oil (Rs.)
	Process 1	Process 2	Process 1	Process 2	Increase in phosphoric acid (%)	Decrease in caustic (%)	
1	1.92	2.0	2.72	1.30	4.2	52.2	+7.7
2	1.85	2.0	3.61	2.40	8.1	33.5	+5.8
3	1.83	2.0	4.63	4.58	9.3	1.1	−1.4
4	1.80	2.0	5.02	4.08	11.1	18.7	+3.6
5	1.96	2.0	7.27	6.15	2.0	15.4	+6.3

[a] All quantities are per ton of initial, well filtered oil.

[b] Cost of 85% phosphoric acid @ Rs. 10.0/-kg.

[c] Cost of caustic 100% basis @ Rs. 6.0/-kg.

consumption of phosphoric acid. This is because phosphoric acid was used on the weight of starting oil while in case of conventional process it is given on the weight of oil recovered after water degumming. Even then there is a marginal reduction in the overall cost of chemicals required for processing of oil (Table II).

Requirement of Process Chemicals

Comparative values of caustic refining loss by two processes are given in Table I. As seen from these data, caustic refining loss in Process 2 is comparatively low. This can be explained by the fact that in Process 2 both hydratable and non-hydratable phosphatides are removed to the maximum extent before caustic treatment of the oil, whereas in Process 1 non-hydratable phosphatides are removed during caustic treatment and hence, more occluded oil goes along with soapstock. Refining factor data in Table I clearly indicate that Process 2 gives a lower caustic refining loss than Process 1. There is an overall reduction in processing loss as indicated in the last column of Table I. There is only one drawback in case of Process 2. That is, the gums obtained in this process are darker than those obtained in the conventional process. However, it was noticed that the separation of gums is sharp and fast in Process 2. It is reported (1) that dark colored gums give inferior quality lecithin. However, as the continuation of the present work, acetone insoluble fractions of gums from Process 1 and Process 2 were run on HPLC. The peaks obtained in both the cases were identical (unpublished data). However, in India, as of today, most soybean gums are not processed for lecithin recovery and separated gums are mixed with the soapstock obtained in the caustic refining step.

Under these circumstances it is worthwhile to consider Process 2 for the processing of solvent extracted soybean oil, as it considerably reduces the overall refining loss and the caustic consumption is also less than that for the conventional process.

It is obvious that Process 2 readily can be applied to continuous processing of solvent extracted soybean oil, which is expected to give still better results in terms of refining loss. However, Process 2 does not offer any significant advantage for expeller soybean oil which contains very few phosphatides in comparison to solvent extracted soybean oil. Oil obtained from the steps described in Process 2 is suitable for further processing for acceptable edible products. Even half a per cent reduction in processing loss will improve the economics of oil refining operation and will save a few hundred tons of oil for the country.

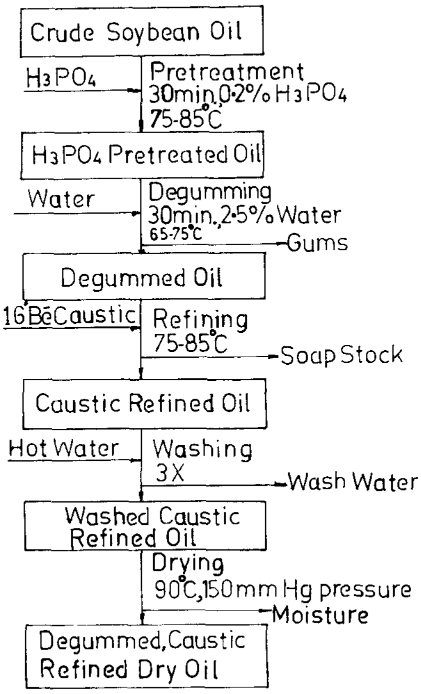

FIG. 1. Process flowsheet.

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