tion of the least soluble compound is demonstrated in Figure I. Accordingly, further addition of soap after the end point has been reached will not necessarily result in a corresponding increase in soap concentration of the same composition as the added soap.

Conclusion. While the authors realize that the procedure in this study does not correspond to that generally employed where soaps and builders are added concomitantly to the hard water, we believe that by prior addition of builder to hard water any soap saving would be favored. On this assumption our results suggest that the builders examined are not efficient in preventing the formation of calcium or magnesium soaps when used with the mixed soaps of commerce.

Summary

1. The reactions in mixtures of dilute solutions of builders, pure soaps and hard water have been examined under conditions for optimum foam stability for the soap solution.

2. An attempt has been made to interpret these reactions on the basis of solubility products.

3. For dilute solutions of soaps of pure fatty acids a minimum mole ratio of builder to calcium or magnesium salts is required to prevent the formation of alkaline earth soaps. These mole ratios are different for each soap studied and vary with the particular calcium or magnesium salt and builder combinations.

4. The procedure used by previous investigators of this subject is discussed.

The authors wish to express their appreciation to C. W. Jakob for performing many of the determinations upon which this paper is based.

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Fixed Oils of Mexico*

I. Oil of Chia-Salvia Hispanica[1]

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THE topography and climate of Mexico are such as to enable Mexico to produce oils of all classes. At the present time substantial quantities of sesame, cottonseed, peanut, coconut, linseed, and castor oils are produced, although in most cases production is insufficient to meet domestic requirements. In addition a number of other oil bearing plants native to Mexico could be grown on a commercial scale. Because of the important position of fixed oils in the industrial development of Mexico a concentrated effort is now being made to expand production to meet the increasing domestic demand for oils and to provide an exportable surplus where possible. In order to determine whether any of the now non-industrial oils of Mexico can share in this program the Banco de Mexico has authorized a study of these oils to be carried out as a cooperative research project between the Armour Research Foundation and the Instituto de Quimica of the National University of Mexico.

Chia oil, from the seeds of *Salvia hispanica L.*, family Labiatae, has long been recognized as an excellent drying oil. In 1918 Lomanitz (1) obtained a patent on a process to obtain a drying oil from chia and for the use of the press cake as a cattle feed. In 1920 Gardner and Holdt (2) studied the oil and reported that the raw oil dried slowly and tended to form droplets but that heat treatment at 210° C. for 15 minutes resulted in an oil of superior drying characteristics to linseed. Heat treatment does not cause appreciable darkening of the oil and its use in light colored varnishes was suggested. Gardner (3) compared the properties of chia oils obtained by hot and cold pressing in a paper published in 1926, showing only slight differences in the quality of the oils obtained by these methods. In 1937, Gardner (4) and Stewart (5) suggested the use of oil of chia as a substitute for tung oil. Also in 1937, Rulfo (6) reported on the cultivation and production of chia in Mexico.

Baughman and Jamieson (7), Gardner (8), and Steger, van Loon, and Pennekamp (9) have studied the composition of chia oil. Their results are summarized in Table I.

TABLE I
Composition of Chia Oil

	B. & J.	Gardner	Steger
Saturated Acids	8.2	8.1	10.6
Oleic Acid	0.8	0.7	—0.8
Linoleic Acid	48.6	45.2	32.0
Linolenic Acid	42.2	39.3	56.2

The composition of the unsaturated acid fractions were calculated by the Kaufman method using the theoretical thiocyanogen values. Since no record could be found of a study of chia oil using empirical thiocyanogen values, it was deemed of interest to repeat this work.

The chia plant is a rather large shrub, sometimes reaching a height of six feet. The seeds are quite small, approximately 2 mm. long and 1 mm. wide.

* Presented at 20th fall meeting, American Oil Chemists' Society, Chicago, Oct. 30-Nov. 1, 1946.

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The yield is variable, but in Mexico is said to average about 1200 pounds per acre annually (9). The yield of oil from the seed varies between 20 and 36%. The seeds are used in Mexico for the preparation of a soft drink, the seed yielding a mucilage similar to that of linseed. However, there are no large cultivations of the plant since the relatively small quantities moving in commercial channels are obtained from wild plants.

Experimental

The seed used in this study was obtained in a local Mexico City market. The moisture content of the seed was 9.2%. The seed was ground in a small mill and extracted with petroleum ether (B. P. 30°-60° C.) in a large Soxhlet extractor. The average yield from three extractions was 24.3%. The oil obtained was light yellow in color and the residue a mottled gray. The protein in the residue was calculated from the Kjeldahl nitrogen and found to be 22.8% on a dry basis.

The usual chemical and physical characteristics of the oil were determined by the standard methods of the A.O.A.C.(10). These values are summarized in Table II. In the 1-hour Wijs iodine determination it was impossible to obtain satisfactory checks between replicates, but the 24-hour Wijs determination gave checks within 1% on triplicate runs.

TABLE II

Characteristics of Oil of Chia

Specific Gravity	0.9330
Refractive Index	1.4812
Relative Viscosity	34.1
Cloud Point	—13.0° C.
Pour Point	—16.5° C.
Titer	—14.7° C.
Unsaponifiable Fraction	1.21%
Acid No.	2.0
Saponification No.	192.0
Iodine No. (Hanus ½ hr.)	186.7
Iodine No. (Wijs 1 hr.)	191.4
Iodine No. (Wijs 24 hrs.)	198.7
Maumene No.	123.5

Separation of Fatty Acids. The oil was saponified and treated by the lead salt method (11). The total fatty acids were found to be 92.1% of the whole oil, and the saturated acids 8.7% and the unsaturated acids 91.3% of the total acids. Calculated on the basis of the whole oil, this is equivalent to 84.1% unsaturated acids and 8.0% saturated acids.

Determination of Unsaturated Fatty Acids. The method of Mathews, Brode, and Brown (12) was used to obtain the thiocyanogen value for oil of chia. Quadruplicate determinations gave a value of 118.6 with 2% checks between high and low values.

Discussion. The calculations for the composition of the unsaturated oils of chia were based on the empirical values of Mathews, Brode, and Brown, namely 89.9 for oleic, 96.6 for linoleic, and 166.3 for linolenic. Table III shows the values obtained, the reported values of Steger, van Loon, and Pennekamp, and the values of Steger, van Loon, and Pennekamp recalculated with Mathews, Brode, and Brown's constants. The Steger values were calculated on the basis of a reported unsaturated fatty acid content of 85.5%, an iodine value of 206.8 and thiocyanogen value of 127.9. Using theoretical thiocyanogen values, the oil in this study calculates to an oleic acid content of —5.0%, linoleic acid 43.0% and linolenic acid 46.1% of the whole oil.

TABLE III

Composition of Acids of Oil of Chia

	% of oil	% of total acids	Steger values (oil)	Recalculated Steger values (oils)
Oleic acid	4.0	4.3	—0.8	10.0
Linoleic acid	26.0	28.2	30.3	9.4
Linolenic acid	54.1	58.8	55.2	66.1
Saturated	8.0	8.7	10.0	10.0

Earlier reports on chia oil indicate an oleic acid content of less than 1%. Steger *et al.* (9) reported that oleic acid is not present in chia oil. In the light of the general acceptance of the use of the empirical thiocyanogen values in the calculations using the Kaufman method it is probable that chia oil contains appreciable quantities of oleic acid.

Summary. A brief survey of the literature on chia oil is given.

The physical and chemical properties of the oil are reported.

By means of empirical thiocyanogen values, the unsaturated fatty acid content of the sample of chia oil used in this study has been calculated as: oleic acid, 4.0%; linoleic acid 26.0%; and linolenic acid 54.1%.

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