CERTAIN PHYSICAL AND CHEMICAL REQUIREMENTS OF FATS IN THE EVAPORATED MILK INDUSTRY

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The following paper was prepared at a time when "filled milk" was in its heyday. Subsequent legislation greatly reduced the commercial importance of the product; but the value of the paper to the scientific investigators has not been diminished.—*The Editor.*

The ice cream, butter and cheese industries generally have a large surplus of skim milk to dispose of during certain seasons of the year During the last few years a certain amount of this skim milk has been turned into sweetened condensed skim milk which is sold to the baking industry and some to the candy manufacturers. Attempts have been made to put up the skim milk as straight evaporated skim in gallon cans for the candy trade etc., but owing to certain properties possessed by skim milk it is necessary to run the total solids very low (around 20%) in order that it will stand up under sterilization treatment.

Certain companies have, therefore, conceived the idea of adding a fat from some suitable source to this skim milk so that its total solids can be run to around normal content for evaporated whole milk (28%) and still withstand sterilization. The addition of this fat was also welcomed by the candy and baking industries since it would thus be a suitable cooking product in the place of whole evaporated milk. This fat-filled skim milk earned the name in trade of "filled milk" or "milk compound."

Without entering upon a discussion of the commercial ethics of such a product—such discussions engrossed the attention of certain factions in both state and federal government for months—I will try to interest you in certain very fundamental research problems which were uncovered by the manufacturers and laboratories connected with the production of compound milk. It should be said that the aim of the producers of the product always had been to secure a highly refined oil for their purposes and to incorporate it under the most sanitary conditions possible. In many instances the character and physical conditions of this fat filled milk has been much superior to some whole milk batches in its working conditions in the vacuum pan and subsequent sterilization.

Processing of Fats in the Compound Milk Industry

The evaporation of milk in a vacuum pan at the temperature and pressure under factory operation and the subsequent sterilization of the product at high temperatures necessitates the consideration of factors in connection with the constitution and physical make-up of fats which are uncommon in all other industries in which fats are used. We might say that those who were pioneers in the compound milk industry were the unquestionable recipients of luck in the choice of fats for their purpose.

In England and Denmark where the nut margarine industry first flourished, and subsequently in the United States, cocoanut fat and palm nut fat were, and are yet, extensively used to manufacture their product. These two fats are reasonably cheap and are easily refined. The former, cocoanut oil, is available in the United States markets from our insular possessions. Inasmuch as the margarine people were using tons of this oil annually in the production of their product it was but natural that the evaporated milk people should look to this fat as the first possiblity for compound milk. It filled the bill admirably. Just why it should be so valuable for evaporated filled milk will be seen in that which follows.

It is fitting that we should turn first to the properties of butter fat to ascertain the factors which it possesses which renders it capable of standing up fairly well during the evaporation in the vacuum pan and during sterilization. An authoritative table of its properties is compiled below: (Leach & Winton; & Allen).

TABLE I.

Factor	Range
Melting Point	28°- 36°C
Solidifying Point	19 - 24°C
Saponification No.	220 -241
Iodine No.	26 - 38
Specific Gr.	0.865 - 0.870
Ref. Ind.	1.4527 - 1.4566
Acetyl No.	1.9 - 8.4

Comparison figures of the various fats suitable for evaporated milk and those which are not suitable as they exist naturally appear in Table II.

TABLE II.

Fat	Melting-Pt. Deg. C.	Solidifying-Pt. Deg. C.	Iodine No.	Saponification No.	Acetyl No.
Butter fat	28-36	19-24	26-38	220-241	1.9- 8.4
Cocoanut fat	20-28	14-23	8-10	246-261	0.9-12.3
Palmnut fat	23-30	20-27	13-18	242-255	1.9- 8.4
Cottonseed		5- 0	104-117	191-195	21. -25.
Peanut		0- 3	83-105	186-196	9.1
Corn		12-10	116-130	189-194	..
Soya Bean		14-15-3	114-139	207-212	..

In the first place butter fat is soft at ordinary room temperature, which bespeaks a fairly moderate content of stearin and palmatin. It contains a very moderate amount of unsaturated glycerines, thus yielding an iodine number of low order. In fact the iodine number of butter fat is from one fourth to one third as high as that of either cottonseed, peanut, corn or soya bean oil. The saponification number is quite high, higher than the same index for the above named oils.

Now we can take the group of food fats which I have termed the butterfat group and which includes butter fat, cocoanut and palm nut, and we can compare this group with another which I have called the cottonoil group and which included cottonseed, peanut, corn and soya bean oil.

The melting point range for all the fats in the butter fat group is from 20 deg. C to 36, whereas the cotton oil group are all liquid fats at room temperatures and do not solidify until 3 deg. C or lower is reached. The solidifying point of the butter fat group ranges from 14 to 27 deg. C.

The iodine numbers of the butter fat group range between 8.0 to 10. for cocoanut, to 26-38 for butter fat, with palm nut fat intermediate. Now with the cotton oil group this factor is from 83 to 139; soya bean oil being least saturated and corn oil next, then following peanut and cotton seed.

The saponification numbers for the butter fat group are between 220 and 261, whereas the cotton oil group lie between 186 and 212.

The acetyl numbers for the butter fat group are all small (i.e., 0.9 to 12.3); while cottonseed oil yields 21 to 25 and peanut greater than 9.1.

We could continue in noting group differences among the physical and chemical factors which have been determined for these fats, but those already mentioned are sufficient to indicate the close relationship to butter fat borne by cocoanut fat and palmnut fat. Is it any wonder then that we believe the evaporated milk people fell into a lucky choice when cocoanut oil was selected to mix with the skim milk? The volatile fatty acids resulting from the hydrolysis of butter fat and cocoanut oil are quite similar in qualitative and quantitative features, the absence of butyric acid in cocoanut oil being the chief difference.

TABLE III.

Fatty Acids obtained by Hydrolysis of the Purified Fats.

Acids	Butterfat % (X)	Cocoanut Fat % (/)
Butyric	5.45	..
Caproic	2.09	2
Caprylic	0.49	9
Capric	0.32	10
Laurie	2.57	45
Myristic	9.89	20
Palmitic	38.61	7
Stearic	1.83	5
Oleic	32.50	2
Dihydroxy Stearic	1.00	..

(x) Brown, J. Am. Chem. Soc. 21, 807 (1899).
(/) Elsdon, Analyst, 38, 8 (1912).

The three fats in this group also contain myristin. The margarine people chose a product very similar to butter in both chemical and physical properties, except that cocoanut oil needed to be hardened in some manner to raise its melting and solidifying point, either by direct hydrogenation or the addition of some other hardened fat.

Now why is it that the fats in the cotton oil series are unsuited, as they exist, for evaporated milk production? In the first place, they all develop more or less rancidity* in the vacuum pan and this is not improved in the sterilization process. In the second place some of them possess certain characteristic flavors in themselves which makes their presence in the sterilized milk obnoxious. These certain characteristic flavors are tied up

*The term rancidity is here used in a loose sense and refers to actual hydrolysis of the fat taking place in both vacuum pan and cans during heat treatment.

intimately with certain protein traces, unusual glycerides or other bodies, and the consequent difficulty of refining the oil so as to eliminate these from the finished product. The highest quality of refined oils as they exist on the market, of this group, are not suitable for regular production of compound milk. We have tried to hydrogenate various of these oils to certain degrees so that we would have a product with a satisfactory melting point for pan use, and a fat with an iodine number low enough to fall within the butter group. In this we met with a very interesting and important observation. As is well known, fats when partially or completely hydrogenated, develop a very marked tallowy odor (and this odor becomes a real flavor in practice); this is more pronounced the greater the degree of hydrogenation, and is characterized in trade parlance as hydrogenation flavor. This tallowy odor or flavor is entirely removed in the vacuum pan in the presence of the milk. I do not mean that the milk absorbs the product causing this odor, but that it is carried out in the condenser water during the concentration. Therefore this constitutes a thread from which it is possible to work out a process of removing hydrogenation flavor.

These partially hydrogenated fats can be used in the compound milk industry providing the iodine number has been reduced to the neighborhood of 30 or lower and the melting and solidifying points are not greater than 50° C. It is very definitely shown in our experience that the iodine number (which is an index of unsaturated glyceride content of a fat) is the controlling factor in rancidity development. But why use these products when cocoanut fat is the natural substitute for butter fat in the United States both economically and nutritionally? I beg to state here that the term nutritional is used in its broader sense and should not be construed to indicate any connection to the vitamin controversy, a controversy which has been used inconsistently and with results unfortunate for filled milk.

The cocoanut oil used to incorporate with the milk is of selected stock. It must have no rancidity or free acid, foreign odor or tallowiness, and it should show only a faint greenish-yellow tint when melted. These requirements are met without any difficulty on the part of the cocoanut oil refiners.

It has been urged, in connection with the tariff, that cocoanut oil receive a heavy tax because it is an imported oil, and is jeopardizing our home grown oil industry. While I believe that such legislation, if any is to be directed at vegetable fats, could without much hardship tax palm nut fat, I am directly opposed to the inclusion of cocoanut fat. Research has very definitely shown that the glyceride balance in cocoanut fat is closely analogous to butter fat. It has further revealed the similarity in physical properties. While this is also true of palm nut oil, the latter is not so extensively produced in United States territories, and could be dispensed with providing a large production of cocoanut oil could be guaranteed.

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