Links between Processes

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ABSTRACT

Sequential process steps—as, for example, crushing, extraction, refining, hydrogenation and fractionation—always include critical points. The origin of oils and fats is recalled, and reference is made to worldwide consumption. Based on up-to-date technology, the importance of links is demonstrated and explained by selected examples supported by graphs and isometric drawings.

Whether in production, research or engineering, it is not enough to assess a process, analysis or the process equipment from an isolated point of view only, while neglecting interrelationships and links with upstream and downstream operations. Dozens of examples are available to demonstrate the crucial significance of these linkages. This applies especially to connections between the various processing steps because the processing industry in the final analysis is the user of existing processes for economic production; we should not forget that technological innovations are a prerequisite for adequate up-to-date production equipment. In this context, it is irrelevant whether reference is made to already known equipment, or whether this is modified or newly developed.

Most certainly, the processing industry will claim that it is the market, i.e., the raw materials, which plays the most important part, while the production processes are only a technological necessity to transform these raw materials into finished products in order to satisfy existing demands for one of the most important basic foods. This "commercially-minded" reference to raw materials is a one-eyed approach, however. By way of provocation, one could say that the availability and quality of the raw materials, i.e., oil and fat, is of much greater significance as they affect technology rather than vice versa. This is quite simply because the process technology is expected to supply a final product which is always of the same high quality, no matter how good or bad the feedstock.

In this connection, reference should be made to two basic facts: first, the original composition of the raw material, i.e., oil and fat. Oil as a raw material is mainly embedded in the cytoplasm of the cell. Being a pure triglyceride, it is a clear and almost colorless liquid without free fatty acids, phosphatides or other foreign matter. However, part of these foreign components are always present as associated in the cell in different quantities, including albumen, starch, color bodies, but almost no free fatty acids. Since the formation and degradation of fat follow the same biochemical principles, the quality of the oil is merely a function of the negative influences. As germination starts, fat as an energy supplier is decomposed into glycerine and fatty acids by the action of enzymes.

Second, the composition of the various oilseeds and fruits being processed requires a multitude of methods for storage, preparation, oil extraction and refining such as are not necessary to such a great extent with any other main food.

For this reason, the material flowsheet showing the individual process stages must be simplified (as in Fig. 1) in order to illustrate the most important links between processes. Even this simplified form of representation appears to be some kind of a puzzle at first sight, although several oil extraction processes—such as those for obtaining olive oil

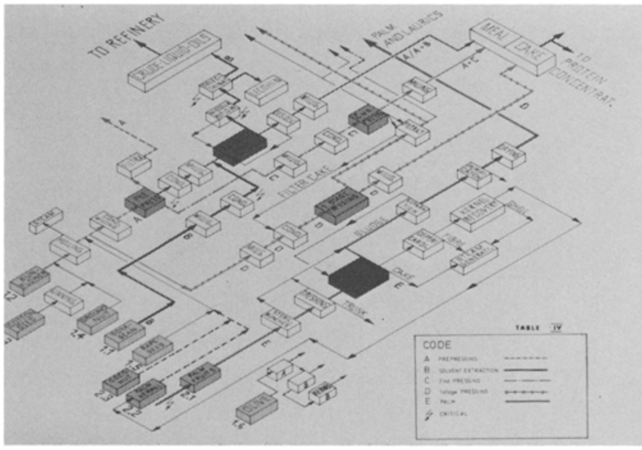

FIG. 1. Fat and oil extraction processes: (A) prepressing ----; (B) solvent extraction ——; (C) 2nd pressing -·-·-; (D) 1st-stage pressing -•-•-; (E) palm-fruit pressing/other fruits ━━; ↯ critical.

or castor oil—have not been included at all.

The main raw material crushing stages are marked with capital letters A, B, C, D, and E: A = prepressing, B = solvent extraction, C = 2nd pressing, D = 1st-stage pressing, and E = palm-fruit pressing/other fruits. Combinations such as A plus B, A plus C, or, with olives, as E plus B, are possible, while direct one-stage processing can be effected via B or D. Accordingly, there are at least one plus five ways for oil extraction. The quality of the oil, cake or meal obtained differs vastly among the individual processes, but additional great differences in quality are also found within the same process stage if only one or two parameters are varied.

Direct extraction of soybeans is a typical example with economic and technological impacts. While neglecting storage, handling and transport conditions, as these influential factors are generally known, reference is only made to three critical points at the beginning and end of the process. These three danger spots are marked with a squiggle resembling an arrow (↯). They are able, individually or collectively as a process stage, to affect the quality of the oil to be extracted and thus in particular the subsequent refining stage. Crude soy oil has an average phosphatide content of 100-170 ppm (as P) when leaving the final stage of extraction, i.e., the degumming stage. The phosphatides remaining in the oil are most nonhydratable. However, this figure can be reduced to ca. 5 ppm by subjecting the soybean to special heat treatment prior to the extraction process according to the recently developed Alcon process. The importance of this for noncaustic refining as applied today for liquid oils can be appreciated by everyone familiar with refining processes.

It is not the free fatty acids, the odorous or flavoring substances or color bodies that are the most undesirable foreign components which present a problem to physical refining or the noncaustic process, but the main problem here is an excessive phosphatide content. Of course, if we take rapeseed or corn as raw material instead of soybean, a phosphatide content of the order of 600 ppm is not unusual. However, reference should be made to the fact that in large-scale industrial application it is quite possible today to reduce this content to ca. 5 ppm in special pretreatment stages before deacidification and deodorization without using any caustic solution. There are many examples also for other types of oilseed and fruit that the crude oil quality can be improved by adopting better extraction practices.

Oxidation, polymerization components and metal contaminations, which exert a negative effect on the refining process and thus on the quality and stability of the oil and fat products, are in the first place caused during oil extraction and storage.

Today's oil refining processes can be combined in many different ways. However, each one of these process stages presupposes a specific condition of the feedstock because otherwise the final product often does not meet pertinent quality requirements. Within the context of this paper, a comparison will not be made of the various processes which are available—e.g., between caustic and noncaustic methods —but reference will be made only to the different routes that can be followed.

Let the main processes commonly used today following the raw oil extraction stage (A, B, C, D, E) be called F, G, H, J, K, L, M and N. Then there is:

F = Caustic process plus H_3PO_4—cleaning of crude oil in a chemical reaction, with an intermediate product being obtained at the same time which is treated in a separate process. Free fatty acids, phosphatides and partly also color are eliminated, while pesticides are not, and metal traces only slightly.

G = Noncaustic processes—pretreatment without reduction of free fatty acids.

H = Bleaching—using bleaching earth and partly activated carbon; a minor chemical reaction is known to occur here through the residual humidity in the oil and traces of hydrochloric acid in the bleaching earth. In addition to color, the filtration also eliminates mechanical and precipitated (chemical) foreign matter.

J = Vacuum/steam distillation—deodorization/deacidification

K = Hydrogenation—partial or selective

L = Fractionation—dry or in solvent

M = Transesterification

N = Winterizing/dewaxing

O = Soapstock splitting

P = Margarine production

Q = Shortening/ghee production

While animal fats and fish oils have not been considered under oil extraction shown in Figure 1, they must be included in Figure 2 (oil refining). Of course, the individual process stages can be further subdivided, but this is not possible in the context of this report, for reasons of time. Further details in this regard will be published later as a follow-up to the present paper.

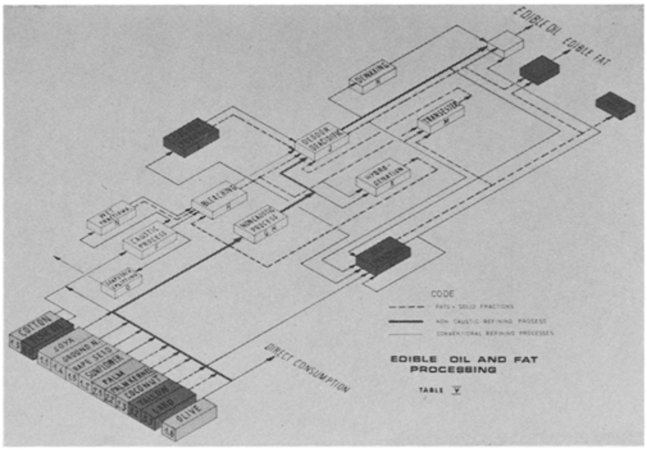

FIG. 2. Edible oil and fat processing: ——— fats plus solid fractions; ——— noncaustic refining process; ——— conventional refining process.

Depending on the type and physical condition (liquid or soft oils, for instance) the fats and oils are processed by very different routes if only one of their characteristics requires that a particular process stage should be included in the overall process sequence. For example, with cottonseed oil, this characteristic feature is gossypol which, to remove it, needs caustic treatment, while soy, peanut, corn, or rapeseed oils do not.

Sunflower oil is naturally of a light color, but includes components with a high melting point (waxes, etc.) which must be eliminated. This requires additional equipment for treatment, either within the process stage "caustic process" or after bleaching, but furthermore in two steps—e.g., together with caustic treatment and additionally after deodorization—in order to achieve a residual wax content of ca. 5 ppm, which often is a requirement today.

When pursuing the available routes of fractionation, which are shown in a simplified form, it becomes apparent that the criteria which determine the processes to be adopted must be very carefully checked. Here, then, interrelations and the links between processes become particularly important.