Using computers for oil blending

In 1975, Norman J. Smallwood and several colleagues initially explored the possible application of computers to make optimum edible oil blends. However, it was not until the early 1980s that the concept was actually developed and implemented at the new Staley refinery in Des Moines. In the following article, Norman J. Smallwood outlines the conventional methods for edible oil blending, identifies the shortcomings of these methods, and describes the advantages of using computers to optimize blending. Smallwood is a partner in The Core Team, PO Box 1321, Hammond, LA 70404, USA.

Many edible oil products such as shortening and margarine consist of a blend of two or more components to meet physical specifications (solid fat index profile, melting point, iodine value, polyunsaturation content). In these cases, it is not technically or economically feasible to make the products as single components from refined and bleached oils or by hydrogenation. Furthermore, within a given class of products, the food processor usually establishes specifications which are somewhat unique. Consequently, the edible oil supplier is confronted with meeting a range of customer specifications for each class of oil products.

To cope with the wide range of oil specifications, suppliers produce a range of hydrogenated base stocks from which two or more can be blended to match a specific product specification. Refined and bleached oils (unhydrogenated) are components for blending with hydrogenated base stocks to produce some products such as soft margarine oils.

Hydrogenated base stocks

The number and complexity of hydrogenated base stocks produced are a function of the finished oil products sold. The specific base stock array varies by company and, within the same company, often varies from plant to plant. Most base stock systems used are the result of practical evolutionary responses to meeting new product specifications.

If the existing array is not satisfactory for producing a new product, additional base stocks are added. Usually, hydrogenated single-component, high-volume products sold are included in the base stock array to make other products. A typical array of hydrogenated soybean oil base stocks is given in Figure 1. Specification limits must be established for producing each hydrogenated base stock to assure consistency when blending to meet the finished product specifications (Fig. 2).

Base stock (component) blending

To produce a new multi-component oil product, repetitive calculations are first made to determine the resultant characteristics of various combinations of

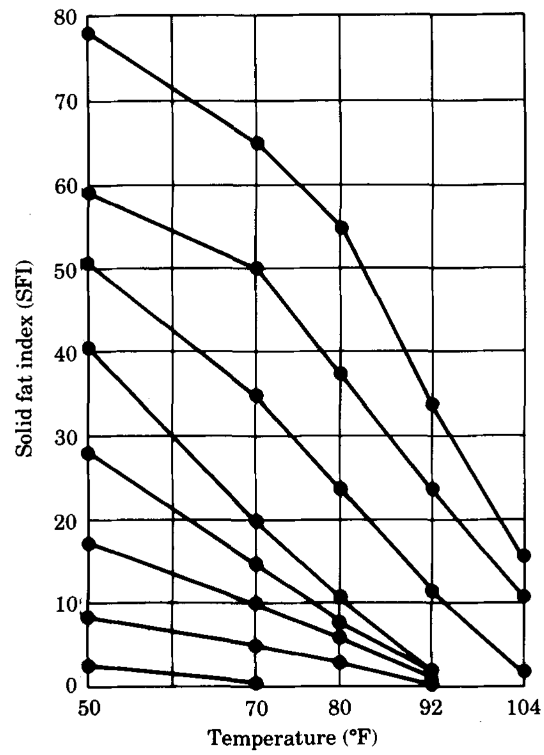

FIG. 1. Typical array of hydrogenated soybean oil base stocks.

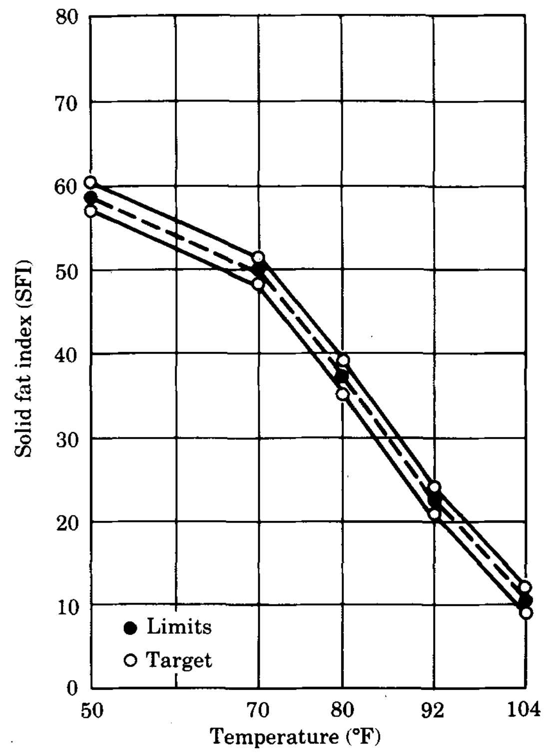

FIG. 2. Example of a base stock SFI specification.

base stocks until a blend is found that meets the finished product specification. Next, a lab-scale blend is made to confirm the calculated blend. If analysis of the lab blend does not confirm in-specification results, the process is repeated until success is achieved.

If the outcome of blending oils of different characteristics is linear, formulation of the final product is relatively simple. It would be a case of selecting various proportions of base stocks, calculating the weighted-average characteristics and determining by trial and error a formulation which was within the product specification. Characteristics such as solid fat index (SFI) and melting point are nonlinear when different stocks are combined. The nonlinear phenomenon involving liquid/solid characteristics is referred to as the eutectic effect (1). Lab-scale blends and analysis are vital to determine the eutectic effect of the actual base stock combination. Once a product is successfully blended on a lab scale, instructions can be prepared for full-scale production.

Component blending to produce oil products on a plant scale is a time-consuming and demanding process. Formulation instructions are normally prepared and available for each product to be produced. The instructions include a list of the base stocks with proportional ranges acceptable to produce the product. The end-product specifications are included for comparison in calculating the blend characteristics. The eutectic effect derived from historical analytical data is provided in some form to arrive at the predictated blend characteristics. Figure 3 illustrates a blend calculation format which has proven useful for both teaching and performing product blend calculation and implementation.

Once a blend has been made by transferring the calculated amount of stocks to a tank and thoroughly mixing the components with the tank agitator, a sample is drawn and analyzed. The actual analytical results of the blend frequently differ from the predicted results because of inadequate eutectic effect adjustment in the calculation, component pumping inaccuracy in making the blend, or inaccurate analytical results on any of the blend components or the final blended product. If the blend characteristics fall outside product specifications, an adjustment must be made in the same manner as making the original blend (Fig. 3). To avoid making an erroneous correction, it is advantageous to first obtain validation by lab-scale trial.

Deodorizer system implications in blending

To produce a deodorized product within specification limits, consideration must be given to the preceding product fed through the deodorizer system (pipelines, vessels, heat exchangers, filters). The amount of residual product from the previous run must be known for each type of stock change procedure used in operating the deodorization system. The amount and characteristics of the residual product should be taken into account whenever possible in making the original blend. Specifically, the residual product in the deodorizer system should be treated as a component in making the initial blend calculation.

Occasionally, the deodorized product characteristics will be outside of specifications. Two options are available to bring the product within specified limits. First, there may be another deodorized product in storage which could be used in a relatively small quantity to blend with the out-of-limits product to meet specifications. This is the obvious preferred option if available. Second, it may be necessary to transfer the product back to the blending stage and to re-blend in the most advantageous manner. Blend calculations in the manner previously described are necessary to choose the best option in this situation.

Attention demands of conventional blending

From the description of the blending process, it is apparent that considerable attention is required to consistently produce products meeting specification. The calculations alone are a significant time-demand requirement. Many trial and error calculations involving weighted-average determination of each physical characteristic are required. If not done properly, the penalty can be the expense of reprocessing, the

BASE STOCK BLENDING TO MEET FINISHED PRODUCT SPECIFICATIONS

	Tank No.	Specifications / Analytical Results															
		IV		MP		SFI											
						50°F		70°F		80°F		92°F					
Finished Product ↳		100%	_%	100%	_%	100%	_%	100%	_%	100%	_%	100%	_%	100%	_%	100%	_%
Base Stock																	
1. ______																	
______ %																	
2. ______																	
______ %																	
3. ______																	
______																	
4. ______																	
______																	
Calculated Blend																	
Eutectic Effect																	
Predicted Results																	
Actual Results																	
Correction																	
1. Blend __%																	
2. Base Stock __%																	
Calculated Results																	
Actual Results																	

Formulation

Base Stock	Tank No.	%	Quantity (Lbs)
1. ______	______	______	______
2. ______	______	______	______
3. ______	______	______	______
4. ______	______	______	______
Finished Product	______	100	______

FIG. 3. Conventional (manual) blend calculation format.

financial burden of product rejection, or ultimate loss of the customer. Blending responsibilities in the edible oil industry are handled in a variety of ways. Conservatively, at least one person per operating plant is devoted fulltime to product blend calculations and coordination (excluding the operating functions).

Financial considerations in blending

To make a given multi-component edible oil product, there are some options available on component (oil-type) selection and range (proportion) of use. Because of component price differences, these options can have a significant financial impact. Due to the complexity of blend calculations by manual methods to meet specification limits, most companies do little to exploit the potential advantage of optimizing blending from a financial perspective.

There is another significant financial dimension to consider in product blending—the actual product cost. Many companies use somewhat generalized models to calculate product cost. Frequently, details which contribute substantially to product cost in the multi-component blending process are missed in cost accounting. As a consequence, the profitability of some products may be considerably overstated at the expense of others. Again, the complexity of manually calculated product blends detracts from effective cost accounting.

Computer application to product blending

Computer programs can be written which will achieve both product-specification and most-favorable-cost objectives. In addition, computer programs can be written to include the calculation of actual product cost by lot. Finally, computers can be used to achieve optimum results in the total spectrum of product-blending functions. Blending-related functions for which computer utilization offers significant advantage include the following:

- Testing possible options to design the ideal base stock array for a given set of finished products.
- Setting the specification limits for individual hydrogenated base stocks.
- Controlling hydrogenation to produce base stocks consistently within the specified limits (2).
- Calculating the optimum blend for the production of each multi-component product within the quality and cost parameters programmed.
- Providing immediate access to base stock, blended product and deodorized product analytical data for efficient process operation.
- Determining quickly the probable component requirements for and the production costs of new products (valuable aid for product development, sales and production functions).
- Controlling the actual blending operations (stock transfer, agitation).

Eutectic effect data can be built into the blending program to give highly accurate characteristic-result predictions. The eutectic effect data can be expanded and updated in the program as frequently as results are generated from lab analytical data. Consequently, when confronted with new product formulation, the accuracy of the computer-determined blend will often result in a single lab-scale blend confirmation.

With computer-aided blending, the implications of product carryover from the preceding deodorizer run can be readily determined. In the conventional approach, this step is usually handled by approximation because of the time and complexity of the calculations. However, this too often results in an out-of-limits deodorized product.

The computer program for multi-component edible oil product blending contains files for finished product specifications, base stock characteristics (updated analytical profile), base stock usage ranges/limits and eutectic effect data. If financial dimensions are incorporated, files are included on market oil price and base stock manufacturing expense. Finally, the program contains a mathematical analytical protocol for determining the "best fit" result which will achieve a product in specification and at the most favorable cost within the restraints imposed.

Computer hardware requirements for the blending program depend upon the complexity of the system and the degree of interaction required with other departments (quality control, financial and production/operation). A personal computer level of hardware could be adequate for a relatively simple base stock and finished product array with the objective of meeting quality specifications. A high-capacity, personal computer network or a mainframe/minicomputer system with multiple terminals would be required to achieve a higher level of complexity involving networking with other departments.

With a single personal computer for product blend calculations, base stock analytical profile and cost data must be input manually. The product blend output data must be manually transmitted for subsequent implementation.

Computer network architecture provides direct data access/updating between departmental functions (Fig. 4). In Figure 5, computer architecture is diagrammed for both functional data access and direct control of the processes involved in product blending.

Computer application for routine blending can be made very "user friendly." Equipped with a personal computer or computer terminal (keyboard and CRT), the user calls up the blend format which can be as simple as the following:

Computer Input Format for Product Blending—
Product code ______;
Quantity (pounds) required ______.

After the computer has calculated the "best fit" blend calculation, the results are displayed on the CRT (Fig. 6).

Justification of computer application for product blending can be determined by evaluating the financial benefit of the following potential improvements:

- Development and maintenance of optimum base stock specifications.
- Reduction of the number of base stocks required compared with the array which typically evolves from conventional management.
- Determination of base stock and blending requirements for and cost of new products on a timely basis (valuable information for both production and sales functions).
- Increased accuracy and timeliness of blend calculations—reduced number of blending corrections, reduced reprocessing expense, reduced production lead time (provide fast response to spot sales opportuni-

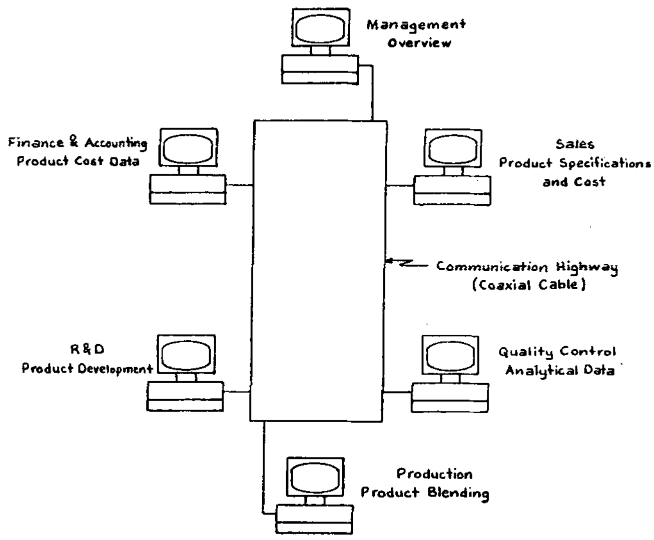

FIG. 4. Computer network for data access related to product blending.

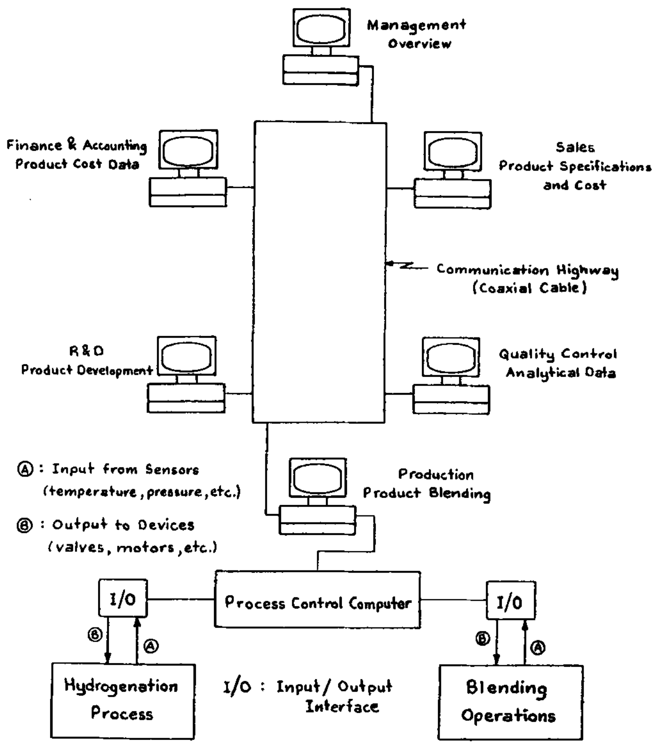

FIG. 5. Computer utilization in all aspects of product blending.

1. Product Code: ____________

2. Finished Product Specifications:

	Limits	Predicted
a. SFI (°F)		
(1) 50	________	________
(2) 70	________	________
(3) 80	________	________
(4) 92	________	________
(5) 104	________	________
b. Iodine Value (IV)	________	________
c. Melting Point (°F)	________	________

3. Formulation:

Base Stock	Quantity (Lbs.)	Storage Tank No.
________	________	________
________	________	________
________	________	________
________	________	________
Total	________	

4.Finished Product Cost ($/Lb.): ____________

FIG. 6. Computer output format for product blending.

ties), improved product quality consistency, and reduced quality control laboratory workload.

• Reduced workload for higher-skilled personnel involved with blending (opportunity to reduce staffing requirements).

• Availability of actual product cost by lot.

• Increased profit margin from most favorable cost component blending within restraints imposed.

• Achievement of a significant step in developing computer controlled and integrated manufacturing.

Summary

Production of multi-component edible oils is both technically demanding and financially significant. Conventional methods used in product blending have serious shortcomings in achieving optimum product quality and financial results. Computer application to product blending provides the opportunity to consistently attain "best case" product quality and financial objectives. The use of computers for product blending can be as simple as a single personal computer for performing "best fit" blend calculations or as complex as networking departmental functions for relevant data access (financial, quality control and production) and for control of the production processes and operations involved.

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BIOTECHNOLOGY

Market applications for microalgae

Alternate sources of fats and oils are being sought on an ongoing basis, with particular attention being paid to novel specialty products of possible high commercial value. At the request of J.B.M. Rattray, Associate Editor for JAOCS *News for Biotechnology, David Kyle of the Martek Corp. in Columbia, Maryland, has prepared the following article on potential applications of microalgae and their relevance to the fats and oils industry.*

Microalgae represent a subset of single-cell microorganisms that generally grow autotrophically using CO_2 as the sole carbon source and light as energy. Some species of microalgae, however, are heterotrophic and can use different forms of organic carbon as nutrient sources.

Although microalgae most commonly inhabit an aquatic environment, they are ubiquitous in nature and have been identified in almost every ecological niche on this planet. Aquatic microalgae have been isolated in areas ranging from hot springs to glacial ice flows; terrestrial species have been identified from the desert to the arctic tundra. Some species are intercellular symbionts with fungi (i.e., lichens) or marine sponges and hydrazoans. In total, there are thought to be over 50,000 different species of microalgae, of which only a few have been characterized in any detail.

This lack of detailed information on microalgae compared with other microorganisms (i.e., bacteria, yeast and fungi) is primarily a consequence of their unconventional cultivation. As a result, they generally have not been included in large-scale industrial screening programs until very recently. Thus, microalgae represent a major untapped resource of genetic potential for valuable bioactive agents or special purpose biochemicals. I will address the question of how this potential resource can be exploited and identify some of the

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