Least Cost Formulation:

Turning mathematics into money

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Meat processors typically struggle with tight margins as they're caught between varying cost and availability of raw materials, operating costs and the constraints of pricing their product at market.

Volume drives margins, but that works both ways: Processors that make the most of their raw materials see the resulting yield improvement as a multiplier effect driving up margins; processors that fail at this, lose yield improvement opportunities and thus leave money on the table.

The introduction of inline Fat Analysis (FA) systems afforded meat processors the opportunity to move beyond the often unreliable, sampling-based and labor-intensive fat measurement techniques of the past. Beyond that, by delivering Chemical Lean (CL) accuracy levels to better than ±1 CL on 100% of the product flow, inline FA also opens the door to a mathematical optimization technique known as Least Cost Formulation (LCF).

Many will be familiar with the process of "standardization" of batches, where meat processors achieve batch recipe targets for CL in an often iterative process of adding corrective meat – be it lean or fat – to a batch in order to meet the target CL values. Inline FA improves batch standardization efficiency by eliminating the need for corrections or allowing it to be automated. LCF takes this process further still, drawing on the information extracted by the inline FA system and combining it with other variables from the production process to ascertain the most cost-effective way to reach a recipe target, whatever the processed meat product is, at time of production.

LCF is a mathematical optimization model that looks at all the different costs associated with producing that final product, including current inventory, and identifies which combination (and proportion) will result in the lowest cost at time of production – importantly, still producing the final product to the same quality.

1. The Role of Fat Analysis (FA) Systems

Since the largest portion of the manufactured product for meat processors is the meat itself, it stands to reason that this is where the attention should be focused. Fat content is a primary determiner of the cost of meat and the ability to measure fat content accurately is crucial to effective LCF.

As the saying goes, "you can't manage what you can't measure." Accurate fat measurement enables LCF, and this is where the advanced x-ray technology behind inline FA comes into play.

Modern in-line FA systems use a technique known as Dual X-ray Absorptiometry or "DEXA" to scan through the entire cross section of meat passing through the system. DEXA uses the differential absorbance of two x-ray energy spectra to measure fat content. This means that 100%, or all, of the meat that goes into the batch is scanned to yield the fat measurement. Comprehensively measuring 100% of the meat, and at accuracies better than ±1 CL, enables LCF control schemes to precisely meet blending targets at lowest cost.

Inline DEXA-based FA systems also simultaneously measure weight and detect physical contaminants throughout the cross section of meat. Precise weight measurement of 100% of the meat provides processors with real-time accumulated weight and weighted CL measurements, enabling control of a total batch to target CL at a given batch weight. Sensitive and reliable detection of physical contaminants is a hallmark of x-ray technology, removing items such as glass shards, metal fragments and calcified bone that may be present in the cross section of the meat. This not only reduces exposure of the meat processor to food safety liabilities from the retail supply chain, it also reduces potential damage, and attendant downtime, to downstream equipment.

2. Factors Considered When Calculating LCF

LCF looks to capture variability in the relative price of raw materials, the availability of those raw materials, and demand (actual orders placed on the production line composed of recipes and their composition). To break it down, LCF factors in the following information in its optimization calculations:

- The cost of raw materials – typically the leaner the product the more expensive it is
- The availability of raw materials
- Variation in the orders demanded on the production line
- How orders are scheduled and produced and at which time in a production run
- Inventory management considerations
- Individual supplier contracts

LCF exploits the variability in all of these factors, that otherwise present processors with a range of different ways to produce the same final product, to select the combination that yields the lowest cost – and always at the same quality level. LCF applies to any number of products, provided you are dealing with three or more raw materials, and it does not necessarily have to be a single product. LCF can be applied to multiple products, on multiple lines, in multiple factories.

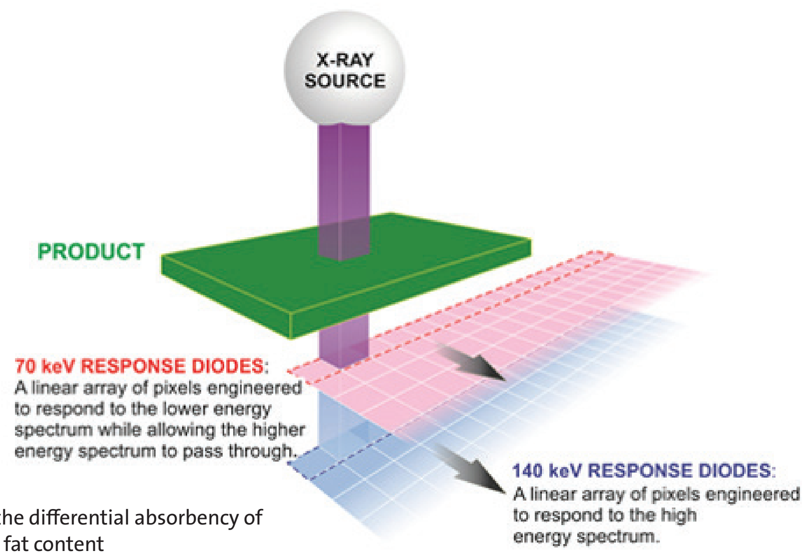

Figure 1: DEXA works by measuring the differential absorbency of two x-ray energy spectra to measure fat content

By itself, implementation of inline FA provides significant savings through standardization and an assortment of other benefits, including cost reduction related to food safety risk, labor reduction and purchasing surveillance. Combining inline FA with an appropriate LCF control scheme delivers an additional 3-5% (or more) savings on the cost of raw materials. For processors producing 10-20 tons a day or more, the savings potential is significant.

3. Combining Information to Produce Effective LCF Calculations

To create effective LCF results, processors need timely access to the data needed to drive the various factors in their LCF model. This creates the need for greater degrees of communication between multiple layers of their business. Some processors will use a Manufacturing Execution System (MES) - a platform on which calculations are made on how to best execute production plans. Information from multiple areas of the business is fed into the MES, giving processors a good understanding of what they have to work with to carry out production plans in the most cost effective way.

As a simple example, consider a sausage production run. A typical sausage recipe would have three meat raw materials: shoulder, belly and back fat. Those raw materials will have a natural variation in fat content and market price. The FA captures the fat variation. See Figure 2.

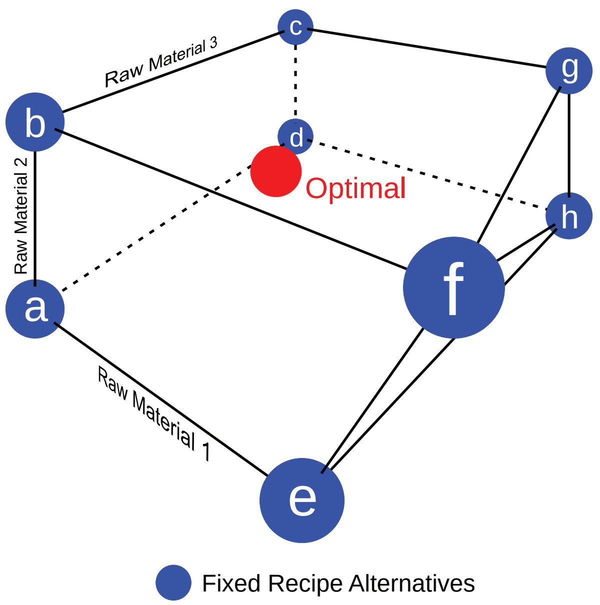

Figure 2: LCF optimized line uses 3 materials to create a 3-dimensional control space

On an LCF optimized line, these three materials create a three-dimensional control space bound by fixed recipe alternatives (a - h) indicating the possible extreme raw material combinations defined by the "constraints" in the LCF model.

The processor must define these constraints to ensure batch-to-batch recipe quality and specification performance is consistent. Examples of constraints include: cannot use more than 10 tons of belly fat or must use at least 20% shoulder. This creates the concept of a "dynamic" recipe, where the recipe can change from batch to batch within this space as the LCF algorithm finds the optimal "least cost" point within that space.

This optimal point at which the recipe can be produced will vary depending on the variability in raw materials. The accurate fat and weight measurements from the FA are critical here. In our simple example, we only considered a model driven by the three meat raw materials. In real world applications, LCF models likely would consider other raw materials (spices, salt) as well as other inputs, but the result is the same: batch-to-batch consistency in recipe quality at the lowest cost per batch. This is what LCF was designed to achieve.

4. Advanced Software Enables LCF

LCF-capable software is available on the market today that allows processors to optimize each recipe or batch based on raw materials currently in inventory – taking the guesswork out of these processes completely.

This software communicates with FA system(s) on the line directly or through plant networks. The data is then interpreted into a convenient "dashboard" real time graphical display of the current batch production vs. target recipe. Recipe statistics, including CL, weight, protein and collagen content, are also displayed in real-time. Based on the graph, the operator and other personnel can quickly see "at a glance" how close the batch is to its target recipe requirements and completion.

For LCF, based on the raw materials available (or those already processed) the operator can choose to optimize a recipe with the click of a button. This will calculate the least cost formulation of raw materials available in inventory based on composition, cost and any pertinent constraints to fulfill the current recipe and product. After this optimization, the software then displays the raw material details the operator (or automatically controlled in-feeds) must add next in order to maximize ingredient utilization.

5. Gaining a Competitive Advantage

Raw materials are the most expensive commodity for meat processors, therefore increasing effectiveness in their use through processes such as LCF is highly desirable. On new processing lines, LCF integration can be factored into installation planning from the outset. However, most processors will have existing lines and may be wondering where to start.

The first step is to install an inline FA system in the line to measure the actual variable composition of the raw materials being processed. Then it is possible to ask the question, “How can my business react to that number?”

Customers know what they want to make and how to produce it. They know what the recipes are, they know what the grinding times are, etc. The FA system supplier will assist the processor in determining the most ideal installation location for the FA in their line so that they can capture that variability in composition of the raw materials to the greatest advantage for their LCF model.

5.1 Selecting an FA System

As it is a critical element driving measurement data to the LCF control, sourcing an accurate and reliable FA system is crucial. Accuracy is a key element, and inline FA systems are available on the market today that are capable of fat analysis to within ±1CL (or better). In addition, FA systems provide accurate weight measurements, which are critical for batch and recipe management.

The ability to measure weight and fat content in line is also highly valuable in terms of productivity. Inline FA systems measure 100% of product in a non-invasive, non-destructive manner in real-time, meaning no slowing of the production line is necessary.

In addition, most FA systems can simultaneously and thoroughly check product for physical contaminants, providing support for food safety programs such

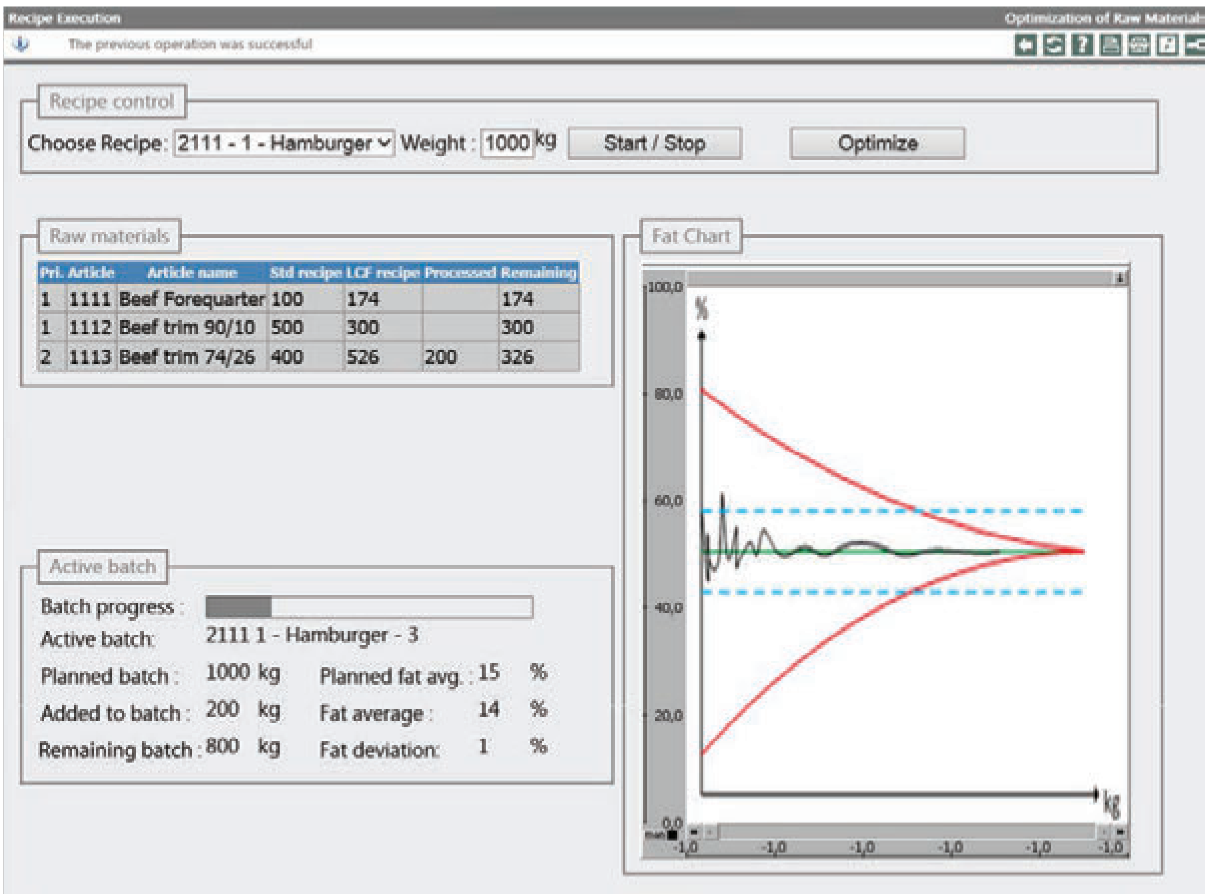

Figure 3: Example of raw material batch optimization software

as HACCP. Some FA suppliers offer reject systems specially-designed and optimized to work with their FA to ensure positive, efficient removal of contaminated product from the product flow – while automatically taking into account the CL and weight of any meat product removed in cumulative batch calculations.

Figure 4: Points to consider before purchasing an FA system

Long term, total cost of ownership is an important consideration with FA systems. Recurring costs related to maintenance, sanitation and calibration can rapidly add up. When considering an FA system purchase, in particular look closely at:

1. Sanitation

- Is it easy to break down and reassemble for sanitation? How long does that process take and how many people are required?

- Is the system designed to be robust against the severe sanitation protocols typical in meat processing?

2. Ease of Use

- What's the learning curve for efficient day-to-day operation of the FA system? Turnover is not uncommon in many meat processing plants, so recurring training costs need to be considered.

3. Maintenance

- How many wear parts are there and what is their expected lifetime?

- Inline FA systems based on DEXA use one or more x-ray tubes. What is the expected lifetime and replacement cost?

4. Calibration

- Any measurement device needs calibration, but also validation, on a regular basis as part of a plant or company measurement system QA program. How complex are these procedures and what special tools are required? Since you will be performing these tasks, especially validation, daily or more often, how much time is required to perform these tasks? Remember, when these tasks are being performed, no product is moving through the system. So, this has an impact on "availability" of your FA system and asset utilization. Note that certain FA systems feature fast, built-in, fully automated calibration and validation requiring no special tools, thus negating the need for operators to handle potentially heavy/unsafe phantom blocks, or possibly compromise line sanitation by passing those blocks through the FA system.

5. Service and Parts

- Buyers of FA, never want to need service or parts for their FA systems and FA system manufacturers try their best to deliver reliable systems. In the event you need factory service or parts, however, the FA system supplier's ability to deliver becomes critical in minimizing downtime and related costs. Does the supplier offer 24/7 technical support, service dispatching, and replacement parts support? Are parts stocked locally (or within the same country)? How many service personnel does the supplier have? How long would it take to get a service engineer on-site at your plant?

5.2 Precise Recipe Control

Once the FA is installed, the information can then be fed into a processors' recipe management system and LCF control. The processor can now control their raw material costs with unprecedented accuracy. Results and reports are reliable and directly tied to cost and profit calculations. This proven connection allows production to run at higher throughputs and make the best use of the inventory available.

5.3 Associated Savings

The elimination of manual formulation and batch rework reduces labor costs and improves asset utilization. Such close regulation of recipes, including constraints and material usage, produces a consistent, high-quality final product at lowest costs, and it does so predictably. Since product constraints and costs are tracked, meat processors can take full advantage of strategic purchases and spot buys to fulfill existing and future orders, which also affords production the agility to utilize materials - even if product or customer demands change.

Further to this, FA enables processors to check all incoming raw materials to ensure it is within purchase specifications and correctly priced. This level of supplier surveillance is very valuable with regard to controlling and reducing raw material costs and, when needed, it supports processors' claims for product that falls outside purchase specifications. Since FA looks at 100% of the meat, there is no sampling error to cast doubt as to the accuracy of the information.

The ability of FA to detect physical contaminants early in the production process can also have a direct effect on cost reduction. Not only are contaminated items removed before any further value is added, the removal of contaminants prevents potential damage to processing equipment further downstream.

6. Conclusion

Meat processors who neglect to take LCF seriously expose themselves to competitive threat from processors that do and fail to achieve the highest production yield for the products they are producing. Inline FA systems, through accurate fat measurement of 100% of the product, enable meat processors to enjoy the benefits of LCF in extracting every ounce of process yield and thus operating margin, from the product they process.

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