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COMPUTER ASSISTED MEAT PRODUCTS FORMULATION TO MEET NUTRITIONAL AND FUNCTIONAL REQUIREMENTS.

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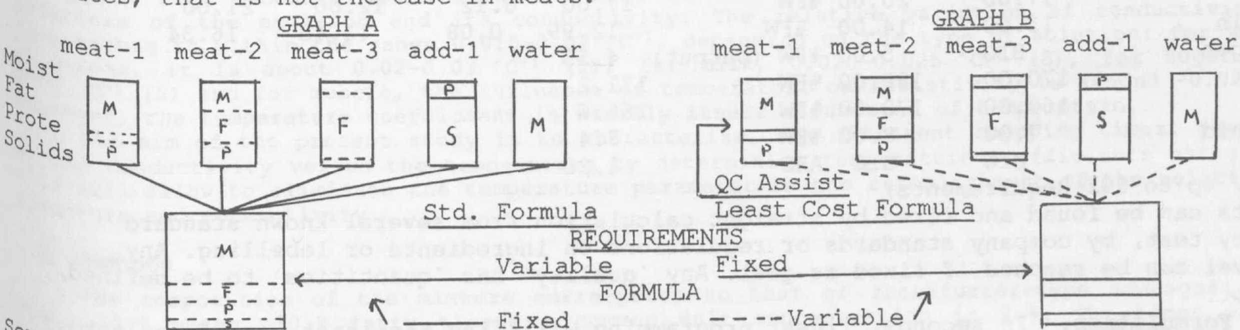
Quality regulations establishes that a quality system must ensure that products () conforms to specified requirements´ regarding purchasing procedures, process control, product traceability, inspection and other elements. See ISO 900x, Bibliog. #1. The availability and economy of computers and specialized software allows to reach these goals to every plant, regardless of its size. These goals cannot be achieved doing formulation in the standard, and isolated, way, because of the particularities of meat as raw materials.

Standard formulae approach does not ensure quality because of internal variability of meats, used in fixed quantities, leading to final product variations that go beyond acceptability (See Graph A vs B. This problem does not exist when ingredients are consistent in its attributes, that is not the case in meats.



Several mathematical and statistical methods can be used to solve this problem and they had been integrated in software packages that shorten the time and operations needed providing, at the same time, the minimum cost possible. Among these methods, linear programming, multiple regression and variation analysys had been applied (See Bibl. #2 and ff.)

The problem can be defined as 'how to obtain a final product consistent and stable in its nutritional and functional requirements, from highly variables an not easily measured raw materials whose cost is not directly affected by their internal attributs but for demand patterns, shapes and/or availability'. So, linear programming can be applied to allocate these raw materials in a formula if, and only if, we can define and measure the requirements in the final product and, henceforth, the attributes into the raw materials.

Basic Requirements. Experience and research along the years had found and fixed a few basic parameters that afect quality (a complex of physical features, at least) in finished meat products. They are Moisture, Fat, Protein and Carbohidrates. No surprise; They count for 97 % and meats are built with the three first. But there are other parameters, besides, like

Color	(Myoglobin content in muscle)
Collagen	(Ratio of protein with different functional behavior than myofibrilar protein)
Bind	(The protein capability to retain fat into its structure)
WHC	(The water holding capacity of the whole system)

that are the most important when the complex of properties called ´texture´ is the goal. These last numbers, in fact, make the difference between a frankfurter and a beauty cream, i. e., that could share exactly the same ´nutritional´ first values! To find these functional figures for meats, in time, is easy and proven.

Raw materials evaluation. Meats are biological systems that cannot be changed easily. There are, hence, strong consistency in any muscles from different industrial species (Beef, Pork, Chicken and Turkey) that, through enough testing, allows to find consistent correlations among moisture and the rest of attributes quoted above. Protein from Moisture or Fat from Moisture can be predicted with less than 0.2 and 0.3 error versus AOAC approved methods, respectively. This allows measuring as many times as needed, fast and cheaply. The test to obtain moisture with a microwave oven takes three minutes and was developed by Pettinatti e. a. (See Bibl. #2). Values obtained by Dr. LaBudde´s QC Assistant with this method, for commonly used meats are:

	B50	P95	PJAWL	PHEART	CMeat	CTHIGH	TMeat	TTHIGH
Moisture	33.9	72.0	39.1	76.2	66.6	73.0	64.9	74.0
Fat	56.3	7.9	49.7	6.8	18.9	4.2	19.6	6.3
Protein	9.5	19.3	10.7	16.1	13.2	21.0	14.3	19.0
Color	20.9	19.4	17.1	32.3	19.2	33.6	21.4	30.5
Collagen	0.38	0.20	0.43	0.27	0.40	0.35	0.40	0.35
Bind	13.2	23.5	7.9	6.1	21.8	38.7	24.3	35.1
WHC	0.41	1.51	0.28	0.32	0.96	2.71	1.15	2.22

Differences among meats are better traced by last figures, (P95 vs PHEARTS).

Finished Product Requirements.

Once having this information, and availability and cost for the raw materials to be used, ´backward´ calculation of the formula to meet the established requirements of the final product can be performed using linear programming. The lineal form of this problem is:

$f= c_1x_1+c_2x_2+...+c_jx_j+...+c_nx_n$

that must be solved with a non-negative solution in which f finds its minimum (or maximum) value. This mathematical method is being applied from 1939 to several economic questions and 20 years ago was applied for the first time to meat products formulation. This application was not easy at the beginning because of scarce value of average analitical data used and because of some misconceptions that actually there was about the same ´emulsion´ concept. Today approach, as stated above, has solved the previous errors and it is being applied by lots of companies now.

Inversely to the standard formula approach, the final product requirement to meet are fixed as:

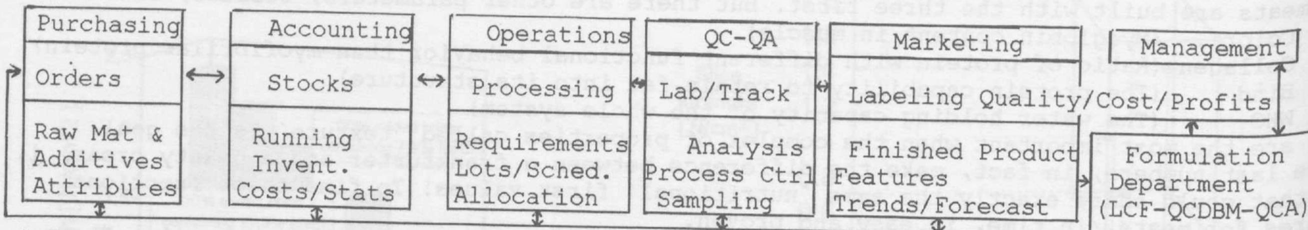
	Low Limit	High	Base	Value	Pnty-Cost	Low Range	High
Moisture	63.00	65.00	%FW	64.99		61.00	69.00
Fat	17.00	20.00	%FW	17.00	0.12	12.00	21.00
Protein	13.00	14.00	%FW	12.99	0.08	11.45	16.34
Collagen	- BIG	5.00	%FW (Output)	4.55			
Color	170.00	180.00	%FW	171.2			
Bind	160.00	170.00	%FW	166.6			
Carbohid	7.00	8.00	%FW	7.4			
WHC	- BIG	BIG	ABS	1.25			
(Etc., up to 192 Requirements)							

These limits can be found and fixed by straight calculation from several known standard formulae, by test, by company standards or regulations on ingredients or labelling. Any Qualyty Level can be reached if fixed as goal. Any ´quality´ has ´quantities´ to be defined, or it is not!

Least Cost Formulation.- In seconds, linear programming will find the least cost formula to meet the requirements by allocating the rounded quantities of raw materials to be used whose attributes will lead to the right solution, always within the security range allowed. Thus, decomposing raw material names into their own attributes content, as process will do later, treating them as meats no more but as ´badly labeled bags´ of moisture, fat and protein, as indeed they are. Simultaneously, LP provides information unavailable before (See output columns previous graph) that allows improvements in the decission-making process in purchasing and management.

The optimized formula will be very close to a standard formula but 4 to 10 % cheaper, according to the previous care taken in the product formulation process, by the optimal use of every raw material. Besides that and more important in the long run, quality (here assumed as equal to consistency, as customer does and regardless of any figure or process involved) will be consistent lot to lot and daily.

Computer Formulation and Company Structure



The information to be input and the output provided creates flows along the company that must be considered. In the Structure Graph can be seen how almost every department is affected. The same concept of Variable Formula raises logical concerns to operations, accounting, marketing and general management. Technical, QC and Lab departments ought to re-invent their function that now can be seen as profit generator rather than expensive and outside-oriented. A system that affects quality so strongly must be understood completely all over the management who has the responsability over the entire company. Scientist and technicians in research, labs, QC or QA, are obliged to use and explain the advantages for all of them arising from using this simulation and optimization tools. Envolvement of every department in quality is the key for a company financial and commercial success. Standard formulation is the surest way to repeat consistently the same errors. Computer assisted formulation allow real changes or simulations fast and securely, documenting every change, assuring quality before, in and after the process and optimizes the use of resources and, therefore, profits.

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