ing a great deal of attention. The use of enriched flour is being broadened to cakes, pancake mixes, and other products. Snack foods are being nutritionally improved and the meat analogs prepared from textured protein offer great possibilities.

In closing, there is one thought that I would particularly like to leave with you. Much effort has been spent in the past trying to produce and market a single food product that is adequate in all nutrients, and our science fiction writers dream of the day when we can get all of our nutrition from a pill. Although such things are technical possibilities and may be useful in emergencies or special situations, they are unrealistic when it comes to the population of this country. We eat meals of combinations of foods and I think we are all going to continue to do so for the foreseeable future. We should create foods which make tasty, satisfying, and nutritionally adequate meals.

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Nutrification: A Concept for Assuring Nutritional Quality by Primary Intervention in Feeding Systems

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Malnutrition can and does exist in highly technological societies. Assuring adequate nutrition on the basis of a balanced intake of commodity foods is impractical because an increasing percentage of the American dietary is derived from preprepared convenience foods with varying nutritional value. Restoration, fortification, and enrichment as classically defined are evidently insufficient in practice to assure a community-wide, fail-safe, balanced nutriture. Nutrification—meaning to make completely nutritious—of selected foods would foster adequate nutrition community-wide in spite of man's diet habits and would thwart malnourishment. Meal replacements as well as any food which provides 7% or more calories as utilizable protein should be considered for proportionate nutrification with the NAS/NRC Recommended Dietary Allowance (RDA) nutrients. This approach, based on protein, would be consistent with nutritional biochemistry principles, existing information on diet habits, and food technology capabilities, as well as leverage for monitoring purposes.

Nutrification is a term meaning "to make *completely* nutritious" and has been proposed to describe the addition of a *proportion* of all necessary vitamins and minerals to food, particularly fabricated food. The objective of nutrification would be to foster nutrition or thwart community malnourishment (Lachance, 1970). A new term is needed, particularly in the case of formulated, fabricated, or engineered foods because such products may have ingredients which have already undergone restoration, enrichment, or fortification or conceivably all three.

We have arrived at a stage in the evolution of nutrition, food technology, marketing, federal guidelines and regulations, and consumer awareness wherein we must simplify and/or broaden our definitions in order to make technical knowledge on the one hand and responsibility to the consumer on the other more compatible.

We must recognize that man is a social being with both instincts and habits, who in the Western world is evolving in an increasingly sophisticated and systematized technological culture, controlled to a significant degree by economics (Lachance, 1971b).

Man has no inborn physiological or instructive urges to keep him on the safe side of malnutrition. He has food tastes (Clark, 1966) and food fashions (Leininger, 1970; Jerome, 1970) but these cannot be relied upon as a sound guide to nutrition, least of all in a technically sophisticated community such as our own.

However, modern man can alter the methods of food processing and food distribution as though the composition of his daily diet was of no greater biochemical importance to him than the style of his clothes or his automobile.

At least 90% of the food consumed in the Western technologically developed nations has benefited in some manner from food technology before the food is purchased by the ultimate consumer (Kertesz, 1966). Further, the effect of science and technology on dietary customs in the West is proving a potent force in the change of food habits, even where older cultures still persist (Pyke, 1968).

The 1965 USDA dietary survey of household diets (ARS, 1968; Leverton, 1971) revealed a 10% increase since 1955 (a 10-yr period) in the percentage of the population purchasing (and supposedly consuming) a poor quality diet (providing nutrients assuring less than $^2/_3$ of the RDA). This inferior input to nutrition is generally supported by the results of the National Nutrition Survey (Schaeffer 1970) and other nutrition studies (Davies *et al.*, 1969; Smith and Unglaub, 1972).

Bivens (1967) utilized the USDA household dietary survey to demonstrate the increase in the consumption of convenience foods over the same 10-yr period. It is my contention (Lachance, 1971a) that the dramatic increase in the consumption of highly palatable and socially acceptable snack type convenience foods, which provide for the most part only energy, has had a dilution effect upon the quality of the input of nutrients from conventional "basic four" type foods, thus decreasing the overall quality of the dietary.

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The resultant is malnutrition in terms of poor or imbalanced nutrient intake and overnutrition in terms of calories. Malnutrition and obesity are occurring together and very often in the same individuals, irrespective of economic status.

The nutrients needed to assure a balanced nutrient intake cannot be added at the agricultural, distribution or end-use stages, but must be added at the processing level since the technology for doing so is available and control mechanisms and experience exists. Further, the cost for doing so is minimal at the processing stage.

The question is not one of the need for nutrification nor of the capability to process or manufacture nutrified foods, but that of determining which foods should be nutrified, with which nutrients, at what level. We must be able to assure a balanced nutrient intake without compromising choice of foods and without fear of creating a nutrient safety problem because of indiscriminate misuse.

RATIONALE

I suggest that a good beginning for nutrification would be concern for the nutrients for which Recommended Dietary Allowances (RDA) now exist. Not only do we know most about these nutrients but they represent a good cross-section of all nutrients. Further, the malnutrition that has been identified is reflected in this list of RDA nutrients.

It may not be necessary for fabricated and some formulated foods which simulate traditional or conventional commodity foods to provide the same nutrients as some prior model because, in so doing, we will be promulgating "*commodity* food combination" rather than "food combinations" and the concepts of "standards of identity" and the label of "imitation" which, in themselves, are of no value to the consumer and thwart innovation. There is no conventional food which is perfect or a nutrition panacea. The goal must be balanced nutrition with organoleptically acceptable convenient food forms at the lowest cost. A standard of identity does not assure balanced, or for that matter, good nutrition. Further, from the point of view of nutrition, there is no such thing as an imitation. An International Working Group (1971) recommended that fabricated (formulated?) foods, particularly meal replacements, should contain nutrients in proportion to their caloric content. The working group appears to be recommending an alternate approach to the problem of "empty calories" by suggesting "fortified conventional foods," that is, foods fortified with certain nutrients beyond present levels of enrichment and/or the nutrification of fabricated foods in proportion to their place (image) in the diet and their caloric content.

I have previously suggested that nutrification should be based on proteins as well as calories (Lachance, 1970) and I am increasingly convinced that protein content and quality would provide a basis for nutrification which is superior to a calorie basis and more amenable to control than calories or restriction of nutrification to selected commodities. A concept based on protein provides a built-in reference standard which would allay indiscriminate use, because protein is a costly ingredient which requires a certain technological expertise that limits the levels that can be used, as well as the foods in which it can be incorporated. Moreover, I believe a concept of nutrification in which other RDA nutrients are titrated on the basis of utilizable protein content permits simple labeling as well as simple menu planning, compatible with consumer awareness and knowledge.

It would seem to me that vitamins/minerals which are for the most part components of protein enzymes (Riboflavin in cytochrome c reductase and L-amino acid oxidase, etc.; niacin in di- and triphosphopyridine nucleotides; pyridoxine coenzyme in transaminase, etc.) or vitamins/minerals in tissue/protein complexes vital to metabolism (vitamin A-opsin; folic acid and blood; iron and hemoglobin; B_{12} in purine biosynthesis and transmethylation etc.; ascorbic acid and collagen synthesis; vitamin D–calcium–bone protein complex) should be sufficient biochemical reason to suggest that vitamins/minerals be titrated into the metabolism on the basis of protein and not simply calories.

To qualify for nutrification a food should contain protein, or be a food which, in terms of diet habits, would *invariably* be used to complement a protein-containing food. For example, nutrification could be permitted in a spread for bread or toast, in a cereal consumed with milk, or in a finished baked product which would ordinarily have fillings, such as a cream-filled cake or toaster-type product, provided the quantity and quality of protein in the product is adequate. In other words, a food which has no protein or has protein which is not utilizable has no business being nutrified unless it invariably complements another protein food, in which case it should be nutrified only with those nutrients needed to make the combination balanced. The exception would be the existing public health enrichments, *e.g.*, iodized salt, vitamin D milk.

The question then arises as to what level of utilizable protein should be present to justify nutrification.

In 1969 an Expert Panel in the United Kingdom recommended that the dietary allowance for proteins be 10% protein calories (*i.e.*, 10% of the total intake of calories should be derived from protein) for all age groups from infants to adults.

This is a very practical guideline applicable to nutrification. Cuthbertson (1964) states that "the literature provides clear evidence of the constancy of the proportion of the total calories represented by protein in the diet. This is particularly so among the different age, sex, and activity groups of the people of the temperate regions of the world, although undoubtedly there are individual divergencies." The ratio of protein calories to total calories is remarkably constant at 10–14%. This constancy has been shown to apply to pregnant women, adolescents, American troops, and lumberjacks (7000 calories/day). In fact, in spite of the wide variation in the proportion of protein coming from animal and from vegetable sources, the ratio of protein calories to total calories is remarkably constant in different FAO countries at the national level except where the staple is very low in protein, *e.g.*, Cassava. The FAO data reveal that this ratio is not seriously affected by the average national caloric intake. It is 10.8% for the low calorie countries and 11.8% for the high calorie countries, with world average being 10.2% calories derived from protein.

I would suggest that since the lowest protein calories percent allowance of the 1968 NAS/NRC RDA is 7.0% that this be considered the minimum calories from protein a food should have to qualify for nutrification, provided the protein is utilizable (*e.g.*, has a PER of 2.0). Ten percent calories derived from utilizable protein would be considered an optimal level.

It would then seem reasonable to expect that when a food provides an acceptable ratio of protein calories to total calories, the same item should also be a candidate for assuring a proportion of the other RDA nutrients. This nutrification should be on the basis of the level of utilizable protein present and its contribution to an "idealized" RDA. If a food or prepackaged combination of foods is intended to be a meal replacement, then it should assure one-third of the averaged RDA for a family of four, as described by Senti (1972). Food

PEANUT BUTTER PASTRIES

TWO PEANUT BUTTER PASTRIES PROVIDE THE FOLLOWING NUTRIENTS:** % M.D.R. CHILDREN 6 YEARS AND OVER

Calories	530
Protein, gms	8
Vitamin A	38%
Vitamin D	9%
Vitamin E, I.U.	6*
Vitamin C	55%
Niacin	80%
Riboflavin	4%
Thiamine	51%
Vitamin B_6, mg	37*
Vitamin B_{12}, mg	.0007*
Calcium	15%
Phosphorus	24%
Iron	60%
Magnesium, mg	69*

*NO MINIMUM DAILY REQUIREMENTS ESTABLISHED.
**ONE SERVING OF 2 PEANUT BUTTER PASTRIES WITH 8 OZ. OF MILK WILL PROVIDE 1/3 OF THE RECOMMENDED DIETARY ALLOWANCE FOR GIRLS AND BOYS 10-12 YEARS OLD.

Figure 1. Example of label for formulated food

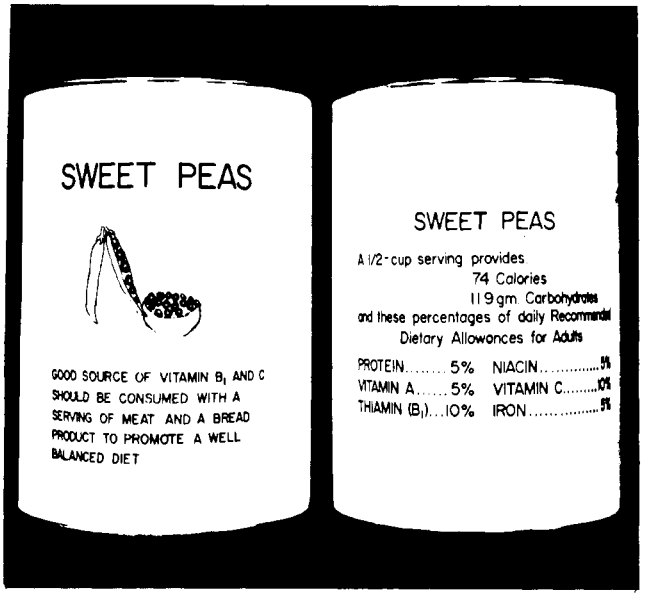

Figure 2. Example of label for commodity food

combinations for breakfast or supplemental feedings should assure at least one-fourth of the idealized RDA.

Table I is an example of two foods whose composition vary in protein at the onset. The calculations made demonstrate that the quantity of utilizable protein which would have to be added to each product in order to provide 7% protein calories can be quite variable. Once the goal is recognized, product development technology will determine whether it is possible to incorporate the additional protein into the product without the original organoleptic characteristics of the product being modified or adversely affected.

Given a product meets the goal, the quantity of protein per serving and its contribution to the daily "idealized" RDA goal would determine the level of concomitant nutrification with RDA micronutrients. For example, if a product provides 5 g of utilizable protein per serving and therefore provides 10% of the idealized allowance for protein, it should also provide the same percentage (10%) of RDA micronutrients. Note that the percentage is the same irrespective of whether a consumer would ingest one serving or 100 g. If a person should happen to be living on a small variety of foods, the probability is greater that a balanced nutriture will be ingested

Table I. Protein Fortification Decision Making for Food in Products Based on the Contribution of Protein Calories[a] to Total Calories

Product	Calories/ item	g protein item	Protein Calories item	% RDA	g of additional protein needed	% needed protein
A	84	1.7	6.8	8.0	0	0
D	12	0.17	0.68	5.7	0.4	25
X	71	0.6	2.4	3.3	0.7	115

[a] Utilizable protein content in grams times 4 cal/g equals protein calories. The goal is to assure the RDA minimum of 7% of calories from utilizable protein.

if some of the food sources, particularly the protein food sources, were nutrified.

Milk is a very good food but it is not a balanced food in that it is a poor source of vitamin E, ascorbic acid, iron, and probably folic. On the basis of its protein content, a serving of milk could easily be made to assure 9 to 18% of the RDA micronutrients. In fact, some chocolate preparations fortified with ascorbic acid and iron have been available which, when added to milk, considerably enhance its balance of nutrients.

An important nutrification precedence has already been established in the case of milk. Since nonfat dry milk does not contain vitamin A and D, it is added to PL-480 purchases of milk by the USDA. Senti (1972) has noted that these micronutrient additions to milk closely approximate the protein level and have little relationship to the caloric value. I am of the opinion that this relationship of micronutrient content of protein content rather than calories is prevalent in many other foods.

The probability of consuming too many nutrients is greater when a calorie basis is used because the relative physiological constancy of "protein calorie" intake is not capitalized upon. Further, the average American consumes greater excesses of calories than of protein. One of the reasons for this is that even when menus are planned on a Food Guide basis (ARS, 1956) the percent of the RDA provided for protein (84%) and micronutrients (79–118%) is more approximate to each other than to calories (55%). We must recognize that Americans eat more than three meals a day. There are usually several food contacts a day in addition to regular meals, *e.g.*, "coffee" breaks with and without snacks, cocktails, and bedtime snacks. All these mini meals are often sources of calories and, as previously stated, there is little scientific basis for nutrifying calories. Further, calories are the one nutrient the consumer can make a decision about by eating less or exercising more, as indicated by his bathroom scale and/or appearance.

NUTRIENT LABELING AND NUTRIFIED FOODS

With respect to nutrient labeling, not even nutritionists agree concerning detailed labeling; however, most agree on the need for nutrient labeling, as well as for minimal label information compatible with a good nutrition education program (Call and Hayes, 1970). Existing nutrient labeling (none or a listing of MDR or RDA) does not educate nor assure the consumer of balanced nutrition. He either must remember a tabulation of the glasses and servings of the various basic four foods per day and guess where and how the convenience food fits in or he must *compute* the individually listed nutrients on the label.

A food identified as being nutrified would not need a catalog listing of nutrients, but only one statement as to the percent

TOTAL RDA provided (except for calories, which could be listed separately). This concept permits the consumer to make his own combinations of foods in a building block fashion, which involves simple arithmetic. For example, three servings of different foods, each providing 10% RDA, would approximate a meal goal of 33%.

Since not all foods will be nutrified and some foods are designed by habit or otherwise to complement each other, nutritional labels which would educate by advocating food combinations would have a higher probability of impact on the consumer. An example of such a label for a formulated food is given in Figure 1. Note the unintelligible and confusing nature of the MDR listing, as compared to the verbal label at the bottom of the legend. It is obvious to the professional that the product is quite well balanced *per se* but that the suggested food combination is even more desirable, irrespective of whether the consumer ingests only *part* of each serving in the combination.

An example of a label for a commodity food is given in Figure 2. Note that the RDA nutrient information does no consider all the RDA nutrients. The nutrient label provides information but it does not educate; however, the word description identifies the important nutrients in the product *and* recommends the necessary complementing food combinations for balanced nutrition to be assured.

The concept of nutrified foods provides the consumer even broader choices than currently available because *basic food* menus are not discriminated against and in fact may be emphasized in order to optimize the social needs of man.

CONTROL (MONITORING) OF NUTRIFICATION

Infant formulas provide an excellent nutrification precedence and considerable experience relevant to the question of control. Industry as well as independent laboratory determinations of protein quantity and quality and selected micronutrients assays should be more than adequate. The quality/-control information would be in addition to certifications provided to food manufacturers by nutrient suppliers.

SUMMARY

In summary, therefore, nutrification is compatible with: The need within the community for improved nutritional status or well being; The social nature, in particular the diet habits, of man; Existing food technology capability.

The concept of nutrification based on the presence of utilizable protein in a food is compatible with the principles of nutritional biochemistry, existing concepts of balanced nutrient intake, and the economics of protein as a food ingredient.

Nutrification on the basis of protein rather than calories is to be recommended because: The role of micronutrients in biochemistry is closely related to protein metabolism or the formation of protein tissues; The caloric consumption of protein is much more constant than the consumption of total calories; The percent of each RDA micronutrient in a typical planned (basic food guide) menu more closely approximates the percent protein than it does percent calories.

The current fortification of a single food such as PL-480 dry milk more closely approximates protein than calories.

Basing nutrification on utilizable protein limits the number of acceptable candidate foods considered suitable concomitant carriers of micronutrients.

Protein is the most expensive and technologically the most difficult nutrient to manipulate in foods and therefore is technologically more self-limiting than calories. Utilizable protein is more amenable to quality control and regulatory monitoring.

Nutrification on the basis of protein permits the consumer to ingest the allowance for micronutrients without constraining his own control of caloric intake.

Nutrification on the basis of protein is more in line with the identifiable malnutrition of poor or malnourished intakes of selected micronutrients and the ingestion of excess calories.

Nutrification fosters the development of products balanced in RDA nutrients and therefore simpler nutrient labeling.

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