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EFFECT OF PROCESSING ON NUTRITIVE VALUE OF FOODS*

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The method of food processing exerts a considerable effect on the nutritive value of the foods we eat. A familiar example is the processing of rice through polishing. As polishing continues and more of the bran is removed (Table 1) the content of thiamine decreases rapidly, Nicholls (7). This loss of thiamine can be decreased by use of a type of food processing common in India, namely, parboiling which causes part of the water soluble thiamine to penetrate into the rice kernel where it is no longer removed during the polishing process. The loss of thiamine in polished rice is often compensated for by various enrichment process. However, effective enrichment is difficult to achieve. In much of Asia, rice is thoroughly washed prior to cooking and, even if thiamine is added to the polished rice, it is either lost during washing or it is discarded in excess water used in cooking.

Dr. E. Mitsuda, of Kyota University, developed a very interesting process for enrichment of rice with thiamine. He used a derivative, di-benzoyl thiamine, which is insoluble in water. Dissolved in alcohol and applied to rice, it penetrates into the kernel. It remains insoluble in water and therefore, impervious to loss through excessive washing or cooking in excess water. In fact, it is not released until the rice is digested in the stomach. This represents a very sophisticated solution through intelligent food processing. Unfortunately the process has been applied on a large scale only in Japan and incipient beri-beri remains a problem in large areas of Asia.

A number of good examples relating food processing to nutritive value are found in the processing of soybeans. Soybeans contain trypsin inhibitors, agglutinins, and other potentially deleterious factors. In fact, rats fed raw soybeans as the only source of protein will die.

It is interesting that the Chinese, who have used soybeans for many centuries, have not utilized the whole soybeans to any extent. They have always either fermented the beans to produce soy sauce, or they have fractionated the beans to produce milk, curd or other products. Many of you may be familiar with the simple processes of making soymilk and soybean curd. Briefly, the soybeans are soaked to about double their original weight, ground with water, and filtered to separate the soy milk from the residue. The steps are discussed in detail by Hand et al (5). Soybean curd (Philippine Tokua) is easily prepared from the soy milk by heating the milk to about 200°F. and precipitating the curd with calcium or magnesium salts. The curd can also precipitated by adjusting the milk to the iso-electric point of the protein (approximately 4.5). The curd is then separated from the whey by filtration.

When various soybean fractions are fed to weanling rats, they show some striking differences in the nutritive value of the protein, Hackler et al (2). This

*A paper presented at the Annual Meeting of the Philippine Association of Food Technologists, NSDB, Manila Oct. 16-18, 1968.

is most notable in a case of the residue (Table 2) which shows the highest protein value of any soybean fraction. This by-product, which generally has been fed to animals, has been shown to have a better protein value because its methionine content is higher than that in other soybean fractions. It has been demonstrated that the protein value of soybean fractions can be raised to that of casein by the simple expedient of adding extra methionine to the soybean fractions.

Another food processing method that has been studied in some detail is the production of Indonesian Tempeh in which dehulled soybeans are fermented with the mold Rhizopus oligosporus, Steinkraus et al (8). During the course of the fermentation, it has been demonstrated that the protein becomes more soluble. Fatty acids are released by the lypolysis of the fat. Breakdown of the intracellular matrix results in a marked decrease in the time required for cooking, results in new flavors, and apparently results in improved digestability on the basis of information collected in prisoner-of war camps during World War II. However, nutritive value of the protein does not increase as the fermentation time increases, (Table 3,) Hackler et al (3). When tempeh is fed to rats, increasing fermentation time is reflected in improved apparent digestion coefficient for only the first 12 hours. As shown in Table 4, the content of two essential amino acids lysine and methionine decreases as fermentation continues, Steinkraus et al (9). Looking at nutritive factors other thanprotein, we note (Table 5) that the content of thiamine and pantothenate decrease during the fermentation while the content of riboflavin, niacin and B-12 increase during the fermentation. For Indonesians subsisting primarily on rice, raising the content of the riboflavin present in tempeh, which is their "meat", can be of considerable importance in their nutrition.

The dramatic effect of relatively small amounts of heat on nutritive value of soybean protein is shown in the cooking of soymilk, Hackler et al (4). If soybean milk, which contains most of the soluble protein, is heat-treated at 250°F for 3 or 4 minutes, it rapidly attains a maximum protein efficiency ratio (PER). However, if we continue to heat soymilk at 250°F beyond to 3 to 4 minutes there is a decrease in nutritive value of the protein. On the other hand, at 200°F it requires 20 to 30 minutes heat treatment to reach the highest PER, and moreover, soybean milk can be heat processed for as long as six hours at 200°F, without seemingly damaging the protein. It is interesting to note that the amount of heat necessary to produce the highest nutritive value of soybean protein is about the same amount of heat that is required to destroy the trypsin inhibitor. Thus, the amount of the heat used in processing is directly related to nutritive value of soymilk.

This can also be demonstrated in the spray-drying of soy milk. The amount of heat applied in the spray-dryer influences the nutritive value of a spray-dried powder as shown in Table 6, Van Buren et al (11). Here you will note that as the temperature in the spray-dryer is increased, the amount of lysine decreases. At the same time, browning of the powder appears as is shown by the steady decrease in the L value as determined in the Hunter color-difference meter. You will also note the solubility of the protein decreases as the temperature in the spray-dryer increases.

The effect of deep fat frying on nutritive value of Indonesian tempeh was studied by Hackler et al (3) and Stillings & Hackler (10). The nutritive value of tempeh protein remained about the same for the first 3 to 5 minutes (Table 7), of deep fat frying. However, if deep fat frying was prolonged for 7 minutes, the

PER decreased drastically.

Finally, how does the amount of heat applied to common pea bean protein effect its nutritive value? In Table 8, Hackler et al (1), we see that nutritive value increased or remained constant as heat was applied at 121 C for up to 20 minutes. As heating i.e., cooking, was continued, the nutritive value of the protein decreased dramatically.

Further examples of the changes of nutritive value that may occur during processing are observed during the sprouting of soybeans McKinney et al (6) Thiamine and folic-acid decrease slightly. Riboflavin, pyridoxine, and biotin increase some. Niacin and pantothenic-acid increase considerably and ascorbic-acid increases markedly. During germination of soybeans, total nitrogen remains about the same; however, protein nitrogen decreases, while non-protein nitrogen increases. During germination, fat decreases while free fatty acids increase. You may wonder, what relationship there is between sprouting soybeans and manufacture of soymilk; however, during soaking of the soybeans, there are pre-germination changes in biochemical factors which influence the nutritional value of the resulting soymilk.

Thus, in order to insure that our foods provide the maximum nutritive value for the consumer, it is essential that nutritive studies be run parallel to food processing studies. Otherwise, the consumers may be eating what appears to be an adequate diet but one in which much of the nutritive value has been destroyed.

We know that foods must be preserved. If heat sterilization is used, the minimum heat treatment needed for sterility should be used to conserve maximum nutritive value of the protein and other factors such as vitamins which may be destroyed by excessive heat treatment.

In conclusion, I have tried to illustrate the close-relationship between food processing and nutritive value. This is a field in which specific data are needed. Many more studies should be conducted in the future.

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TABLE 1

Effect of Polishing Rice on Thiamine Content (7)

Bran Removed (% of whole grain)	Thiamine in the milled rice (Micrograms/gram) Raw rice	Parboiled rice
0	3.5	2.5*
6	2.6	2.5
8	2.3	2.5
12	1.6	2.4
15	0.9	2.3
20	0.5	2.2

*30 per cent. has been lost during parboiling

TABLE 2

A Summary of the Effect of Soybean Fractions upon Growth of Weanling Rats When Diets Supplied 10% Protein (2)

	Diet designation by protein supplement					
	Casein	Dehulled soybeans	Residue	Soymilk	Curd	Whey
Average daily gain, g	4.18	3.95	4.90	2.63	2.69	1.37
Average, feed intake, g	14.34	15.59	18.22	12.70	12.20	7.08
Protein efficiency ratio	2.86	2.61	2.71	2.11	2.20	1.93

TABLE 3

Summary of the Effect of Length of fermentation on Subsequent Utilization of of Tempeh Protein by Weanling Rats When Diets Supplied 10% Protein (3)

	Length of fermentation, hours				
	0[a]	12	24	36	72
Average daily gain, g	3.81	3.46	3.24	3.11	2.86
Average feed intake, g	14.90	13.70	12.43	12.20	11.68
Protein efficiency ratio	2.63	2.47	2.56	2.49	2.44
Apparent digestion coefficient, %	86.9	88.0	86.2	85.3	85.4

[a]Soybean oil meal (commercial) represents the zero-hour of fermentation.

Effect of Spray Drying Temperature
on Protein Quality Indices of Soymilk[a] (11)

Spray Drier Temperature at inlet °F	Soluble nitrogen %	Available lysine grams per 16 grams N	Hunter "L"
290	38	5.5	75
330	44	5.6	78
360	34	5.5	73
440	15	5.1	72
530	8	4.1	61
600	6	2.0	33

[a]Heated for 10 minutes at 250°F. before spray drying.

TABLE 7
Effect of deep-fat frying of Tempeh Protein when fed to weanling rats in diets supplying 10% protein (3)

	Tempeh, minutes deep-fat fried					
	0	1	3	5	7	Casein
Average daily gain, g	2.18	2.18	2.44	1.96	0.46	3.08
Average feed intake, g	10.73	10.97	11.95	11.08	7.41	11.70
Protein efficiency ratio	2.02	1.93	1.98	1.80	0.61	2.54
Apparent digestion coefficient, %	86.8	87.4	84.4	82.8	79.0	93.1

TABLE 8

Effect of cooking time at 121°C on nutritive value of Pea Bean Protein (1)

Minutes at 121°C	Adjusted PER[a]
0	-----b
5	1.29
10	1.26
20	1.20
40	.91
60	.82
120	.41

[a]Protein efficiency ratio's were adjusted to a casein standard equal to 2.50.

[b]All of the rats (10) died during the 4-week experiment.