THE PREPARATION AND KEEPING QUALITY OF THE NNRI FOOD MIXTURE (PVM)*

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When the development of a product intended to supplement a deficient or marginal diet is undertaken, it is important that the food technologist concerned should comply, as far as possible, with the requirements established by nutritionists. In the case of the NNRI food mixture (protein-vitamin-mineral supplement, PVM), which is designed to provide the normal, predominantly maize-meal diet of the Bantu with important nutritive additions, there were 2 requirements in particular which had to be met. These were:

(*i*) the preparation of the soy-beans should be carried out in such a way that the detrimental effects of certain constituents would be eliminated and the optimal nutritive value of the soy-beans would be attained; and

(*ii*) the mixing procedure should be carried out in such a manner that a completely homogeneous mixture of the constituents would be obtained. In the case of the NNRI food mixture this would involve the uniform distribution of very small quantities of vitamins and minerals throughout large quantities of the basic raw materials.

It was further of the greatest importance that the keeping qualities of the product should be reasonably good.

DESCRIPTION OF PREPARATION

Processing of Soy-Beans

It is necessary to follow a sequence of process procedures when preparing soy-bean meal of high nutritive value, as soy-beans contain bitter substances and other undesirable constituents which have to be rendered ineffective or removed before the beans can be used for human consumption. Dreyer *et al.*[1] reviewed information on toxic factors present in soy-beans and mentioned in particular the antitryptic factor which inhibits trypsin activity and which stimulates pancreatic secretion, thus impairing the digestion and retention of proteins. The effect of most toxic factors can be reduced to a minimum, or even eliminated, by the application of suitable heating processes.

Dreyer and co-workers[1] found, for example, that the antitryptic factor present in haricot beans was reduced to a minimum by autoclaving at 15 lb. steam pressure/sq.in. for only 5 minutes, and that the digestibility was increased from 30% to 75%. However, the digestibility decreased with longer heating to 60% after autoclaving for 3 hours. Rackis[2] also reported on the trypsin-inhibiting activity and mentioned that four causative factors were known to be present in raw soy-beans and in some soy-bean fractions. All the antitryptic factors could be destroyed by moderate steam heating. He found that the increase of protein efficiency and destruction of the pancreatic hypertrophic factor parallel inactivation of the trypsin inhibitor caused by steaming soy-bean flakes at atmospheric pressure. At 100°C, steaming for 15 minutes is adequate to obtain maximum protein efficiency values and to inactivate the trypsin inhibitors of either full-fat or defatted soy-bean flakes of about 1/100th inch thick. A longer steaming period would be required to achieve this with whole beans, but overheating must be avoided in order to prevent protein damage and consequent reduction of digestibility, as previously mentioned.

Iriarte and Barnes[3] also investigated the effects of overheating on certain nutritive properties of the proteins of soy-beans and found that the only factors to contribute to the decreased nutritive value of the protein of excessively-heated soy-beans were a destruction of cystine and a decrease in nitrogen absorbability. They found also that the heat treatment required to destroy the growth inhibitors present in raw soy-beans is almost as great as that that would destroy sufficient cystine to make this amino acid 'first limiting'.

It is therefore very important to determine, by the investigation of the various heating processes, the most satisfactory processing conditions for soy-beans, which

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form the main ingredient of the NNRI food mixture. The process which is being used at present for the preparation of experimental quantities of soy-bean meal, and which complies reasonably well with requirements, is the following:

The soy-beans are washed in cold water and thereafter steamed for 20 - 25 minutes at atmospheric pressure. The warm beans are rinsed with cold water to loosen the husks, then placed into water at 60°C and allowed to stand for 10 minutes. The husks are removed from the beans by friction and are screened off.

The dehusked beans are soaked in water overnight, strained and rinsed a few times with clean water to remove the saponins. Thereafter they are autoclaved in water for 20 minutes at 15 lb. pressure, after which the water is removed and the beans are dried, e.g. in a forced-draught oven, at a temperature not exceeding 50°C.

The beans are reduced to a fine meal in a two-stage milling process.

The possibility of preparing soy-bean meal of comparable quality by modern, continuous techniques is being investigated.[4]

Mixing Procedure

It is known that in some instances it is extremely difficult to obtain a homogeneous mixture of materials which differ in particle size and shape, specific gravity, sedimentation properties or tendency to agglomerate. The proportions of the various materials being mixed also have a very important bearing on the homogeneity of the resultant mixture. Demixing can also take place.[5]

An 8-step mixing procedure was used to mix the small quantities of single nutrients homogeneously into the larger bulk of proteinaceous materials. No full-fat soy-bean meal was used in making the premixes, as this product is inclined to agglomerate.

The results of 10 analyses for nicotinic acid and vitamin C showed that the final mixture was reasonably homogeneous and indicated that satisfactory mixing could be attained in large-scale production.

Keeping Quality

It is of great importance that a product such as the NNRI food mixture should have as long a shelf-life as possible. An investigation into the stability of the mixture was, therefore, conducted, and is still under way, to determine the shelf-life of the product in different packaging materials and under various climatic conditions.

In the first storage test 3 types of packaging material were examined, namely bags of polyethylene, of kraft paper laminated with polyethylene and of ordinary kraft paper. Storage was conducted under ambient conditions in Pretoria, during which temperatures varied from 10 to 30°C and humidities ranged from below 40 to 80%, and under more severe conditions, with a higher temperature (between 25 and 35°C) and relative humidity (between 70 and 90%). Anti-oxidants were added to some of the samples to determine whether these would extend the shelf-life.

Control samples were stored in polyethylene bags in a closed container at approximately −8°C.

In the second storage test only polyethylene bags were used as packaging material.

The following investigations were conducted during storage:

Organoleptic tests were conducted monthly by both White and Bantu tasting panels, each consisting of 10 members. The Bantu panel only was used for the second test. The method used was to prepare a thin gruel from the mixture by stirring together 50 G of the NNRI food mixture with one teaspoonful of thin cooked maize porridge and 100 ml. boiling water and to serve it as a gravy with a stiff maize porridge. The samples were always evaluated against control samples by a set point-rating system.

Chemical assays were carried out by methods adopted as standard procedures at the NNRI.

The total bacteria and mould counts were performed monthly by NNRI routine testing procedures. Possible contamination by salmonellae and staphylococci was checked only at the beginning and at the end of each test, and in every case the absence of these microorganisms was determined.

RESULTS AND DISCUSSION

The results of the storage tests are given briefly below. In some instances considerable variations in the concentrations of minor constituents, ascribed to unsatisfactory mixing procedures, were determined. In addition, as the product was stored in 1-lb. packages, scientific bulk sampling procedures could not be applied.

The results were analysed statistically. All the tests showed that the product remained in satisfactory condition for a longer period with polyethylene packaging than with the other two materials tested. This can most certainly be ascribed to the lower gas and moisture permeability of polyethylene. In view of the overt superiority of this packaging material, reference to, and discussion of, results are restricted to those obtained using packages made of this polymer.

Organoleptic Investigation

The findings of both the White and Bantu panels for the organoleptic evaluation of the product were almost identical, so that the results of both groups could be combined and discussed together. From the assessments made it was determined that samples stored in polyethylene bags under climatic conditions in Pretoria kept well for 12 months. The samples stored under the adverse climatic conditions developed an unacceptable off-flavour after 5 - 6 months. The results obtained are shown graphically in Fig. 1.

The addition of anti-oxidants (0·01% BHA + 0·01% BHT) resulted in a definite improvement in keeping quality, and such samples were found to be better after storage for 13 months than were untreated samples after being stored for 4 - 6 months.

Chemical Analysis

The moisture content increased from about 5 to 6% during storage under ambient conditions. Under the more adverse storage conditions the moisture content increased more rapidly, viz. to 8% after 10 months. In the second investigation the moisture content did not exceed 6·8% after 8 - 11 months' storage under the adverse conditions.

The free-fatty-acid and peroxide contents of the extracted fat were determined at regular intervals throughout the tests. The results obtained during the second storage test showed a steady increase in free-fatty-acid

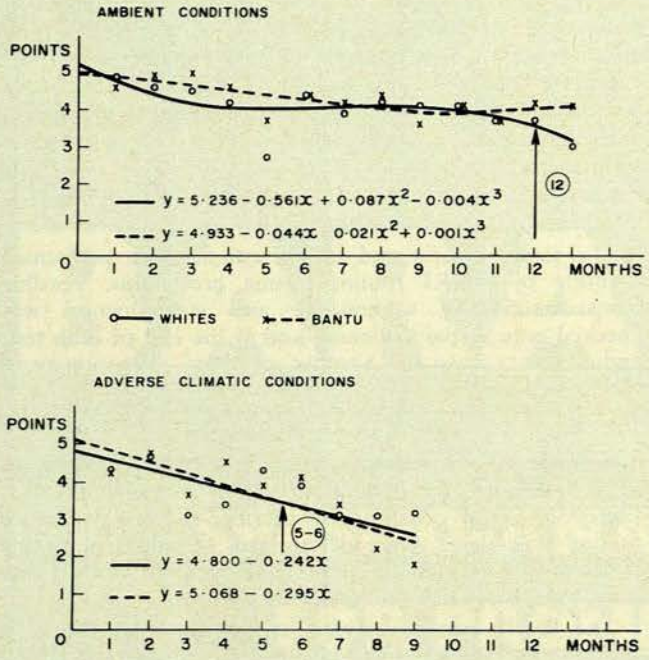

Fig. 1. Sensory evaluation of the NNRI food mixture stored in polyethylene bags.

content which rose from the initial level of 176 mg./100 G fat to 1,280 mg./100 G fat after 10 months' storage under favourable conditions (approx. 20°C and 50% relative humidity) and to above 5,000 mg. after storage at 30°C and 65% relative humidity for only 8 months (Table I). Since the organoleptic rating decreased as the free-fatty-acid content increased, it is possible that the latter may be used to assess the deterioration in the organoleptic qualities of the NNRI food mixture.

TABLE I. CHANGES IN FREE-FATTY-ACID CONTENT OF THE NNRI FOOD MIXTURE DURING STORAGE IN POLYETHYLENE BAGS (MG. $NaOH$/100 G FAT)

Storage period (months)	*Storage conditions*	
	20°C and 50% relative humidity	*30°C and 65% relative humidity*
0	176	176
1	251	570
2	291	577
3	383	863
4	588	1,372
5	554	1,820
6	633	1,720
7	640	3,000
8	1,074	5,370
9	1,233	5,376
10	1,280	—

The peroxide values were erratic (probably due to destruction of some of the peroxides formed) and could not be correlated with organoleptic acceptance.

The determination of all the vitamins was not performed every month. The values obtained are given in Table II. Vitamin-A and ascorbic acid contents were determined monthly, but only some of the values obtained are given in the table.

TABLE II. STABILITY OF VITAMINS IN THE NNRI FOOD MIXTURE DURING STORAGE IN POLYETHYLENE BAGS

Vitamin	*Storage period (months)*	*Ambient conditions*	*Adverse climatic conditions*
Thiamine	0	2·90	2·90
(mg./100 ml.)	9	—	1·47
	13	1·41	—
Riboflavin	0	3·66	3·66
(mg./100 ml.)	9	—	3·27
	13	3·43	—
Nicotinic acid	0	31·50	31·50
(mg./100 ml.)	9	—	28·82
	13	33·14	—
Pyridoxin	0	5·0	5·0
(mg./100 ml.)	9	—	7·4
	13	5·5	—
Pantothenic acid	0	15·2	15·2
(mg./100 ml.)	9	—	16·0
	13	15·6	—
Vitamin A	1*	5,942	5,316
(IU/100 G)	2	3,563	3,482
	6	3,203	3,733
	9	3,750	3,175
	13	4,238	—
Ascorbic acid	1*	194	181
(mg./100 ml.)	2	200	165
	6	169	72
	9	151	15
	13	136	—

* Initial value not obtained.

Vitamin-A content decreased moderately rapidly during the first few months, even under ambient conditions in Pretoria, after which the loss of this vitamin proceeded more slowly. After 5 - 6 months the level had fallen to about half of the initial concentration and remained approximately constant for the remainder of the storage test.* Under unfavourable climatic conditions the vitamin-A loss occurred slightly more rapidly than when the product was stored under ambient conditions.

The ascorbic acid content decreased very rapidly under adverse climatic conditions and was practically zero after 9 months. Under ambient conditions, however, the ascorbic acid content was well maintained, ranging from 194 mg./100 ml. after the first month to 136 mg./100 ml. after 13 months' storage.

Under ambient conditions thiamine decreased from 2·9 mg./100 ml. at the commencement of the storage test to an average of 1·4 mg./100 ml. after 13 months' storage. Under adverse conditions the decrease after 9 months was already as great as that after 13 months under favourable conditions. It is clear that the thiamine loss in the NNRI food mixture during long-term storage is significant, but, even so, the content of this vitamin was found to be adequate after storage of the mixture for 13 months.

*With further samples, in which the vitamin-A content was raised to 16,000 IU, storage for 6 months in polyethylene packaging in both ambient and 'adverse' conditions resulted in a loss of approximately 25% of the vitamin-A content Where anti-oxidants were added the loss was reduced to about 5%.

Riboflavin, nicotinic acid, pyridoxine and pantothenic acid contents remained virtually constant under both ambient and adverse climatic conditions.

In the microbiological investigation particular attention was paid to total bacteria and mould counts. Statistical evaluation of the results obtained showed that the bacteria count increased from approximately 20×10^4/G initially to 50×10^4/G after 6 months' storage under ambient conditions. Further storage resulted in somewhat lower counts. Under adverse conditions the bacteria count increased to 80×10^4/G after 6 - 7 months. The bacteria counts for the second storage test were lower, the initial bacteria count of about 40×10^3/G remaining approximately constant throughout the test for the product stored under both conditions. These counts were all considered to be satisfactory.

The mould counts, which were very low at the start of the test (140), increased rapidly in all instances during the first 3 months and thereafter decreased slightly. Statistical examination of the data obtained showed that the maximum mould count obtained was approximately 60,000 with storage under both conditions. Subsequently the mould count decreased, but in no instance did it fall below 10,000. For the second storage test the mould counts remained low throughout the storage period and at no time exceeded 800.

It can be concluded from the results of the storage tests thus far obtained that simple and cheap polyethylene packaging provides adequate protection for the product. In this packaging the NNRI food mixture can be stored under ambient climatic conditions in Pretoria for about a year. Under the more extreme test conditions a shelf-life of at least 5 - 6 months may be expected. It is considered that such a shelf-life would be satisfactory for all practical purposes.

It has also been shown that the NNRI food mixture remains organoleptically acceptable for a longer period when an anti-oxidant is added.

The initial contents of vitamin A and ascorbic acid have been adjusted to a higher level in view of the vitamin loss shown to occur during storage. The levels now specified will ensure adequate concentrations in the product after a storage period of 6 months when it is packed in polyethylene bags, even under the adverse climatic test conditions.

SUMMARY

The processing procedure required to render soy-beans nutritionally acceptable is discussed and the techniques employed to prepare soy-bean meal as an ingredient of the NNRI food mixture are given. Difficulties encountered in obtaining homogeneity of the mixture are mentioned. Available results of storage tests conducted with different packaging materials and storage conditions are given and discussed.

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