THE PROCESSING AND FORMULATION OF WEANING FOODS BASED ON THE WINGED BEAN

J. Maud Kordylas

Yaa Difie Osei &

E. Asibey Berko

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ABSTRACT

This experiment set out to process winged beans into flour and to utilize the processed flour in combination with other vegetable protein sources in the formulation of weaning foods. The efficiency of utilization of these vegetable protein combinations were tested by animal feeding trials. Because of variation found to exist in the protein contents of the experimental diets, PER values were considered not to be comparable and therefore may not give accurate evaluation. Protein Conversion Ratios (PCR) based on protein retention in the carcass on dried weight basis and total dietary protein intake also on dried weight basis were therefore used as basis for comparison and evaluation

The basis for the method used in the evaluation of the protein efficiencies of the formulations were discussed. A suggestion has been made that although the winged bean can be utilized as the main source of protein in combination with other cereals in the formulation of weaning foods, it is necessary to provide an adequate minimum protein level which in this case was found to be about 16 per cent rather than a higher percentage level. The results of the experiments brought to light that there is an inverse relationship between efficiency of protein utilization (PCR) and the per cent dietary protein level. Protein levels in various existing vegetable protein mixtures were reviewed and found to be very high. Doubts were therefore, stressed whether there are any benefits to be derived from the practice of making vegetable protein mixture with very high levels of protein.

INTRODUCTION

Previous work done in our laboratories in Ghana revealed that the dried matured seeds of the winged bean have a nutritional potential that can be compared favourably with that of the soybean. The quality of the proteins were also shown to be similar to those of the soybean in digestibility and composition (Cerny et al 1971). Trial feeding of children suffering from kwashiorkor, with a diet in which the winged bean provided the major part of the protein

~~gave~~ ~~results~~ which showed that the winged bean can be well tolerated by children and that it can be safely utilized as a vegetable protein substitute for milk in the treatment of protein calorie malnutrition in Ghanaian children (Cerny and Addy 1972).

Although the winged bean has the advantage of possessing a pleasant sweet taste over the soybean, its skin is tough and difficult to remove and therefore makes direct utilization of the dried seed as human food problematic (Kordylas 1976). To explore the nutritional potential of the winged bean seed therefore, industrial processing of the seed into easily usable products is highly desirable. This paper therefore, reports on a laboratory attempt made in the processing of the dried matured winged bean seed into flour and results obtained with trial feeding of weaning formulations based on the flour to laboratory animals.

EXPERIMENTAL

Processing of Seeds

Dried matured winged bean seeds (Psophocarpus Tetragonolobus) harvested from the winged bean field trials at the Crops Research Institute Experimental Station at Bunso, were used for the experiment. A sample batch of seeds was washed, steeped in water overnight, autoclaved, cooled and seedcoats removed by hand. The cleaned seeds were dried and coarsely milled for solvent extraction of the fat. The defatted meal was thoroughly dried till all traces of solvent had been removed before finely milled and sifted to produce the winged bean flour. Samples of groundnut (Arachis Hypogea) and melon seed (Cucumeropsis Edulia) were given similar treatment to obtain defatted groundnut and melon seed flours respectively. The amino acide composition of the groundnuts and melon seeds were kindly determined for us by the Food Industry Research Institute, Czech Academy of Agriculture, Prague. Samples of maize, rice and guinea corn used in the preparation of the diets were pre-cooked, dried, milled and sifted to obtain fine cereal meals. Skimmed milk powder was obtained from local sources.

Preparation of the Weaning Formulations

Six weaning formulations were prepared. The protein contents of the first three diets, Diets I, II & III were adjusted to 16 per cent, with Diet I containing Winged Bean (WB) and corn meal (C); Diet II Winged Bean (WB), Groundnut (G) and Corn meal (C); Diet III Winged Bean (WB), Melon seed (M) and Corn meal (C). The remaining three diets were prepared to contain 16 per cent protein from Winged Bean and 3.3 per cent protein from either Corn meal (C), Guinea corn (GC) or Rice (R) to make Diets IV, V and VI respectively with a total protein content of 19.3 percent. A milk diet, Diet VII, in which skimmed milk powder provided 12 per cent protein and the remaining 4 per cent was obtained from corn meal was used as the control diet at 16% protein level. Codliver oil was added to all the diets at a level of 1% and the total fat was adjusted to 15% level with groundnut oil. All the diets included 10% sucrose and 4% mineral mixture and provided between 404 to 406 calories per 100gm. Since a lot of different sources of protein were introduced into the diet formulations, the moisture, crude protein on both wet and dried weight basis were determined on all the diets in order to find some common basis when evaluating the various protein combinations.

Testing of the Weaning Formulations

Groups of hooded weaning rats obtained from the Food Research Institute rat stock were matched with respect to litter, initial bodyweight and these utilized as test rats for the various winged bean cereal weaning formulations. The rats were placed in individual cages, four rats per group, food and water were provided ad lib and food consumption was recorded daily while the rats were weighed three times per week. The feeding experiment was continued for a total of 30 days at the end of which, the animals were sacrificed and their bodies dried to determine body moisture and protein contents of the carcasses. Carcass fat was also determined by difference.

RESULTS

Composition of the Vegetable Protein Seeds

Composition of the vegetable seeds used as protein source in the formulation of the diets are shown in Table 1. After solvent extraction of the oil from the seeds, crude protein content of the flours produced were found to be 70.0g per 100g for the melon seed flour, 57.2g per 100g for the groundnut flour and 57.3g per 100g for the winged bean flour. Seed coat, course grits and oil were obtained as by-products. Analyses done on the seed coat and grits obtained from the winged beans gave 7.0g and 42.4 per cent protein respectively (Table 1).

Table 2 gives the amino acid composition of the melon seed and groundnut seed as compared with that of the winged bean. It can be noted that although the lysine contents of the melon and groundnut seeds were lower than the winged bean, the methionine level in the melon seed was twice as high as that obtained in the winged bean. This was used as basis for including a diet composed of winged bean and melon seed mixtures, hoping that the methionine of the melon seed would supplement that of the winged bean.

Protein Intake

Results for moisture, protein content based on wet and dried weight of the diet, mean diet intake and mean protein intake (dried weight basis) of the groups of rats put on the various diets are shown in table 3. It can be pointed out that although the diets were carefully mixed to contain either 16 or 19.3% protein, the actual protein levels as analyzed showed differences which ranged from 0.18 to 3.02 from the supposed protein levels. It was also found that there were variations in the moisture contents of the various diets, which also affected the final protein contents when determined on dried weight basis. The mean protein intake of the groups on dried weight basis over the 30 days experimental period are shown to vary from 33.8 to 52.8 with the highest protein intake of 52.8g corresponding to the highest food intake by the milk control group.

Growth

Figure 1 shows the growth curves obtained for the various groups of rats put on the different dietary formulations over the 30 days experimental period. The mean weight gains and mean final body weights are shown in table 4. An attempt was made to determine the composition of each rat body as obtained at its final weight and these are presented as mean body moisture, dried carcass protein and dried carcass fat (by difference). It can be seen that for each group of rats the sum total of the body moisture, carcass protein and carcass fat add up to the final body weight. It is also interesting to note that in almost all cases the ratio of body moisture to dried carcass protein to dried carcass fat is 4:1:1 as shown in parenthesis in table 4.

Evaluation of Protein Efficiency

The PER as calculated for the various diets are shown in table 5. According to the values obtained the order of efficiency of the protein combinations as given in the diets are Diet VII milk control (16.18% P) > Diet IV WB + C (16.28% P) > Diet I, WB + C (18.08% P) > WB + G + C (18.34% P) > WB + M + C (17.74% P) > WB + GC (21.90% P) > WB + R (18.73% P).

Protein Conversion Ratio (PCR) based on dried carcass protein and total dried dietary protein intake were calculated for each of the groups, the results are also shown in table 5. The amounts of dietary protein needed to deposit one gram of carcass protein were also determined for each group and the results are also shown in table 5. The figures in parenthesis in table 5 compare the order of efficiency of protein utilization in the diets as determined by PER, PCR and weight gain.

DISCUSSION

Basis for the Method of Evaluation of Protein Efficiency Used in this Study

Since various combinations of proteins were fed and there were some variations in the protein contents of the different diets (table 3), it was felt that the conventional PER as usually calculated (based on weight gain and protein intake) could not be accurately used to evluate the efficiency or the quality of quality of the protein combinations as given in these diets.

According to Allison (1955) PER varies with protein content of diet, the ratio increasing to a maximum and then decreasing as the level of dietary protein is raised. The protein, therefore must be fed at an adequate but not excessive level, since at high levels, the weight gain does not increase proportionately, with the protein intake. It has also been suggested that methods that precisely define protein retention are likely to yield more accurate results than PER values. An attempt was therefore made in this study, to evaluate the protein efficiency on the basis of carcass protein retention.

Although water content of foods does not contribute to nutritive value in the usual sense, energy value tends to vary inversely with water content. As water content increases, the protein, carbohydrates and fats contribute to the value of the foods, tend to be present in relatively lesser amounts. This fact is usually ignored when preparing diets for protein efficiency evaluation. Although care is taken to balance the major nutrients in the diets, the moisture content is more often ignored, hence the protein intake per unit of diet eaten may invariably differ, thus not giving the experimental animal groups the chance of equal protein intake per unit diet.

Although the moisture content of the experimental diets in this experiment was not initially balanced, care was taken at the end of the experiment to determine the moisture contents in order to calculate the mean protein intake per group on dried weight basis thus giving some absolute basis on which to make comparisons (table 3) between the efficiency of the dietary proteins eaten in relation to retained carcass protein.

With the ratio of 4:1:1 (Body Moisture: Dried Carcass Protein: Dried Carcass Fat) found to exist with various Body Weights analysed at the end of the experiment, (table 4), it could be assumed that this ratio may exist throughout the growing period. The initial dried carcass protein for each rat, was therefore calculated from this ratio, this subtracted from the final dried carcass protein gave the value of dried carcass protein, which could then be directly related to the sum total of dietary protein eaten, metabolised and retained during the experimental period. Absolute conversion values were then calculated for each diet and used as a more accurate basis for comparison of the dietary protein combinations fed in the experiment.

The mean and standard deviations of these ratios obtained and shown in table 5 gave the efficiency of conversion of one gram of dietary protein eaten into carcass protein to be in the order of 0.383 for the Milk Control group Diet VII (16.18% P) 0.280 for Diet IV (WB + C; 16.28% P) 0.264 - Diet III (WB + M + C; 17.74 P) 0.262 - Diet II (WB + G + C, 18.34 P) 0.245 - Diet I (WB + C; 18.08% P) 0.230 - Diet V (WB + GC, 21.90% P) 0.213 - Diet VI (WB + R 18.73 P) comparing the PER and PCR values, it can be seen that except for Diets III and I whose positions were reversed, the evaluation of the other diets correspond in efficiency when both methods were considered.

The ratio of 4:1:1 also revealed that whether the dietary protein came from animal or vegetable sources, the same ratio of body moisture, to dried carcass protein, to dried carcass fat, in relation to body weight was maintained during the growing period. For this ratio, which could be equated to growth therefore, to occur, the quality of the protein in the diet must be optimum and in such levels that only some minimum amount would be required to provide the necessary tools for the ratio of 4:1:1 to be achieved in the shortest possible time.

The lesser the protein quality, the more would be needed to be eaten, and hence the longer the time needed for this growth to be achieved. Determination of the minimum dietary protein eaten per gram of carcass protein deposited, therefore, may be used as a basis for comparison and evaluation of efficient utilization of the protein given. Thus dividing the total amount (dried wt basis) of dietary protein intake over the specified period, by the deposited carcass protein produced over the same period (Final dried carcass protein - Initial dried carcass protein) would provide the amount of dietary protein eaten for retention of one gram of carcass protein. Figures shown in table 5 reveal that Diet VII needed about 2.61 gms of dietary protein to be eaten/gm carcass protein as compared with 3.57 for Diet IV, 3.79 for Diet III, 3.82 for Diet II, 4.04 for Diet I, 4.30 for Diet V and 4.68 for Diet VI.

The Diet with the least dietary protein intake per gram carcass protein deposited thus showed the fastest growth rate. It is suggested that if all the dietary components, protein level, carbohydrate, fat, energy and moisture had been properly balanced in the experimental diets given the gwowth rates alone might have reflected the protein quality.

Relation Between Per Cent Dietary Protein Level and Efficiency Utilization

Most weaning formulations based on vegetable protein sources have protein contents higher than 16%. Some examples are soy-corn mixture made in Brazil with 30% protein. Groundnut and wheat preparation produced in India with 42% protein. A mixture of groundnut, millet and milk produced in Senegal has between 18 to 20% protein. Cotton seed, soya, rice, sorghum and wheat mixture made in Central and South America has between 25 to 35% protein. In South Africa, a mixture of soya, groundnut, fish protein, maize and wheat germ preparation produced has 22% protein. Another product produced in Rhodesia containing maize, soya, groundnut, fish and skimmed milk is 23.4% protein and Uganda has a product made up of groundnut, skimmed milk and maize flour which contains 20% protein (Orr and Adair 1967).

In preparing the weaning formulations tested in this experiment, a deliberate attempt was made to evaluate the efficiency of utilization of two protein levels, that at 16% and 19.3%. As indicated in table 3, the actual protein levels of the prepared diets tested varied from 16.18 to 21.90%. This, therefore, provided sufficient dietary protein per cent range to enable an assessment of the relationship between dietary protein level and the efficiency of utilization of the dietary protein. Fig. 2 illustrates the relationship between per cent dietary protein content and protein convension Ratio (PCR). The graph reveals a definite inverse relation between the protein content of the diet and the efficiency with which it was utilized by the body, with the highest efficiency ratios being associated with the lowest per cent protein levels, those nearest 16% in this case. The same point was further illustrated by the fact that Diets I and IV which were both composed of winged bean and corn meal were not rated with the same efficiency, although they were of similar composition, with respect to protein quality. Diet IV with the lower protein content (16.28%) was shown to have a better protein efficiency than Diet I with the higher percentage protein level (18.08%). (Tables 3 and 5).

These results, therefore, reveal that not only does the efficiency of utilization of dietary protein in the body depend on the quality of the proteins in the diet, but may also be dependent on some desirable protein level. Such a desirable level, it is felt, must be ascertained, in order to make the most optimum combination, with available proteins so that the maximum efficient utilization could be obtained.

The fact that a definite inverse relationship has been shown in this study, to exist between the percentage dietary protein level and the efficiency of utilization therefore, puts some doubts on whether there are any benefits to be derived from the practice of making vegetable protein mixture with very high levels of protein.

CONCLUSION

It can therefore be concluded that weaning formulations can be made from the Winged Bean as the main source of protein in combination with other cereals. The minimum percentage protein level needed in the weaning formulation to give maximum protein efficiency, however, must be determined on the mixtures formulated since the results of this experiment brought to light that there is an inverse relation between the efficiency of protein utilization and the percentage level of dietary protein. Sixteen per cent protein level in this case was found to give better efficiency of protein utilization than the higher dietary protein levels. Doubts have therefore been stressed on whether there are benefits to be gained with the practice of making vegetable protein mixtures with very high levels of protein.

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