Philippine Journal of Science
129 (2): 77-83, December 2000
ISSN 0031-7683

Technical Feasibility of Developing an Instant Tube Feeding Formula

C.C. Tanchoco*, M.F. Villadolid, A.S. Natividad, M.P. Rodriguez, A.B. Martin, R.L. Santos, M.A. Udarbe and W.N. Lainez

Food and Nutrition Research Institute
Department of Science and Technology
General Santos Avenue, Bicutan, Taguig, Metro Manila, Philippines

A study was undertaken to determine the feasibility of developing a low cost, instant tube feeding formula from indigenous food sources. These includes shelf-life studies, quality control, nutrient content determination and assessment of the microbiological safety of the product. As a result, a dehydrated instant tube feeding formula with a nutrient density of 1 kcal/ml was developed from a mixture of flour prepared from a 70:30 combination of germinated rice and mungbean (GRM), squash powder, skimmed milk, corn oil and sugar (53:5:12:20:10). The rice mungbean flour was packed in plain polyethylene bags for storage studies for a period of six months at room temperature conditions. Microbiological evaluation undertaken during storage showed the sample to be safe. Proximate composition, vitamin, and mineral analyses showed the formula to be more than 50% adequate in energy, protein, calcium, iron, retinol, thiamine and riboflavin recommended daily allowance (RDA) of a 20-39 year old reference man. Protein quality evaluation revealed that the amino acid values approximated the FAO reference pattern except for lysine and is comparable to casein in terms of weight gain per day. The formula was found to be comparable to the commercial formula in terms of nutrient density and is twelve and a half (12.5) times cheaper. The potential of the dehydrated tube feeding formula developed holds promise in contributing to the nutritional care of enterally-fed patients and will be a significant development in the food industry.

Key words: Enteral nutrition, enteral feeding, nutrition support

Tube feeding is considered very essential to hospital patients. It serves as a major source if not the only source of nutrition for hospitalized patients whose gastrointestinal tracts are non-functional. It is therefore of great nutritional significance to develop tube feeding formulas in order to help alleviate malnutrition among hospitalized patients.

Tube feeding formulas that are available commercially in the Philippines are mostly imported and marketed by big multinational corporations and thus, are very expensive and beyond the purchasing power of certain population groups and are only within the reach of high and moderate income level families.

Blenderized formulas, on the other hand, are sold commercially in some hospitals but these are cumbersome to prepare and may contain high microbial loads (Tanchoco et al. 1990) which may worsen the condition of the patient.

The need therefore for the development of a locally formulated tube feeding formula from indigenous sources that is easy to prepare, with minimal use of equipment, cheaper and microbiologically safe becomes more real and urgent in the light of increasing prices of its commercial counterpart.

*Corresponding author: cct@fnri.dost.gov.ph

In view of this, the study was undertaken to determine the feasibility of developing an instant tube feeding formula. Specifically, it aimed: 1) to develop a low-cost and easy to prepare instant tube feeding formula from common/indigenous food sources; 2) to conduct shelf-life studies, quality control and nutrient content determination of the instant tube feeding formula; and 3) to assess the microbiological safety of the product.

Materials and Methods

Preparation of Flour Samples

Rice-mungbean flour was prepared from germinated rice-mungbean (GRM) with germination periods of 72 and 48 hours respectively according to the standardized technology for flour production (Marero et al. 1988). The washed germinated seeds were dried in the forced draft oven at 60-65°C for 10 to 12 hours after which the seeds were cleaned of sprouts and hulls by rubbing and winnowing. Seventy parts of the dried germinated rice were combined with 30 parts of mungbean (by weight) to balance the protein and amino acid profile of the blend (Marero et al. 1988). The blend was homogenously mixed before extrusion. The extrudate was dried in a forced draft dryer and later milled to yield the rice-mungbean flour. Figure 1 shows the processing operation involved in the preparation of rice mungbean flour.

Preparation and Packaging of Tube Feeding Formula

A dehydrated instant tube feeding formula with a nutrient density of 1 kcal/ml was developed from locally available raw materials. The formula contains 53% rice mungbean flour, 5% commercially prepared squash powder, 12% skimmed milk, 20% oil and 10% sugar per 1 000 kilocalories. The formula was packed in oriented polypropylene-vacuum metallized cast polypropylene (OPP-VM-CPP) of about 50 grams containing 250 kilocalories. The corn oil and sugar were packed separately in plain polyethylene plastic bag (3 mils).

Microbiological and Analytical Tests

Samples of the germinated rice mungbean flour for analytical tests were packed in thick polyethylene bags (0.5mm), sealed and stored in the freezer (0°C) until use. Proximate composition as well as the vitamin and mineral analyses of the sample were determined using the official methods of AOAC (1980). Food energy was determined by calculation using the Atwater factor (4 x protein, 9 x fat and 4 x carbohydrates). Using the standardized microbiological procedure for food (APHA, 1958), total plate count (TPC), yeast and molds counts, coliforms and staphylococci were done in the thawed sample, monthly for six months.

The protein quality of the tube feeding formula was evaluated in terms of Protein Digestibility Corrected-Amino Acid Score (PDC-AAS) according to the Joint FAO/WHO/UNU method (1985). The control (casein) and test (tube feeding formula) diets were prepared and analyzed for proximate and amino acid composition using AOAC methods (1980) and high performance liquid chromatography (HPLC) respectively. Casein was incorporated into the test diet at a 10% protein level. A protein-free diet was also prepared for evaluation. The composition of the test diets are presented in Table 1. The test diets were made isocaloric.

Thirty male, 8 weeks old Sprague-Dawley rats with mean weight of 254± 11.51 grams were divided into two groups: control and test. They were housed individually in stainless steel cages and fed with their respective diets for 7 days. Water was given ad libitum. Feces were collected; food intake and spillage were recorded on the 4th till the 7th day of the study. On the 8th till the 14th day, both groups were given a non-protein diet. Fecal collection, food intake and spillage were recorded on the 11th till the 14th day. The nitrogen intake of the rats were computed and the fecal nitrogen on both the test and non-protein diet were analyzed. True digestibility (TD) was computed as follows:

Table 1. Composition of test diets (g/100 g)

Constituent	Diet	
	Casein (g)	Tube Feeding Formula (g)
Casein	12.06	-
Tube Feeding Formula	-	76.22
Corn Oil (10%)	10.00	5.22
Salt Mixture (4%)	4.00	4.00
Alphacel (5%)	5.00	4.34
Vitamin Mixture (1%)	1.00	1.00
Cornstarch	67.94	9.22
Total	100.00	100.00

$$\text{True Digestibility} = \frac{\text{Intake} - (\text{Fecal of test diet} - \text{Fecal of non-protein diet})}{\text{Intake}} \times 100$$

Amino acid score of the test diet was computed and multiplied with the true digestibility to obtain the protein digestibility-corrected amino acid scoring (PDC-AAS) of the test product.

Data were analyzed and presented in means ± S.D. Differences in mean protein quality indices of the test and control samples were also tested for significance.

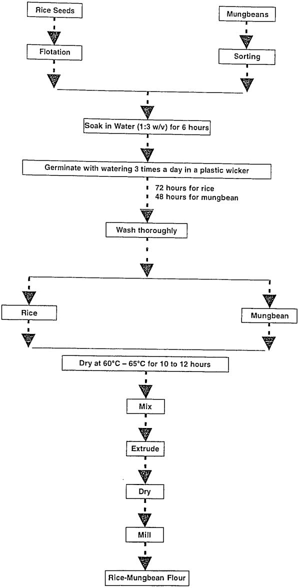

Figure 1. Flow sheet for the preparation of flour from germinated rice and mungbean flour.

Results and Discussion

Mungbean was used in the cereal based weaning foods since it was found to be relatively free from toxic factors, flatus producing substances and trypsin inhibitors (Desikachar 1981).

Table 2 shows the food and nutrient composition of the tube feeding formula developed. The table further shows that per 100 grams sample contains 12.38% calories from protein, 68.09% calories carbohydrates, 20.57% calories from fat and 420 calories. These levels are comparable to the normal percentage distribution of calories from these macronutrients.

Table 2a compares the nutrient density of the developed FNRI formula and the commercial formula and was found to be comparable. The developed formula provided fair to more than adequate amounts of protein, calcium, iron and the major vitamins except niacin and vitamin C. Per 500 kcal, the raw food cost of the developed formula is twelve and a half (12.5) times cheaper than the cost of the commercial formula.

The percentage adequacy of the 2000 kilocalories of the tube feeding formula was compared to the recommended daily allowance (RDA) of the reference man as shown in Table 3. It can be observed that the formula is more than 50% adequate in terms of energy, protein, calcium, iron, retinol, thiamine and riboflavin.

Protein quality evaluation in terms of PDC-AAS revealed that the amino acid values of the formula approximated the FAO reference pattern (1985) except for lysine and is comparable to casein in terms of weight gain per day indicating no adverse effects after the feeding period of one week. It was noted however, that the PDC-AAS of the formula was found to be inferior to casein of milk (0.86 v.s. 1.20) as a protein source for maintenance of biological life processes brought about by the lower TD. These findings may be due to the anti-nutritional factors (e.g. trypsin inhibitors, hemaglutinins and tannins) and/or

Table 2. Food and nutrient composition of the developed tube feeding formula.

Nutrient	Food	Rice-Mungbean	Squash Powder	Skimmed Milk	Corn Oil	White Sugar	Per 500 KCal	Per 100 KCal	Per 100GM
	Weight (g)	74	7.8	17.2	11.6	13.5	124.1		
Energy, kcal[a]		279	27	60	102	52	521	104	420
Protein, g[a]		9.4	0.6	6.2	0.0	0.0	16.1	3.2	13
Carbohydrate, g[a]		60	6.1	9.1	0.0	13.5	88.7	17.7	71.5
Fat, g[a]		0.2	0.1	0.1	11.6	0.0	11.9	2.4	9.6
Ash, g[a]		1.1	0.5	–	Tr	0.0	1.6	0.3	1.3
Calcium, mg[a]		16	9	220	4	0.0	248	50	20
Phosphorus, mg[a]		148	29	167	0	0	344	69	277
Iron, mg[a]		8.9	0.2	0.05	0.02	0.0	9.1	1.8	7.4
Retinol, ug[a]		ND	268	60	–	–	140	28	113
Beta-Carotene, ug[a]		ND	160	0.9	3	–	35	7	28
Thiamin, mg[a]		0.18	-	0.07	Tr	Tr	0.24	0.05	0.20
Riboflavin, mg[a]		0.07	-	0.28	0.001	0.001	0.35	0.07	0.28
Niacin, mg[a]		2.0	-	0.2	Tr	Tr	2.2	0.4	1.7
Vitamin C, mg[a]		0.3	1	–	–	–	1	0.3	1
Sodium, mg*		9	8	95	Tr	Tr	112	22	90
Potassium, mg*		216	-	273	Tr	0.3	489	98	394
Magnesium, mg*		70	-	22	Tr	Tr	92	18	74
Zinc, mg*		2.03	-	0.69	Tr	0.03	2.74	0.55	2.21
Copper, mg*		0.21	-	Tr	Tr	0.03	0.21	0.04	0.17
Manganese, mg*		0.69	-	Tr	Tr	Tr	Tr	Tr	Tr
Iodine, mg*		ND	-	–	N	Tr	ND	ND	ND
Pyridoxine, mg*		0.14	-	0.10	–	0	0.25	0.05	0.20
Vitamin B12, mg*		–	-	0.45	–	0	0.45	0.09	0.36
Folic Acid, mg*		0.24	–	8.77	–	0	9.01	1.80	7.26
Fatty Acids, Sat., g*		–	–	0.07	1.47	0	1.54	0.31	1.24
Mono., g*		–	–	0.03	2.87	0	2.90	0.58	2.34
Poly., g*		–	–	Tr	6.70	0	6.70	1.34	5.40
Cholesterol, mg*		–	–	2.06	0	–	2.06	0.41	1.66
Dietary Fiber, g*		7.7	1.3	–	–	–	9.08	1.82	7.32

[a] Values taken from FNRI Food Composition Table (FCT), 1990

* Values taken from McCance and Widdowson's The Composition of Foods, 1991

ND = not detectable

Tr = trace

Table 2a. Comparison of nutrient density of FNRI formula and commercial formula.

Nutrients	FNRI Formula*	Commercial**
Energy, kcal	1.04	1.00
Protein, g	0.03	0.03
Carbohydrates, g	0.18	0.12
Fat, g	0.02	0.04
Ash, g	0.003	0.006
Calcium, mg	0.5	0.6
Phosphorus, mg	0.69	0.5
Iron, mg	0.02	0.01
Retinol, ug	1.4	0.005
Beta-Carotene, ug	0.35	No nutrient information
Thiamin, mg	0.002	0.002
Riboflavin, mg	0.004	1.075
Niacin, mg	0.022	0.025
Vitamin C, mg	0.05	0.15
Sodium, mg	1.12	0.5
Potassium, mg	0.98	1.25
Magnesium, mg	0.18	0.2
Zinc, mg	0.0004	1.0
Manganese, mg	Tr	0.0025
Iodine, mg	ND	0.00008
Pyridoxine, mg	0.0005	0.002
Vitamin B12, mg	0.001	0.000008
Follic Acid, mg: Sat., g	0.018	0.002
Mono., g	0.003	No nutrient information
Poly., g	0.013	No nutrient information
Cholesterol, mg	0.004	No nutrient information
Dietary Fiber, g	0.018	No nutrient information

*Raw food cost per 500 kcal = P8.00
**Cost per 500 kcal = P100.00

Table 3. Percentage adequacy of 2000 kcal of tube feeding formula compared to RDA reference man, age 20-39 years.

Nutrients	PER 2000 KCAL	RDA	ADEQUACY (%)
Energy, kcal	2020	2570	78.60
Protein, g	62	60	103.33
Carbohydrate, g	336	–	–
Fat, g	48	–	–
Ash, g	6	–	–
Calcium, mg	1100	500	220.00
Phosphorus	780	–	–
Iron, mg	8	12	66.67
Retinol, ug	560	525	106.67
Beta-Carotene	80	–	–
Thiamin, mg	1	1.3	76.92
Riboflavin, mg	1.4	1.3	107.69
Niacin, mg	8	25	32.00
Vitamin C, mg	12	75	16.00
Sodium, mg	414	–	–
Potassium, mg	1960	–	–
Magnesium, mg	380	–	–
Zinc, mg	11	–	–
Copper, mg	1.0	–	–
Manganese, mg	2.8	–	–
Iodine, mg	27.4	120	22.83
Fatty Acids, Sat., g	6.2	–	–
Mono., g	11.6	–	–
Poly., g	26.8	–	–
Cholesterol, mg	8.4	–	–
Dietary Fiber, g	36	–	–

Table 4. Nutritional composition of test and control samples.

Sample	Moisuture (%)	Protein (%)	Fat (%)	Crude Fiber (%)	Carbo-hydrate by difference (%)	ASH (%)	ISO (%)	LEU (mg/g)	LYS mg/g	Sulfur Amino Acids mg/g	Aromatic Amino Acids mg/g	THR (mg/g)	TRY (mg/g)	VAL (mg/g)
Tube Feeding Formula, Freeze-Dried (1)	6.14	13.12	6.27	0.87	69.94	2.24	43.6	90.1	58.0	34.4	80.1	33.6	28.6	60.8
Case in Control, Sigma	n.a.	82.88	n.a.	n.a.	n.a.	n.a.	53.3	104.6	101.2	n.a.	115.0	42.3	12.6	72.0

(1) Germinated rice: mungbean (70:30), 60g; Skimmed milk, 14g; Squash powder, 6.3g; Corn oil, 9.3g; Sugar, 10g; mixed in 239 mL water and freeze dried (25 microns and -50° to -150°F)
(2) FAO Reference Pattern, 2-5 year child. Joint FAO/WHO/UNU Expert Consultation, 1985
n.a. = not analyzed

heat treatment employed in the preparation of the product (Sarwar & Peace 1994) as seen in the brown coloration of the extruded formula compared to its creamish raw state. On the other hand, the PDC-AAS of the formula was still higher than the values reported for the average Filipino diet of 0.76 (Intengan & Marfori, 1971) and the analyzed protein value of whole milk powder which is 0.82 (1990). (Tables 4 and 4a).

Microbiological examination of the product before storage and until the 6th month of storage at room temperature conditions gave a very low aerobic plate count as well as yeast and mold counts, based on the FAO/WHO (1983) limit for foods and the values of Hobbs and Greene (1976). The coliform, *E. coli* and Staphylococcus *aureus* were also found to be negative in the product (Table 5).

Table 4a. Protein quality indices of test and control samples.

	Diet Intake g/day	Protein Intake g/day	Weight Gain g/day	Amino Acid Score	True Digestability (%)	PDC-AAS
Tube Feeding Formula	11.6 ± 2.47[b]	1.68 ± 0.25[a]	5.40 ± 2.36[a]	0.99 (Thr)	87.1 ± 2.82[b]	0.86
Case in Control	14.2 ± 3.31[a]	1.40 ± 0.33[b]	5.22 ± 3.09[b]	1.24 (Thr)	96.7 ± 1.24[a]	1.20

Values are presented in x̄ ± SD
Values within the same column with different superscript are statistically significant at P≤0.05

Table 5. Microbiological analysis of germinated rice-mungbean flour during storage at room temperature.

Storage Period (month)	Microbial Count (CFU/g)				
	TPC	Y&M	Coliform	*E. coli*	*S.aureus*
Initial	13 x 10^1	5	Negative	Negative	Negative
1st Month	15 x 10^1	5	Negative	Negative	Negative
2nd Month	15 x 10^1	13 x 10^1	Negative	Negative	Negative
3rd Month	9 x 10^1	4 x 10^1	Negative	Negative	Negative
4th Month	7 x 10^1	3 x 10^1	Negative	Negative	Negative
5th Month	13 x 10^1	3 x 10^1	Negative	Negative	Negative
6th Month	12 x 10^1	2 x 10^1	Negative	Negative	Negative

CFU = Colony forming forming unit; TPC = Total plate count; Y&M = Yeast and mold counts

Conclusion

The potential of the dehydrated tube feeding formula developed hold promise in contributing to the nutritional care of enterally-fed patients and will be a significant development in the food industry. The pilot level of production will pave the way for the subsequent commercial scale production of the formula.

References

AOAC. 1980. Official methods of analyses, (Ed.) W. Horwitz. Assoc. official analytical chemists, Washington. DC.

APHA. 1958. Recommended methods for the microbiological examination of foods, American Public Health Association Inc., New York.p.285.

Christian JHB. 1983. Microbiological criteria for foods. Summary of recommendations of FAO/WHO expert consultations and working groups. 1975-1981. WHO, Geneva, Switzerland, p. 7.

Desikachar HSR. 1981. Development of weaning foods with high calorie density and low paste viscosity using traditional technologies. Food Nutrition Bulletin 2:21.

Food and Nutrition Research Institute. 1990. Food Composition Tables. Handbook 1, 6th revision, vol.1. Department of Science and Technology, Metro Manila.

Hobbs WE & WV Greene. 1976. Compendium of methods for the microbiological examination of foods. American Public Health Association Washington, D.C., p.25.

Holland B, Welch AA, Unwin ID, Buss DH, Paul AA & DAT Southgate. 1991.

McCance & Widdowson's The Composition of Foods. The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food. United Kingdom.

Intengan CLl & Marfori CG. 1971. The Protein quality of the Filipino diet. Philippine Journal of Nutrition 24:37-43, 1971.

Joint FAO/WHO/UNU Expert Consultations. 1985. Energy and protein requirements . WHO Technical Report Series No. 724. WHO, Geneva, Switzerland, p. 7.

Marero et al. 1988. Technology of weaning food formulations prepared from germinated cereals and legumes. Journal of Food Science 53:1391-1395.

Marero et al. 1988. Nutritional characteristics of weaning foods prepared from germinated cereals and legumes. Journal of Food Science 53:1399-1402.

Sarwar G & Peace R. 1994. The protein quality of some enteral products is inferior to that of casein as assessed by rat growth methods and digestibility-corrected amino acid scores. Journal of Nutrition 124:2223-2232.

Tanchoco CC, Florentino RF, Gopez MD, Pingol MC, & Castro Ma CA.1990. Survey of blenderized diets prepared by some hospitals in Metro Manila: Phase III. Microbiological analysis of blenderized diets. Hospital Journal 22(4):27-30.