J. KOREAN SOC. FOOD NUTR.
13(4) 377~380 (1984)

Development and Product Quality of High Nutrition Low Cost Supplementary Foods for Children

Part II. Nutritional Evaluation of Proposed Supplementary Foods

Hong-Sik Cheigh, Chung-Hee Ryu* and Tai-Wan Kwon*
Dept. Food Science and Nutrition, Pusan National Univ., Pusan, Korea,
**Div. of Biological Science and Engineering, Korea Advanced Institute of Science and Technology, Seoul, Korea*
(*Received June* 10, 1984)

어린이용 고영양 보충식품의 개발에 관한 연구

2. 개발제품의 영양학적 고찰

최 홍 식·유 정 희*·권 태 완*
부산대학교 식품영양학과, *한국과학기술원 생물공학부
(1984년 6월 10일 접수)

Abstract

Nutritional evaluation of the proposed supplementary foods (high nutrition-low cost foods) for children were conducted for the "Wonseong County Comprehensive Nutrition Program" in Korea. Proximate composition, mineral, vitamin and amino acid composition were determined and also protein efficiency ratio(PER) was evaluated for the propsed formulas which were recommended as CSS (corn-soybean-sesame blend)—3, CSS—4 and BSS (barley-soybean-sesame blend)—4 in previous study. Protein and caloric contents of the formulas were around 18% and 400 Kcal/100 *g* respectively, and they have reasonable contents of mineral and vitamin. Amino acid score (83-89) and PER (2.33-2.36) of the proposed formulas were considered to be in adequate range of protein quality for feeding the target group in Wonseong County area.

Introduction

In order to develop the high nutrition-low cost (HNLC) supplementary foods for children for "Wonseong County Comprehensive Nutrition Program" in Korea, the formulation and production performance of selected supplementary foods was conducted[1]. The basic formulas recommendable from the experimental results were considered as CSS—3, CSS—4 and BSS—4. All these formulas as enriched snack or powder type-HNLC supplementary foods were found in the acceptable range of mechanical, organoleptical and economical point of view[1,2].

In this study, nutritional quality of the proposed supplementary foods was evaluated and discussed based on the results of nutritional survey in Wonseong County[3] and PAG Guideline[4].

Experimental Methods

Formulation and Preparation of Proposed Foods

Formulation of the proposed HNLC supplementary foods are described in Table 1, which was based on the results of previous study[2]. Pearled and ground naked barley (pearling rate: 58%, particle size: 40—60 mesh), corn flour (Chunil Grain Co., Seoul), defatted soybean flour (Dongbang Oil Co., Seoul), sesame flour, oil, salt were edible grade and obtained in common market. Vitamins (vita min A acetate, vitamin B_2) and minerals ($CaHPO_4 \cdot 2H_2O$ and $FeSO_4 \cdot 7H_2O$) were obtained from Pfizer, Inc. (New York, USA) and were used for fortification. Preparation of proposed food products were conducted with procedure of KIST-MFM Extrusion Cooking System[2] which is outlined in Figure 1.

Analytical Methods

Crude Protein, fat, ash. fibre and moisture contents were analyzed by AOAC Methods[5]. Vitamin contents of A, B_1, B_2 and niacin were determined by Carr-Price reaction method, thiochrome method, fluro-

Tabale 1. Material composition of the selected (proposed) formulas for HNLC supplementary foods

Materials	Formulas (%)		
	CSS-3	CSS-4	BSS-4
Corn flour	65.0	68.0	—
Barley flour	—	—	65.0
Defatted soybean flour	25.0	20.0	25.0
Sesame flour	2.0	2.0	2.0
Soybean oil	2.0	—	2.0
Corn oil	—	3.0	—
Sugar	4.0	5.5	4.0
Salt	1.0	0.5	1.0
Others*	1.0	1.0	1.0

*Others include vitamins, minerals and other additives

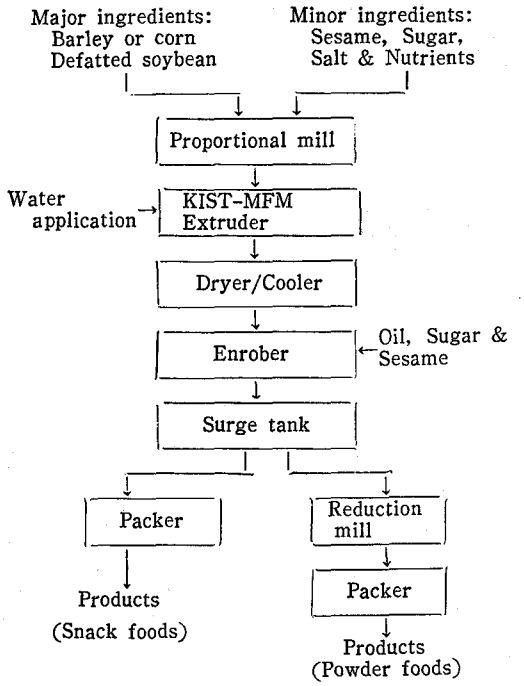

Fig. 1. Flow chart of KIST-MFM extrusion cooking system for the production of HNLC supplementary foods

metric method and cyanogen-bromide method, respectively[6]. And also KMnO4 quantitative method was used for calcium and ortho-phenanthrolin method was adapted for iron determination[5,7]. Amino acid analysis was done according to Spackman et. al.[8,9], using Beckman automatic amino acid analyzer(Model 116, Beckman Instruments Inc., USA).

Determination of Protein Efficiency Ratio (PER)

The PERs of the individual formula were determined by the rat growth method[10]. Weanling albino rat (Spragu Dowley, average 25 days old) weighing 52±5 g from Laboratory Animal Division, Mogul Co. (USA) were used and initially fed on the standard diet for 5 days. And then the 28 male rats were alloted to 4 groups according to simple randomized design. All dietary formulas, which were produced by KIST-MFM Extrusion System, were adjusted as the level of 10±0.3% protein and 400 ±2.0 Kcal and were contained with other proper nutrients.

The diets were fed ad libi to the rats for four weeks. Records of food intake maintained for each animal and the rat were weighed weekly.

Results and Discussion

General Nutritional Composition

Proximate composition and caloric content of three formulas (CSS-3, CSS-4 and BSS-4) are shown in Table 2. The foods were generally high protein level and over 18% of protein content. The calorie is ranged to about 400 Kcal per 100g of food on the average, while CSS-4 formla indicated a little higher level than other formulas. And they have reasonable contents of minerals and vitamins (Table 3). Compared with BSS-4 formula, CSS-3 and CSS-4 formulas had higher amounts of vitamin A and niacin. But three formula provide a considerable amount of these vitamins and minerals. This is considered as resulting from the fortification with vitamin A and B_2, calcium and iron, and such a result is also considered helpful in filling the nutrision gap as disclosed by the study on nutrition survey of Wonseong County people[3].

Table 2. Proximate composition of the proposed supplementary foods

Components	Formulas		
	CSS-3	CSS-4	BSS-4
Moisture(%)	5.9	6.5	6.6
Crude protein(%)	18.5	18.4	18.8
Crude fat(%)	2.7	4.7	2.9
Crude ash(%)	4.3	4.4	4.2
Calorie (Kcal)	398	409	391

Table 3. Contents of vitamins and minerals of the proposed supplementary foods

Components	Formulas		
	CSS-3	CSS-4	BSS-4
Calcium(mg%)	332.5	323.3	348.0
Iron(mg%)	4.7	4.4	5.7
Vitamin A (IU/g)	53	53	40
Vitamin B_1 (μg/g)	1.7	1.6	1.7
Vitamin B_2 (μg/g)	6.2	6.0	5.1
Niacin (μg/g)	85	84	76

Amino Acid Composition and Amino Acid Score

Amino acid composition of the developed supplementary food products are listed in Table 4. Analysis revealed that the value of glutamic acid was on the highest level followed by aspartic acid and leucine. Increasing soybean of the formulas increased lysine content but decreased the content of both methionine and cystine when expressed as mg of amino acid per g of protein[11]. The average amino acid score was calculated by comparing the results with the FAO reference amino acid pattern[12]. Amino acid score was found around 86 on the average, indicating sulfur containing amino acid as the first limiting amino acid.

Protein Efficiency Ratio(PER)

Results of PER studies are given in Table 6. Protein quality of the proposed foods, as determined by rat growth studies, was superior to that of barley or rice flour only[13]. PER 2.3 and higher results were possible by blending soybean flour and sesame in cereals. BSS-4 formula was determined to be of the highest PER and it was

Table 4. Amino acid composition of the proposed supplementary foods

(Unit: %)

Amino acids	Formulas		
	CSS-3	CSS-4	BSS-4
Lysine	0.941	0.921	0.879
Histidine	0.478	0.492	0.431
Arginine	1.050	1.136	1.010
Aspartic acid	1.673	1.601	1.878
Threonine	0.785	0.799	0.757
Serine	1.062	1.051	0.995
Glutamic acid	3.929	3.706	3.818
Proline	1.206	1.262	1.570
Glycine	0.773	0.788	0.822
Alanine	1.073	1.072	0.902
Valine	0.809	0.824	0.887
Methionine+cys.*	0.528	0.542	0.573
Isoleucine	0.707	0.712	0.762
Leucine	1.721	1.656	1.431
Tyrosine	0.534	0.527	0.663
Phenylalanine	0.912	0.910	1.041
Amino acid score	83	86	89

*Limiting amino acid

also noted that all the CSS formulas were of higher PER as compared with full-fat soybean of 1.9-2.1 PER[14].

Table 5. Protein efficiency ratio of the proposed supplementary foods

Formulas	PER*	Adjusted PER**
CSS—3	3.37±0.10	2.33
CSS—4	3.41±0.11	2.33
BSS—4	3.47±0.10	2.36

*Average weight gain(g) per average protein intake(g) for 4 weeks.

**Recalculated PER based on the standard casein value.

요 약

원성군 시범 종합영양사업을 위하여 개발된 고영양 보충식품(high nutrition-low cost supplementary foods)들의 영양학적 고찰을 행하였다. 전보에서 보고된 결과를 바탕으로 추천된 CSS—3, CSS—4 및 BSS—4 제품들의 일반성분, 무기질 성분, 비타민 성분 및 아미노산 조성을 분석하였고, 단백질 효율(PER)을 조사하였다.

단백질 함량은 평균 18% 이상, 열량은 100 g 당 400 Kcal 내외, 그리고 주민들의 영양필요량을 채워줄 수 있는 무기질 및 비타민 성분들을 함유하고 있었다.

함유 단백질의 아미노산가는 83-89 범위 그리고 PER은 2.33-2.36의 범위를 보여 주는 양질의 단백질이었다.

Acknowledgement

The authors express their appreciation to the Local Government of Wonseong County, Kangwon Province, Korea and Meals for Million Foundation, USA for providing for this research project.

References

1. Korea Institute of Science and Technology: Development of the High Nutrition-Low cost Supplementary Food and Its Production System for Wonseong County Comprehensive Nutrition Program, KIST Report BSG 251-1185-5 (1978)
2. Cheigh, H. S., Pyun, Y.R., Ryu, C. H. and Kwon, T.W.: *Korean J. Nutr.*, **13**(4), 199 (1980)
3. Ju, J.S.: *Korean J. Nutr.*, **10** (4), 33(1977).
4. FAO/WHO/UNICEF, Protein Advisory Group: *PAG Guideline*, No. 8 (1971)
5. Associ. of Official Anal. Chemists: *Official Methods of Analysis*, 12th ed., Washington, D.C. (1966)
6. Associ. of Vitamin Chem.: *Method of Vitamin Assay*, 3d ed., Interscience Publ., New York (1966)
7. Kent-Jones, D.W. and Amos, A. J.: *Modern Cereal Chem.*, Food Trade Press Ltd., 573, (1967)
8. Speckman, D.H., Stein, W.H. and Moore, S.: *Anal. Chem.*, **30**, 1190 (1958)
9. Moore, S., Spackman, D.H. and Stein, W.H.: *Anal. Chem.*, **30**, 1185 (1958)
10. Chapman, D.G., Castillo, R. and Campbell, J.A.: *Canadian J. of Biochem. and Physiology*, **37**, 679 (1959)
11. UN/FAO: *Amino acid content of foods and biological data on proteins*, FAO, Rome (1970)
12. FAO/UN: *Energy and Protein Requirements*, FAO Nutrition Meetings Report Series No. 52, Rome (1973)
13. Colorado State Univ.: *Low Cost Extrusion Cookers*, Internatiotional Workshop Proceedings, Fort Collins, Colrado (1976)
14. Bookwalter G.N., Mustakas, G.C,. Kwolek, W.F., Mcghee, J.E. and Albrecht, W.J.: *J. Food Sci.*, **36**, 5 (1971)