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# Preparation of Drum-dried Weaning Food Based on Sweet Potato and Soybean

by

**Su Rae Lee**

*Department of Food Technology, College of Agriculture*
*Seoul National University, Suwon*

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# 고구마와 콩을 이용한 이유식품의 제조에 관한 연구

서울대학교 농과대학 식품공학과

이 서 래

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요 약

1) 고구마의 경제적 활용과 이유식품의 개발을 목적으로 고구마·대두분 및 기타 영양소를 사용하여 단백함량이 20%되는 이유식품을 드럼건조법에 의하여 제조하는 방법을 설정하였다.

2) 이 제품의 단백효율(PER)은 2.63으로서 고구마 대신 옥수수전분을 사용한 제품의 PER(3.30)보다 낮았는데, 이는 드럼건조중 가용태 라이신의 파괴에 의함을 알았다.

3) 본 이유식품의 전체영양가 (사료효율, 체성분의 조성, 단백질보유율)는 우유식품이나 고구마 대신 옥수수전분을 사용한 이유식품과 비슷하였다.

## Introduction

Sweet potato (*Ipomoea batatas*) is a starch-producing tuber cultivated extensively in parts of Far East Asia, Africa and America.[1] As a staple foodstuff and as a source of food starch and industrial starch, this crop has much to command it because of its economic production. It can replace other industrial plantation crops as a supplier of raw materials for the local industries and for export. Since sweet potato is particularly a heavy yielder, it may hold a prominent role in the food economy of developing countries. As a good example, its production in South Korea has nearly tripled during last decade to reach 2 million tons in 1968[2] and this can be further increased if new methods of economic utilization can be developed for this crop. However, its use as a staple should give rise to malnutrition and limited consumption because of its low protein content and poor acceptability according to the conventional way of consumption.

Extensive studies on the preparation of instant sweet potato flakes as developed by American investigators [8-19] showed a good promise in searching a new use of sweet potato for food purpose. Some modification was, however, necessary since such type of processed food was not common in Korea. Therefore, an attempt was made to supplement this starchy food with inexpensive vegetable protein (full-fat soy flour) and deficient nutrients and to process in the form of flakes in the hope to prepare protein-rich foods suitable for weaned children who are most vulnerable to malnutrition, intaking foods mostly in the form of porridge and for whom their parents shall purchase such processed foods.

Since malnutrition is prevailing among infants and children of many developing countries, every efforts are being made to overcome this problem in several areas[20]. Though this problem also exists in Korea according to several nutrition and dietary surveys [21-24], only a few studies[25,26] were reported on the preparation of protein-enriched food products suitable for weaned children of this country.

This paper describes the preparation of precooked weaning food based on sweet potato and full-fat soy flour and its nutritional studies to examine the possibility of employing sweet potato as a major carbohydrate source without any ill effect.

## Materials and Methods

### 1. Raw materials

For the preparation of weaning food, freshly harvested sweet potato tubers of white-fleshed, brown-skinned, globular variety grown in Mysore State, India were used. Analytical data of the tubers are given below: average tuber weight 120 g, peel 15%, moisture 68%, total sugars 4.3% and reducing sugars 0.7%.

Full-fat soy flour was prepared as follows: commercially available, yellow-skinned variety of soybean was tempered with a small quantity of water, roasted slightly (15 minutes at 80°C), cracked and hulls removed by a pneumatic separator. This dehulled split soybean was moistened by soaking half a minute in water, draining off the water and allowing the adhering water to get absorbed for 3 hours, which was then autoclaved 30 minutes at 10-lbs. pressure, dried and ground to pass through a 25-mesh sieve. Analysis of the full-fat soy flour showed: moisture 5.2%, protein (N×6.25) 48.0%, crude fat 19.6%, ash 5.4%, crude fiber 2.6%, nitrogen solubility index 11, available lysine 4.64 g/16 g N, trypsin inhibitor activity 99.2% of original activity in raw soybean destructed.

### 2. Analytical methods

Proximate principles were analyzed by standard AOAC methods[27]. Available lysine was estimated by Carpenter's method[28] in which correction was not made for losses due to hydrolysis. Trypsin inhibitor activity was measured according to Kunitz[29] and nitrogen solubility index, by the method of Albrecht et al.[30]. Fat acidity and peroxide value were estimated by AACS method[31] and Lea's method[32], respectively.

### 3. Preparation of weaning food

Sweet potato tubers (30 kg) were washed, sliced into one-inch thickness, sulfited by soaking in 0.25% sulfite solution (sodium sulfite: sodium bisulfite=3 : 1) and cooked 30 minutes in steam. The slices were manually peeled and ground into puree by a tomato pulper set with an 0.06-inch screen (24 kg yield, having about 30% solids content). Although lye-peeling process is recommended for a large quantity of raw materials, manual peeling was done in this work for convenience.

A double-drum drier with rollers of 15.3 cm diameter and 19.7 cm length was employed. The blends as given in Table 1 were made into slurry by adding enough water to make 20% total solids and fed into the drier operating at 0.05 mm drum clearance, revolution of 6 rpm and steam pressure of 50 psig inside the drum unless otherwise stated. Dried flakes scrapped from the surface of rollers were collected and ground to pass through a 16-mesh sieve. Corn-starch control food was also prepared according to the same procedure by replacing sweet potato puree with corn starch for nutritional studies. The whole process is outlined in Diagram 1.

### 4. Animal experiments

The protein efficiency ratio (PER) of the drum-dried weaning food based on sweet potato and soy flour was determined in comparison with those of the

**Table 1. Composition of blends used for drum drying (parts)**

| Constituents | Weaning food | Corn-starch control food |
|---|---|---|
| Sweet potato puree (on a solid basis) | 50 | — |
| Corn starch | — | 50 |
| Full-fat soy flour | 40 | 40 |
| DL-Methionine | 0.5 | 0.5 |
| Cane sugar | 5 | 5 |
| Calcium carbonate | 1 | 1 |
| Dicalcium phosphate | 1 | 1 |
| Common salt | 1.5 | 1.5 |
| Vitamin premix* | 1.5 | 1.5 |

* This was prepared in full-fat soy flour to provide 3,000 I.U. vitamin A, 300 I.U. vitamin D, 1.1mg thiamine, 1.8mg riboflavin, 6.0mg nicotinamide, and 2.2$\mu$g vitamin $B_{12}$ per 100g of dried product.

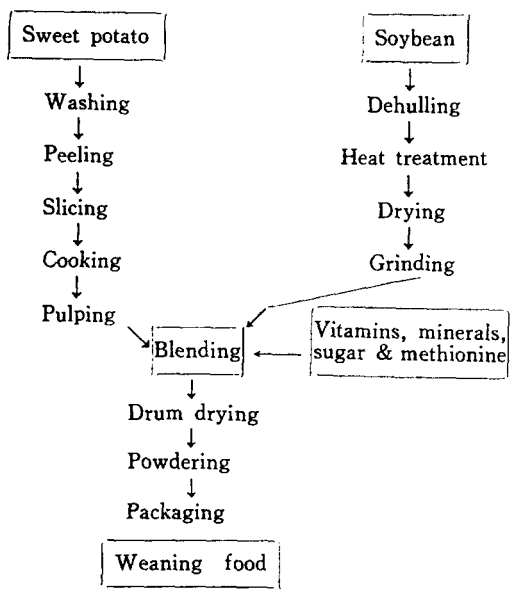


**Diagram 1. A process for the preparation of precooked weaning food based on sweet potato and full-fat soy flour**

product containing corn starch in place of sweet potato puree and of casein at 10% protein level according to the growth method of Osborne, Mendel and Ferry [33]. The composition of experimental diets are given in Table 2. Twenty-day-old weaned male rats weighing about 38 g were alloted to 3 groups(10 rats per group) according to body weight in a randomized block design. The rats were housed individually in cages with raised wire screen bottoms. Each group was fed on one of the experimental diets in dry state for a period of 4 weeks. Records of food intake and increase in body weight of each animal were maintained.

The overall nutritive value of the weaning food, as it is, as compared with corn-starch control food and milk food (prepared by mixing 72 parts skim-milk powder, 28 parts peanut oil, 1,500 I.U. vitamin A, 400 I.U. vitamin D, and 5 parts cellulose powder; protein, 20.8% on a dry weight basis) was determined by the rat growth method. Three groups of 20-day-old weaned rats (6 males and 6 females per group weighing about 36 g and equally distributed according to sex and body weight in a randomized block design) were used. After feeding 4 weeks, the animals were sacrificed, their livers analyzed for total fat according to the wet extraction method of Folch et al.[34] and carcasses estimated for moisture and protein contents after complete drying.

**Table 2. Composition of experimental diets used for determination of PER**

| Ingredients | Diet I (weaning food) | Diet II (corn-starch control food) | Diet III (casein control) |
|---|---|---|---|
| Weaning food | 45.8 | — | — |
| Corn-starch control food | — | 44.0 | — |
| Casein | — | — | 11.5 |
| Corn starch | 29.2 | 31.0 | 60.5 |
| Sugar powder | 10 | 10 | 10 |
| Peanut oil | 7 | 7 | 10 |
| Cellulose powder | 5 | 5 | 5 |
| Salt mixture* | 2 | 2 | 2 |
| Vitamin mixture** | 1 | 1 | 1 |

* Hubbel, Mendel and Wakeman salt mixture.
** Chapman et al.; Can. J. Biochem. Physiol., 37, 679 (1959).

## Results and Discussion

### 1. Chemical composition of the weaning food

Proximate principles and vitamins added before drum drying are given in Table 3.

**Table 3. Chemical composition of the weaning food**

(values/100 g material)

| Constituents | Weaning food | Corn-starch control food |
|---|---|---|
| Moisture (g) | 5.1 | 6.1 |
| Protein (g) | 20.1 | 20.9 |
| Fat (g) | 8.2 | 8.1 |
| Ash (g) | 5.9 | 5.4 |
| Carbohydrate(by difference) (g) | 60.7 | 59.5 |
| Calcium (g) | 0.87 | 0.80 |
| Phosphorus (g) | 0.60 | 0.52 |
| Vitamins added | | |
| Vitamin A (I.U.) | 3,000 | 3,000 |
| Thiamine·HCl (mg) | 1.1 | 1.1 |
| Riboflavin (mg) | 1.8 | 1.8 |
| Nicotinamide (mg) | 6.0 | 6.0 |
| Vitamin D (I.U.) | 300 | 300 |
| Vitamin $B_{12}$ ($\mu$g) | 2.2 | 2.2 |

## 2. Effect of drying conditions on the product quality

Effect of drum drying on the properties of weaning food based on sweet potato and soy flour was studied by varying the steam pressure inside the drum drier in comparison with the blend based on corn starch and soy flour, maintaining the standard conditions of operation. The results are given in Tables 4 and 5.

**Table 4. Some properties of the weaning food drum-dried at different steam pressure**

| Products | Steam pressure (psig) | Flake moisture (%) | Drying rate (kg/hr.m²) | Bulk density (g/100cc) |
|---|---|---|---|---|
| Weaning food | 30 | 5.8 | 5.51 | 25.0 |
| | 50 | 3.6 | 5.46 | 25.5 |
| | 70 | 3.5 | 5.41 | 26.9 |
| Corn-starch control food | 30 | 6.8 | 9.90 | 30.5 |
| | 50 | 5.0 | 8.51 | 25.8 |
| | 70 | 4.0 | 7.24 | 24.3 |

Drum drying of the weaning food based on sweet potato and soy flour caused the destruction of available lysine, the content of which was proportional to the steam pressure applied inside the drum. On the other hand, the control food based on corn starch and soy flour did not bring about the destruction of available lysine, due to the absence of reducing sugars in the blend.

**Table 5. Effect of drying temperature on the available lysine content of the products**

| Products | Treatment | Available lysine (g/16gN) | Lysine destruction (%) |
|---|---|---|---|
| Full-fat soy flour | None | 4.64 | |
| Weaning food | Before drying | 4.17 | 0 |
| | Drying at 30 psig | 3.40 | 18 |
| | Drying at 50 psig | 3.17 | 24 |
| | Drying at 70 psig | 2.77 | 33 |
| Corn-starch control food | Before drying | 4.22 | 0 |
| | Drying at 30 psig | 4.21 | 0 |
| | Drying at 50 psig | 4.18 | 1 |
| | Drying at 70 psig | 4.16 | 1 |

It is generally preferable to dry sweet potato flakes to moisture content below 4%. It was, therefore, decided to employ 50-psig steam pressure for the preparation of weaning food based on sweet potato and soy flour to minimize the destruction of available lysine, obtaining the desirable moisture content.

## 3. Shelf-life studies of the weaning food

The drum-dried weaning food based on sweet potato and soy flour was packed in polyethylene bags and stored in sealed tin containers at room temperature, 37°C and 50°C for a 3-month period. The product was tested monthly for free fatty acid and peroxide value. The results are shown in Table 6. The food was organoleptically acceptable after 3-month storage

**Table 6. Keeping quality of the weaning food (3-month storage)**

| Storage temperature | Free fatty acid* | Peroxide value** |
|---|---|---|
| Initial | 9.3 | 1.0 |
| Room temperature | 11.3 | 1.6 |
| 37°C | 12.3 | 4.6 |
| 50°C | 13.5 | 16.9 |

* Expressed as mg KOH per 100 g of sample on a dry weight basis.

** Expressed as millimoles of oxygen per kg of fat.

at 50°C and it is considered that the product can be stored safely at room temperature for a one-year period.

**4. Protein efficiency ratio of the weaning food**

As can be seen in Table 7, PER of the weaning food was 2.63 which was lower than 3.30, the PER of corn-starch control food. This is accounted for by the low available lysine content of the weaning food (3.17 g/16 gN) as compared to that of corn-starch control food (4.18 g/16 gN) and by the fact that lysine should be acting as the limiting amino acid in the diet since original soybean protein was already supplemented with its limiting amino acid methionine in the blends.

**Table 7. PER of the weaning food at 10% protein level**

| Diet | Weight gain(g) | Protein intake(g) | PER | PER reoalculated |
|---|---|---|---|---|
| I. Weaning food | 56.3 | 23.8 | 2.37±0.048* | 2.63 |
| II. Corn-starch control food | 76.1 | 25.5 | 2.97±0.076 | 3.30 |
| III. Casein control | 57.0 | 21.1 | 2.70±0.045 | 3.00 |

* Statistical error (d.f.=9)
Statistical analysis for the difference of PER among diets:
I~II: Significant at 0.1% level
I~III: Significant at 0.1% level

**5. Overall nutritive value of the weaning food**

The results are given in Tables 8 and 9. When the weaning food was fed at about 20% protein level, as it is, the overall growth was comparable to corn-starch control food and milk food. There was no remarkable difference in body composition and protein retention among different foods though the reason for the slightly higher value of liver fat in the rats fed on milk food was not explained. It is, therefore, concluded that the drum-dried weaning food based on sweet potato and soy flour is comparable to milk food or control food based on corn starch and soy flour in overall nutritive value and it has no ill effect even when sweet potato was employed as the major carbohydrate source in the formulation of protein-enriched food products.

**Table 8. Overall growth test of the weaning food (Duration of experiment, 4 weeks; mean values for 6 males and 6 females in each group)**

| Diet | Weight gain(g) | Food intake(g) | Feed efficiency** |
|---|---|---|---|
| I. Weaning food | 84.5±5.2* | 236 | 2.84±0.081* |
| II. Corn-starch control food | 85.3±5.2 | 223 | 2.71±0.150 |
| III. Milk food | 78.8±4.0 | 207 | 2.66±0.100 |
| Expressed as milk solids | — | 196 | 2.54±0.095 |

* Standard error (d.f.=11)
** Expressed as the amount of food intake(g) required to gain 1 g of body weight. Statistical analysis for the difference of weight gain: I~II, I~III: insignificant.
Statistical analysis for the difference of feed efficiency: I~II, I~III: insignificant
I~III (as milk solids): significant at 1% level.

**Table 9. Body composition and protein retention of animals fed on the weaning food (Duration of experiment, 4 weeks; mean values and standard error for 6 males in each group)**

| Diet | Body moisture(%) | Body protein(%) | Liver fat(%) | Protein retention(%) |
|---|---|---|---|---|
| I. Weaning food | 65.7±0.47 | 18.9±0.21 | 4.80±0.075 | 35.2±1.21 |
| II. Corn-starch control food | 66.8±0.84 | 19.4±0.50 | 4.84±0.096 | 40.3±1.75 |
| III. Milk food | 67.1±1.15 | 18.5±0.23 | 6.26±0.199 | 38.5±1.75 |

## Summary

1) A process was described for the preparation of drum-dried weaning food containing about 20% protein and based on a blend of sweet potato, full-fat soy flour, minerals, vitamins and methionine.

2) The protein efficiency ratio of this product was 2.63 as compared to 3.30 for the blend containing corn starch in place of sweet potato. This is attributed to the partial destruction of available lysine in the

presence of sweet potato during the drum-drying process.

3) Overall nutritive value of the weaning food was comparable to milk food and control food based on corn starch and soy flour in terms of feed efficiency, body composition and protein retention.

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