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Development of Instant High Fiber Processed Food

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ABSTRACT

Five high fiber processed foods were formulated by using high fiber sources such as beans, unpolished rice, sesame. The product formulas were : I) kidney bean : unpolished rice : white sesame (70:20:10), II) kidney bean : sweet potato : job's tears seed (45:35:20), III) mungbean : pineapple : pumpkin (50:30:20), IV) corn : mungbean : unpolished rice (60:30:10), and V) banana : pumpkin : corn : unpolished rice (30:25:25:20). These products were prepared in powder form by drum dryer and then ground with pin mill. The particle size, bulk density and viscosity of the plain products ranged from 141.6 - 186.5 μm, 0.75 - 0.82 g/ml and 1,750-7,208 cps, respectively. After flavoring with sugar, skimmed milk, cocoa or vanilla, the Water Absorption Index (WAI) and water activity (a_w) of flavored products ranged from 2.81-5.59 and 0.27-0.31, respectively. Flavored products prepared for sensory evaluation were conducted by adding warm water in four different ratio, products to water as 1:3, 1:4, 1:5 and 1:6 by weight. The results showed that the ratio 1:4 of most formulas had scores of acceptance ranged from 6.29-7.35 which was higher than the other ratios. Protein, fat and total dietary fiber of all flavored products ranged from 14.54-20.50 , 1.02-4.25, and 5.89-11.88 g/100 g , respectively.

Key words: high fiber, instant food, dietary fiber, drum dryer

INTRODUCTION

In recent years, epidemiological evidence has suggested that a reduction in dietary fiber is related to an increase in certain diseases such as diverticulosis (Painter and Burkitt, 1971) and colonic cancer (Burkitt, 1971). Dietary fiber acted as a bulking agent that increased intestinal motility and moisture content of feces (Forsythe *et al.*, 1976). It was postulated that those effects were important in preventing disease of the colon (Trowell, 1973). Other studies showed evidence that plant fiber could decrease serum cholesterol level (Forsythe *et al.*, 1976; Tsia *et al.*, 1976) and improved oral glucose tolerance in humans (Kay, 1982).

In view of the recently proposed physiological role and medical advantage of dietary fiber, along with the increasing interest demonstrated in the scientific and consumer world, it was the interest of food research and product development to examine more closely the application of fiber ingredients in commercial formulations. It led to the purpose of this study to develop a profile of high-fiber processed food by using several potential sources of dietary fiber as the ingredients.

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MATERIALS AND METHODS

1. Products preparation

Pulses, cereals, sesame and seeds were used as potential sources of dietary fiber in the products. Five product formulas are shown in as follows.

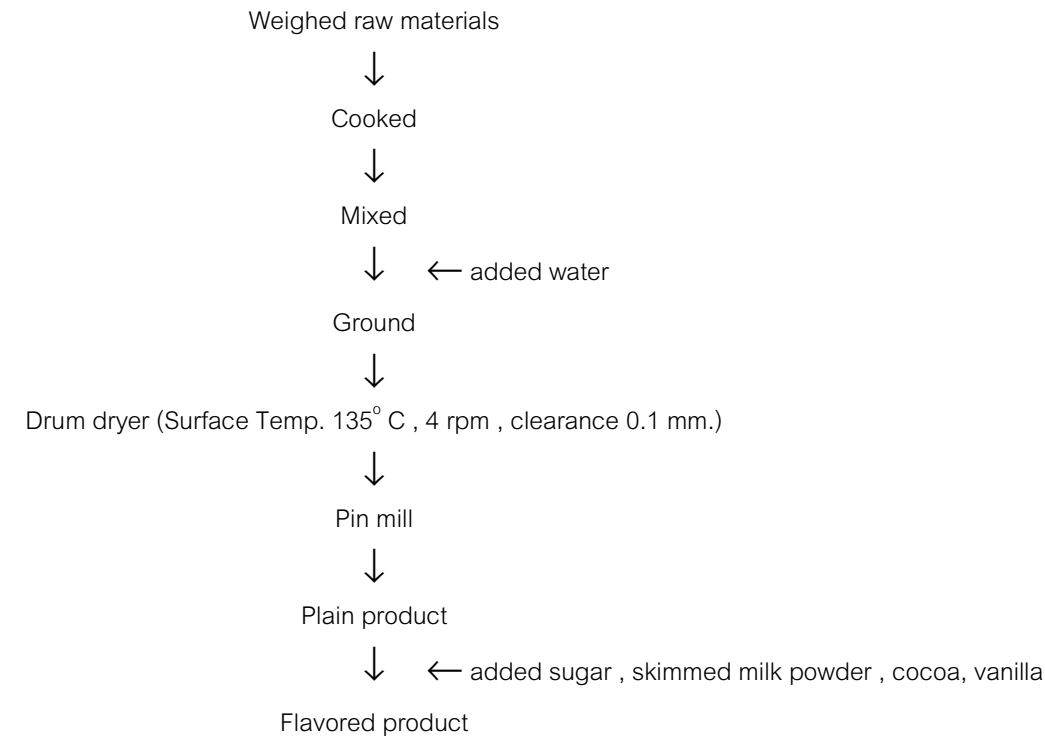
Formula	Fiber source	Ratio
I	kidney bean : unpolished rice : white sesame	70:20:10
II	kidney bean : sweet potato : job's tears seed	45:35:20
III	mungbean : pineapple : pumpkin	50:30:20
IV	corn : mungbean : unpolished rice	60:30:10
V	banana : pumpkin : corn : unpolished rice	30:25:25:20

Products were formulated to meet Recommended Daily Dietary Allowances for healthy Thais which should contain protein about 20% of total energy and 5 g/100 g of dietary fiber (RDA,1989). Process of high fiber food production is shown as flow chart.

2. Physical properties

Particle size Twenty five grams of milled product were placed on the largest of a descending 60 , 80 , 100 mesh stainless steel U.S. Standard Sieves that were fitted with a pan and cover. The "nested" sieves were shaken for 10 min , disassembled and contents were stirred lightly , then shaked for an additional 5 min. The residue on each sieve was carefully removed with the aid of a brush and weighed. Each residue was expressed as percent by weight of the original sample.

Density determinations For density determination , a calibrated graduate cylinder was



filled, with each milled product and slightly shaked. The contents of milled product in the cylinder were weighed and the average of triplicate determinations was expressed as g/ml.

Bulk density Bulk density was measured with a calibrated graduate syringe (open and packed with cotton). The syringe was filled with a known amount of sample , which varied somewhat depending on particle size and density. Pressure was applied manually until additional pressure would not furtherly reduce the volume.

Viscosity Viscosity was measured by using a Brookfield model RVT viscometer with no. 3, 4, 5 spindle at 50 rpm (Synchro-Lectric Viscometer model RVT Brookfield engineering Laboratories, INC).

Water Absorption Index (WAI) Water Absorption Index was measured by the procedure of Anderson *et al.*, 1969.

Water activity (a_w) Water activity was measured by Novasina EEJA –3 at 25°C.

3. Chemical composition

Moisture, ash, protein and fat were analysed by following AOAC procedure (1990). Dietary fiber was determined by enzymatic gravimetric method (AOAC, 1990).

4. Preparation of flavored products

Flavoring agents and carboxy methyl cellulose (CMC) were added into each formula accordingly as follows.

Ingredients	High fiber processed food formula number				
(g)	I	II	III	IV	V
Plain product	50	50	50	50	50
Sugar	25	25	25	25	25
Skimmed milk powder	20	20	24.8	24.95	24.95
Cocoa powder	4.95	4.95	-	-	-
Vanilla	-	-	0.15	-	-
CMC	0.05	0.05	0.05	0.05	0.05

5. Sensory evaluation of flavored products

Sensory evaluation of flavored products was tested by adding warm water in the ratio of instant powder to water, 1:3 1:4 1:5 and 1:6. Color, odor , flavor , thickness , texture and acceptance were evaluated by 20 experience panelists. The acceptance was done using the 9-point hedonic scale (max. value 9 = like extremely , min. value 1 = dislike extremely) , whereas color , odour , flavor , thickness and texture were determined by 5-point scale for perceived intensity scores (max. value = 5, min. value = 1) (ASTM, 1968). Color tone , strength of smell , sweetness and viscosity of the tested products were comparatively justified.

The hedonic and scoring rating were analysed by Analysis of variance (Randomized Complete Block Design) and Duncan's Multiple Range Test at 95% confidential level.

RESULTS AND DISCUSSION

Materials selected to develop instant high fiber processed foods were red kidney bean, mungbean, white sesame seeds, unpolished rice, corn, sweet potato, pumpkin, pineapple, job's tear and banana. These food sources provided either nutritional value, dietary fiber, fruity flavor and/or color to the developing products. For nutritional value point of view, protein content was the most concern. Red kidney bean, mungbean, white sesame seeds and job's tear contained a considered amount of protein. The amounts of dietary fiber were high in red kidney beans , mungbean and sesame which were 30.2 , 28.9 and 22.3 g/100 g (dry weigh basis), respectively (Puwastien, 1990), whereas , dry matter of pumpkin, corn, sweet potato, pineapple, banana, job's tear and unpolished rice contained lower fiber of 16.4, 13.4, 8.6, 8.0, 6.6, 4.15 and 2.4 g/100 g, respectively (Puwastien, 1990).

Physical properties

The results showed that most of the particle size (> 50%) of the formula I II III and IV ranged from 180 - 150 μm (Table 1) which were smaller than the particle size of the formula V (average 186.5 μm). Mix of different particle sizes in one formula implied existing of various fiber sizes. Kimura (1977) reported that mix of various particle size of fiber increased rate of water absorption in human. Therefore, the formula I and II should be superior to the formula III, IV and V.

WAI of formula I was the lowest, 2.81, while that of formula V was the highest, 5.59. The result indicated that formula V imbibed more water than formula I as demonstrated by Chen *et al.* (1988). Sieve size as well influenced on the water absorption. Water absorption could be decreased by the reduction of powder particle size (Cadden, 1987) , suggesting that small size of materials might be less porous and would be unable to imbibe as much water as large size. This study displayed WAI trend similar to Cadden (1987) except formula I (Table 1). From calculating carbohydrate content, formula I, II, III, IV and V contained 48.3, 59.1, 66.9, 70.7 and 82.4 g/ 100g (dry weight basis), respectively. Amount of carbohydrate might affect water absorption, illustrated in formula I. Besides that type of carbohydrate, starch or cellulose, also influenced water absorption.

Sensory evaluation

Developed products displayed their characteristic in color depend upon the ingredients. Formula I and II contained red kidney beans, therefore, both formulas had red-purplish tone. Mungbean provided greenish color and pineapple, pumpkin and corn gave yellowish color to the formula III and IV. Color of formula V was similar to formula III and IV, but brighter in yellow caused by banana.

Each formula was designed to have individual characteristic in odor. Formula I expected

Table 1 Physical properties of plain and flavored products.

Property	High fiber processed food formula number				
	I	II	III	IV	V
Plain product					
Particle size*					
60-80 mesh (250-180 μm)	39.4	25.2	4.2	5.6	56.7
80-100 mesh (180-150 μm)	50.1	62.1	67.5	78.0	35.7
>100 mesh (<150 μm)	10.7	12.7	28.3	16.7	7.6
Particle size (μm)	175.0	166.2	141.6	153.0	186.5
Direct density (g/ml)	0.66	0.62	0.66	0.60	0.54
Bulk density (g/ml)	0.82	0.75	0.82	0.80	0.79
Viscosity (cps)	1750	6040	3820	7208	6440
Flavored product					
Water Absorption Index (WAI)	2.81	3.75	3.80	3.80	5.59
Water activity (a_w)	0.27	0.31	0.30	0.31	0.27

* Percent of sample retained on U.S. standard sieves

kidney bean flavor mix with cocoa. Job's tear and cocoa powder contributed odor to the formula II. Formula III was dressed with vanilla. Corn and banana were natural odor in formula IV and V, respectively.

Sensory evaluation of flavored products is shown in Table 2. The ratio of 1:4 in most formulas had higher acceptance scores than the others. In particularly, the formula IV obtained the highest scores. The reason was formula IV contained corn up to 60%. This amount of corn provide good odor and flavor to the product. Panelists' commendation revealed that odor was the most important factor for them to decide their preference.

Table 2 Sensory evaluation of 5 formulas of high fiber processed food.

Ratio (Instant powder : water)	Mean					
	Color	Odor	Flavor	Thickness	Texture	acceptance
Formula I						
1 : 3	4.19^{a}	3.44^{a}	3.63^{a}	4.44^{a}	2.56^{a}	6.25^{ab}
1 : 4	3.00^{b}	2.88^{ab}	2.69^{b}	3.06^{b}	2.06^{b}	7.00^{a}
1 : 5	2.25^{c}	2.63^{b}	2.00^{c}	2.25^{c}	1.81^{b}	6.13^{ab}
1 : 6	1.38^{d}	2.69^{ab}	1.38^{d}	1.31^{d}	1.63^{b}	5.50^{b}
Formula II						
1 : 3	4.07^{a}	2.57^{a}	3.43^{a}	4.64^{a}	2.36^{a}	5.86^{a}
1 : 4	3.21^{b}	3.07^{a}	2.71^{b}	3.50^{b}	2.29^{a}	6.29^{a}
1 : 5	2.14^{c}	2.86^{a}	2.21^{c}	2.43^{c}	2.07^{a}	6.36^{a}
1 : 6	1.43^{d}	2.93^{a}	1.50^{d}	1.79^{d}	1.86^{a}	5.79^{a}
Formula III						
1 : 3	3.88^{a}	2.41^{a}	3.82^{a}	4.41^{a}	1.94^{a}	5.94^{b}
1 : 4	2.88^{b}	2.47^{a}	2.94^{b}	3.18^{b}	1.71^{ab}	7.24^{a}
1 : 5	2.18^{c}	2.29^{a}	2.41^{c}	2.12^{c}	1.47^{bc}	7.18^{a}
1 : 6	1.65^{d}	2.18^{a}	1.53^{d}	1.24^{d}	1.29^{c}	5.71^{b}
Formula IV						
1 : 3	3.70^{a}	3.00^{ab}	3.40^{a}	4.45^{a}	2.50^{a}	5.35^{b}
1 : 4	2.95^{b}	3.10^{a}	2.90^{b}	3.25^{b}	1.95^{b}	7.35^{a}
1 : 5	2.30^{c}	2.60^{b}	2.10^{c}	2.35^{c}	1.90^{b}	6.95^{a}
1 : 6	1.75^{d}	2.10^{c}	1.50^{d}	1.40^{d}	1.60^{b}	5.70^{b}
Formula V						
1 : 3	4.15^{a}	3.54^{a}	3.92^{a}	4.62^{a}	1.38^{a}	5.15^{b}
1 : 4	3.23^{b}	2.77^{b}	2.92^{b}	3.38^{b}	1.38^{a}	7.15^{a}
1 : 5	2.77^{c}	2.38^{b}	2.23^{c}	2.62^{c}	1.31^{a}	6.92^{a}
1 : 6	2.23^{d}	1.77^{c}	1.62^{d}	1.77^{d}	1.31^{a}	6.69^{a}

*In each formula, mean in the same column having different superscripts were significantly different according to DMRT ($P < 0.05$)

In all developed products, there was an unsatisfied characteristic of gritty texture. This gritty texture may be caused by bean hull, corn seed pericarp, sesame seed coat and cellulose in pineapple. Those coarse particles distributed irritating effect to the throat. The result of this experiment agreed to the previous report that If a fiber with low water holding capacity was added to a beverage system , the beverage may have a gritty texture (Schmidl *et al.*, 1985). However, throat irritated feeling could be minimized by increasing water content (Table 2). The bigger number on texture represented the more irritating feeling.

Chemical composition

The protein contents of plain formula I to IV ranged from 18.59 - 21.99 g per 100 g which accounted as 24.17% , 23.10% , 27.56% and 23.12% of total calories, respectively (Table 3). These were higher than the contents in the flavored products, which were 20.71% 20.08% 22.35% and 21.84% of total calories, respectively. Among 5 formulas, the protein contents of plain (10.75 g/100g) and flavored (14.54 g/100g) of formula V were the lowest, 12.0% and 16.11% of total calories, respectively. The reason was main ingredients were banana, pumpkin, corn and unpolished rice which were naturally low in protein contents.

Fat contents of all plain products, formula I to V, accounted as 22.83%, 6.18%, 3.61%, 9.43% and 7.83% of total calories, respectively. Formula I provided highest fat content according to one of the components was sesame which contained fat 56.2 g/100 g. (Nutrition Division, 1992).

The results showed that the plain formula I had a very high dietary fiber contents of 20.59 g/ 100g. The reason was that 70% of total weight of all ingredients were red kidney beans which were rich in dietary fiber, 27.7 g/100g (Puwastien, 1990). The plain formula II and III also provided a high level of dietary fiber of 15.38 - 15.85 g/100g which was found to be associated with the selected

Table 3 Chemical composition of 5 formulas of plain and flavored high fiber processed food (per 100 g).

Product	Moisture (g)	Protein (g)	Fat (g)	Ash (g)	Dietary fiber (g)	CHO (g)	Energy (Kcal)
Plain							
Formula I	3.91	20.11	8.44	2.86	20.59 (5.84)*	44.09	332.76
Formula II	3.71	18.59	2.21	2.72	15.85 (4.49)	56.92	321.93
Formula III	2.95	21.99	1.28	3.47	15.38 (4.36)	54.93	319.20
Formula IV	3.77	19.74	3.58	2.96	12.35 (3.50)	57.60	341.58
Formula V	2.82	10.75	3.12	2.85	8.62 (2.44)	71.84	358.44
Flavored							
Formula I	3.08	18.07	4.25	3.10	11.88 (3.37)*	59.62	349.01
Formula II	2.78	17.62	1.02	3.14	7.63 (2.16)	67.81	350.90
Formula III	2.48	20.50	3.21	3.56	6.26 (1.77)	63.99	366.85
Formula IV	2.90	19.57	1.46	3.43	5.89 (1.67)	66.75	358.42
Formula V	2.35	14.54	1.46	3.28	5.96 (1.69)	72.41	360.94

* The numbers in the parenthesis referred to the contents of dietary fiber in g/1 - 0Z serving

ingredients, kidney bean and mungbean The plain formula V possessed the lowest of dietary fiber of 8.62 g/100g.

The amount of dietary fiber in flavored products ranged from 5.96 to 11.88 g/100 g which were substantially higher than some commercial products. It was reported that dietary fiber contents of commercial breakfast cereal ranged from 0.2 - 34.06 g/100g (Jwuang, 1979; Baker, 1981; Douglass *et al*., 1982; Mongeau and Brassard, 1982; Marlett, 1992).

The flavored powder of formula I, II, III, IV and V providing energy ranged from 319.20 - 358.44 Kcal equaling 4.88% 9.00% 14.93% 4.93% and 0.70%, respectively,which were greater than the plained formulas. The increasing calorie was due to sugar and skimmed milk, 36.7 Kcal/100g, (Whitney and Hamilton, 1981).

CONCLUSION

All of the flavored products provided dietary fiber ranged from 5.89 - 11.88 g/100 g which were substantially higher than thore of some comercial products. The most preference one was Formula IV due to accustomed and adored fragrance of corn. In this study, the production cost of Formula IV calculated only on raw materials was 40 baht / kg. The cost could certainly be reduced if industrial scale was conducted. Producing these higher nutritional products would provide another option for consumers who concern of their health.

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