Kasetsart J. (Nat. Sci.) 33 : 284 - 293 (1999)

Production of Kaset Protein from Defatted Glandless Cottonseed Flour

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ABSTRACT

Six formulae of defatted glandless cottonseed Kaset protein were prepared by using the village texturizer. They were prepared from defatted glandless cottonseed flour, defatted glandless cottonseed flour adding full fat soy flour, defatted groundnut flour, defatted sesame flour and L-methionine. The six formulae of defatted glandless cottonseed Kaset protein were used for sensory evaluation in the form of snack and three kinds of Thai dishes: kang-pa, kuay-teuw-pad-kee-mao, pad-prik-sod. The average score from sensory evaluation of six different formulations of defatted glandless cottonseed Kaset protein in term of color, flavor, texture and acceptability showed that three formulae of defatted glandless cottonseed snacks which were formula number 3, 5 and 6 (formula number 3, 5 and 6 made from defatted glandless cottonseed flour adding 25%, 35%, 40% of full fat soy flour and 20%, 10%, and 5% of defatted sesame flour by weight, respectively and the 0.45% of L-methionine was added in defatted glandless cottonseed Kaset protein formula number 6) were the best accepted in the level of like very much ($p > 0.05$). The protein and fat contents of the three accepted defatted glandless cottonseed Kaset protein ranged from 44.44 - 45.93% and 23.19-25.11% on dry weight basis, respectively. The protein quality of the three accepted defatted glandless cottonseed Kaset protein showed higher chemical score of lysine and methionine + cystine ranged from 73-84% and 83-100%, respectively and PER ranged from 2.14 ± 0.11 - 2.36 ± 0.11, compared to chemical score 69%, 77% and PER 1.87 ± 0.07 (PER of casein = 2.50 ± 0.21) of Kaset protein made from defatted glandless cottonseed flour alone. These were due to the added flours such as full fat soy flour and defatted groundnut flour which were rich in lysine content and the added L-methionine. The added defatted sesame flour was rich in methionine + cystine content.

Key words: defatted glandless cottonseed Kaset protein, defatted glandless cottonseed flour, full fat soy flour, defatted groundnut flour, defatted sesame flour, village texturizer.

INTRODUCTION

Kaset protein is the product from research work of the Institute of Food Research and Product Development, Kasetsart University. It is produced from defatted soy flour and 1% of DL - methionine by Cooker Extruder X-25 and it can be used as meat substitute to replace the expensive meat in the preparation of various kinds of dishes. Its protein quality is the same as animal protein and its cost is cheaper about 3-4 times than meat. This high - protin low - cost product is well accepted by Thai

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people but the problem is that the defatted soy flour is imported from the foreign countries. The specification of Cooker Extruder X-25 is used only for the raw material with its oil content is not more than 1% (Prabhavat *et al*., 1984). The village texturizer is developed by Meals for Millions Foundation. It is the machine that can produce texturized products or structured vegetable protein (SVP) from flour of legumes, soybean, oilseeds and cereals etc. at village level. The expansion of dough upon sudden release of pressure, provide porous texture with crispness after drying. It is constructed in Thailand (following the construction pattern from Meals for Millions Foundation by Institute of Food Research and Product Development, Kasetsart University by the cooperation of the Faculty of Engineering, Kasetsart University using the available local raw material in Thailand (Anon, 1984; Prabhavat, 1989). Prabhavat, *et al*., (1990a) produced the accepted high - protein low - cost Kaset protein from full fat soy flour by using the village texturizer. It can be used as meat substitute with its protein quality similar to animal protein. The defatted groundnut flour also can be used to make accepted high - protein low - cost Kaset protein by using the village texturizer and its protein quality is adjusted to be the same as animal protein (Prabhavat *et al*., 1990b). The other oilseed, except soybean and groundnut, is glandless cottonseed which is interesting raw material to produce Kaset protein by using the village texturizer.

The glandless variety discovered in 1953 has a number of advantages, the crude oil is much lighter in color and consequently easier and less costly to refine. The meal is completely edible to both ruminants and monogastric animals. A variety of human food products such as breads, biscuits, doughnuts, baby foods, tortillas and snack items, can be produced from glandless cottonseed flour. (Abraham and Horn, 1992; Simmons *et al*., 1987; Lusas and Jividen, 1987). The FDA regulations specify that the maximum content of free gossypol in glandless cottonseed kernel and glandless cottonseed flour for human food use shall not be exceed 450 parts per million (ppm). This generally has been interpreted as total gossypol in the goals of the glandless cottonseed industry. (Simmons *et al.*, 1987; Lusas and Jividen, 1987).

In Thailand, the glanded cottonseed is mainly used for oil production and the cake (50 - 60% protein) is used mostly for fertilizer and animal feed. The gossypol is deactivated during processing by binding with protein especially lysine and the quality of protein is reduced. The glandless cottonseed is cultivated in Thailand under the KU-DORAS (Kasetsart University Development Oriented Research on Agrarian Systems) Project is to be considered for the preparation of human food. The protein and fat content of glandless cottonseed kernel are 36.2 and 36.9%, respectively and in the flour were 62.6 and 0.8%, respectively (Anon, 1987; Simmons *et al.*, 1987). Its protein quality can be improved by fortification with the protein source from various kinds of beans such as soybean and mungbean whose protein is rich in lysine (but deficient in methionine + cystine) and sesame, other cereals such as rice and wheat whose protein are rich in methionine + cystine. (Anon, 1990; Cheman *et al*., 1992).

The purpose of this research is to develop the accepted low - cost high - protein Kaset protein from glandless cottonseed (received from KU - DORAS project) with improvement to protein quality by adding flour from soybean and sesame. The accepted product not only adds the value to the low - cost glandless cottonseed produced in Thailand, but also provides nutritive Kaset protein to the people of different age group especially in the rural area and food industries in the future.

MATERIALS AND METHODS

Preparation of individual flours

1. Defatted glandless cottonseed flour, defatted groundnut flour, defatted sesame flour and full fat soyflour.

Twenty kgs of glandless cottonseed, 4 kgs of selected groundnut, 4 kgs. of selected white sesame seed and 4 kgs. of selected soybean were used for preparation of flours. The glandless cottonseed was cracked by using stone grinder and its hull was removed by using a vibroscreen separator (4, 6, 8 mesh screen). The obtained glandless cottonseed kernel (24.64% by weight of the whole glandless cottonseed), groundnut, sesame and soybean were separately washed 4 times with water until clean. Then the washed glandless cottonseed kernel, groundnut, sesame and soybean were separately dried in a cabinet dryer at 50° - 60° C for 10, 10, 5 and 10 hours, respectively. The dried groundnut was cracked into two parts by pressing with drum stick and its hull was removed by using a bamboo pan to get the groundnut dhal. The dried soybean was cracked with a hand grinder and its hull was removed by using a bamboo pan to get the soybean dhal. The three obtained products except soybean dhal were separately pressed with hydraulic press (Caver laboratory press, USA) at the pressure 10 - 11 tons for 5 times. The each of three pressed cakes and soybean dhal were separately ground with a pin mill into flours (80 mesh). The defatted glandless cottonseed flour, defatted groundnut flour, defatted sesame flour and full fat soyflour were obtained.

Each individual flour was analyzed for chemical and essential amino acid composition. The laboratory of the Institute of Food Research and Product Development, Kasetsart University analyzed for chemical composition by using the method of A.O.A.C. (1984). The Department of Science Service, Ministry of Science, Technology and Environment analyzed each individual flour for essential amino acid composition and the glandless cottonseed kernel and defatted glandless cottonseed flour for free gossypol.

Preparation of defatted glandless cottondseed Kaset protein flours.

Six formulae of defatted glandless cottonseed Kaset protein flours were prepared from the individual flours and L - methionine as shown in Table 3 and mixed well in polyethylene bag for 3 minutes to get each of 500 grams of mixed flour.

Preparation of Kaset protein

Every fifteen grams of cane sugar, 5 grams of salt powder were dissolved in 75 mls of water for adding into each of 500 grams of six formulae of fortified defatted glandless cottonseed flour formula number 2 - 6 and one unfortified glandless cottonseed flour formula number 1, respectively. Then each of 500 grams of flour was mixed with prepared ingredient solutions in Kenwood mixer for 3 minutes. Each dough was divided into 10 gram portions, rolled into a ball shape and pressed into circular shape before putting in the cup of the village texturizer.

The temperature of the cup and the lid was 170° - 180° C. The lid was centered over the cup and pressed with pressure 400 psi and holding time for 10 - 15 seconds. Then the lid was released from the cup. Moist Kaset proteins were obtained and they were cut into rectangular shapes (5 x 1 cm). Then they were dried in a cabinet dryer at 50° - 60° C for 2 hours. The dried defatted glandless cottonseed Kaset protein (puffed, crisp texture) formula number 1 - 6 were obtained. After that they were packed separately in sealed polyethylene bags for determination of characteristics in terms of color, flavor, texture, outer appearance and acceptability.

Organoleptic evaluation of Kaset protein

The acceptability test was done for each of the six formulae of defatted glandless cottonseed Kaset protein by 10 panelists (reseachers of the Institute of Food Research and Product Development, Kasetsart University) for investigation of the different characteristics in terms of color, flavor, texture and acceptabiligy by using Hedonie scale scoring : score 9 - the extreme like, and score 1 - extreme dislike. The difference in statistics was determined by using ANOV and DMRT at 95% significant level. The test was replicated 4 times and the duration for each time was one day. Six formulae of Kaset protein were studied by using the dried Kaset proteins as snacks for the first day of taste panel. The soaked Kaset protein (each of six formulae of Kaset protein) were separately soaked in water at room temperature for 3 minutes until its texture was soft and they were used for the preparation of kang pa, kuay - teuw - pad - kee - mao and pad - prick sod for the taste panel on the second, third and fourth day, respectively. The accepted formula of Kaset protein were analyzed for chemical and amino acid compositions in the same way as individual flour. The Biological Testing Laboratory, Institute of Food Research and Product Development, Kasetsart University analyzed protein efficiency ratio (PER) for the accepted formula of defatted glandless cottonseed Kaset protein.

RESULTS AND DISCUSSION

The percentage yield of defatted glandless cottonseed flour was 76.20% by weight of the whole kernels. The “free” gossypol contents in glandless cottonseed kernel and defatted glandless cottonseed flour were 17.1 and 19.5 ppm, respectively while the FDA regulations required the maximum content of free gossypol not be exceed 450 ppm for human food use in both of kernel and flour (Simmons *et al*., 1987; Lusas and Jividen, 1987). The percentage yields of full fat soy flour, defatted groundnut flour and defatted sesame flour were 81.50, 57.00 and 56.25% by weight of raw material, respectively. The pretein contents of defatted glandless cottonseed flour, full fat soy flour, defatted groundnut flour and defatted sesame flour were 45.19, 45.55, 44.25 and 36.96% on dry weight, respectively and the fat contents were 23.69, 25.73, 3.59 and 38.15% on dry weight, respectively as shown in Table 1.

Essential amino acid composition of each individual flour with its limiting amino acid is

Table 1 Chemical composition of various kind of flours.

Kinds of flours	Chemical composition (% Dry weight)						
	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	Crude fiber (%)	Carbo-hydrate (%)	Energy cal/100 gram
Defatted glandless cottonseed flour (DGCF)	7.11	23.69	45.19	7.26	2.01	21.85	481
Full fat soyflour (FFSF)	6.14	25.73	45.55	5.68	1.03	22.01	502
Defatted groundnut flour (DFGF)	4.08	31.48	44.25	3.59	2.84	17.84	532
Defatted sesame flour (DFSF)	4.09	38.15	36.96	5.08	4.95	14.86	551

shown in Table 2. This indicated that the protein from different sources were incompleted. The lysine was the limiting amino acid of protein from defatted glandless cottonseed flour and defatted sesame flour whose chemical scores were in the ranges of 46 - 69% while methionine + cystine were 86 - 143%. Yet, the methionine + cystine was the limiting amino acid of protein from full fat soy flour and defatted groundnut flour whose chemical score were in the ranges of 63 - 69% while lysine were in the range of 75 - 104%. The essential amino acid contents of Kaset protein from defatted glandless cottonseed flour could be improved by adding two or more flours (which were rich in lysine such as full fat soy flour, defatted groundnut flour and also adding defatted sesame flour which was rich in methionine + cystine content) together to make composite flours before making Kaset protein by using a village texturizer as shown in Table 3.

Table 2 Essential amino acid composition of various kind of flours and FAO/WHO standard.

Essential amino acid	Amino acid, mg/gm of protein of				FAO/WHO[3]
	DGCF	FFSF	DFGF	DFSF	
Isoleucine	30	35	36	30	40
Leucine	57	70	75	62	70
Lysine	38 (69)[2]	57 (104)[1]	41 (75)[1]	25 (46)[2]	55
Methionine + Cystine	30 (86)[1]	24 (69)[2]	22 (63)[2]	50 (143)[1]	35
Phenylalanine + Tyrosine	89	82	96	77	60
Threonine	31	37	32	34	40
Tryptophan	18	16	12	16	10
Valine	39	37	43	38	50

[1] (-) Chemical score in parenthesis
[2] (-) Limiting amino acid with chemical score
[3] Source : Food Composition Table for use in East Asia (FAO, 1972)

$$\text{Chemical score} = \frac{\text{amino acid content in protein of flour} \times 100}{\text{amino acid content in FAO/WHO standard}}$$

Table 3 Composition of six formulae of defatted glandless cottonseed Kaset protein.

Formula number	Composition, %				
	DGCF	FFSF	DFGF	DFSF	L -methionine
1	100	-	-	-	-
2	55	20	5	20	-
3	55	25	-	20	-
4	55	30	5	10	-
5	55	35	-	10	-
6	54.55	40	5	-	0.45

The results of the organoleptic evaluation for different characteristics in terms of color, flavor, texture and acceptability of six formulae of defatted glandless cottonseed Kaset protein in the form of snacks, kang - pa, kuay - teuw - pad - kee - mao and pad - prick - sod are shown in Table 4,5,6 and 7, respectively.

It appeared that the defatted glandless

Table 4 Organoleptic evaluation of six formulae of defatted glandless cottonseed Kaset protein when consumed as snacks.

Characteristics	Defatted glandless cottonseed Kaset protein formula number					
	1	2	3	4	5	6
Color	5.80^{c}	6.30^{abc}	6.70^{a}	6.10^{bc}	6.50^{ab}	6.50^{ab}
Flavor	6.10^{a}	6.20^{a}	6.20^{a}	5.80^{a}	6.10^{a}	5.80^{a}
Texture	6.00^{a}	6.00^{a}	6.20^{a}	5.50^{a}	6.00^{a}	6.00^{a}
Acceptability	5.90^{a}	6.10^{a}	6.10^{a}	5.40^{a}	5.90^{a}	5.90^{a}

The figures on the same row with the same letter are not defferent ($p > 0.05$)

Table 5 Organoleptic evaluation of kang - pa prepared from six formulae of defatted glandless cottonseed Kaset protein.

Characteristics	Kang - pa from defatted glandless cottonseed Kaset protein formula number					
	1	2	3	4	5	6
Color	6.50^{a}	6.80^{a}	6.70^{a}	6.60^{a}	7.00^{a}	6.90^{a}
Flavor	6.40^{a}	6.70^{a}	6.60^{a}	6.50^{a}	6.50^{a}	6.70^{a}
Texture	5.70^{b}	6.10^{ab}	6.60^{a}	6.00^{ab}	6.00^{ab}	6.40^{ab}
Acceptability	6.00^{a}	6.20^{a}	6.70^{a}	6.10^{a}	6.40^{a}	6.70^{a}

The figures on the same row with the same letter are not different ($p > 0.05$).

Table 6 Organoleptic evaluation of kuay - teuw - pad - kee -mao prepared from six formulae of defatted glandless cottonseed Kaset protein.

Characteristics	Kuay - teuw - pad - kee - mao from defatted glandless cottonseed Kaset protein formula number					
	1	2	3	4	5	6
Color	7.10^{a}	7.50^{a}	7.50^{a}	7.40^{a}	7.30^{a}	7.30^{a}
Flavor	6.60^{ab}	6.60^{ab}	7.10^{a}	6.20^{b}	6.80^{ab}	7.00^{a}
Texture	6.90^{a}	6.70^{a}	6.90^{a}	6.40^{a}	6.90^{a}	6.80^{a}
Acceptability	6.80^{a}	6.70^{a}	7.10^{a}	6.40^{a}	6.80^{a}	6.90^{a}

The figures on the same row with the same letter are not different ($p > 0.05$).

cottonseed Kaset protein formula number 1 - 3 and 5 - 6 were more accepted than the other samples ($p < 0.05$) when consumed as snacks; formula number 2 - 6 for kang – pa ($p < 0.05$); formula number 1 - 6 for kuay - teaw - pad - kee – mao ($p > 0.05$); formula number 3 - 6 for pad - prick – sod ($p < 0.05$), respectively and the scores were at the level of like very much, while the glandless cottonseed Kaset protein formula number 3, 5 and 6 (formla number 3, 5 and 6 made from defatted glandless cottonseed flour adding 25, 35 and 40% of full fat soyflour and 20, 10 and 5% of defatted sesame flour by weight, respectively. The 0.45% of L - methionine was added in defatted glandless cottonseed flour formula number 6) were the best accepted ($p > 0.05$) in the level of like very much.

The chemical composition of the best three accepted defatted glandless cottonseed Kaset protein (formula number 3, 5 and 6) are shown in Table 8. The protein and fat contents of the three accepted defatted glandless cottonseed Kaset protein (formula number 3, 5 and 6) were in the ranges of 44.44 - 45.93% and 23.19 - 25.11% on dry weight, respectively.

The essential amino acid composition of the three accepted defatted glandless cottonseed Kaset

Table 7 Organoleptic evaluation of pad - prick - sod prepared from six formulae of defatted glandless cottonseed Kaset protein.

Characteristics	Pad - prick - sod from defatted glandless cottonseed Kaset protein formula number					
	1	2	3	4	5	6
Color	6.50^{b}	6.90^{ab}	7.10^{a}	7.10^{a}	7.00^{ab}	6.90^{ab}
Flavor	6.80^{ab}	6.60^{b}	7.30^{a}	6.80^{ab}	6.90^{ab}	6.90^{ab}
Texture	6.20^{c}	6.40^{bc}	7.30^{a}	7.10^{ab}	7.00^{abc}	6.90^{abc}
Acceptability	6.40^{b}	6.30^{b}	7.50^{a}	6.90^{ab}	7.00^{ab}	7.00^{ab}

The figures on the same row with the same letter are not different ($p > 0.05$).

Table 8 Chemical composition of the three accepted defatted glandless cottonseed Kaset protien (formula number 3, 5 and 6).

Chemical composition	Defatted glandless cottonseed Kaset protein formula number		
(% Dry weight)	3	5	6
Moisture	3.35	3.50	3.96
Fat	25.11	25.10	23.19
Protein	45.09	44.44	45.93
Ash	6.02	6.18	6.38
Crude fiber	2.79	2.80	2.07
Carbohydrate	20.99	21.48	22.43
Energy, cal/100 gram	490	490	482

protein are shown in Table 9. The chemical score of the limiting amino acid lysine of defatted glandless cottonseed Kaset protein formula number 1 (made from defatted glandless cottonseed flour alone) was 69% and PER was 1.87 ± 0.07. The chemical score of the three accepted of defatted glandless cottonseed Kaset protein formula number 3, 5 and 6 increased to 73, 78 and 84%, respectively and the PER increased to 2.16 ± 0.12, 2.14 ± 0.11 and 2.36 ± 0.11, respectively while the PER of casein was 2.50 ± 0.21. The increasing of chemical score and the PER of the three accepted defatted glandless cottonseed Kaset protein formula number 3, 5 and 6 were due to high lysine but low in methionine + cystine contents of protein of full fat soy flour, defatted groundnut flour and high methionine + cystine content of protein in defatted sesame flour, synthetic L - methionine added into defatted glandless cottonseed flour before making Kaset protein to improve the protein quality of the three accepted products.

Characteristics of the best three accepted defatted glandless cottonseed Kaset protein

The color of the three accepted defatted glandless cottonseed Kaset protein formula number 3, 5 and 6 (when they are consumed as snacks) are yellowish brown. Their flavor are good salted, sweet and nutty taste with roasted soybean odor. In terms of texture, the defatted glandless cottonseed Kaset protein formula number 3, 5 and 6 are good soft crisp, puffy and porous. The color of defatted glandless cottonseed Kaset protein formula number 1 (made from defatted glandless cottonseed flour

Table 9 Essential amino acid composition of the three accepted defatted glandless cottonseed Kaset protein formula number 3, 5 and 6 compare to defatted glandless cottonseed Kaset protein formula number 1 made from defatted glandless cottonseed flour alone.

Essential amino acid	Defatted glandless cottonseed Kaset protein formula number				FAO/WHO[3]
	1	3	5	6	
Isoleucine	30	33	33	34	40
Leucine	51	57	58	59	70
Lysine	38 (69)[2]	40 (73)[1]	43 (78)[1]	46 (84)[1]	55
Methionine + Cystine	27 (77)[1]	29 (83)[1]	29 (83)[1]	35 (100)[1]	35
Phenylalanine + Tyrosine	74	76	77	78	60
Threonine	29	31	33	32	40
Tryptophan	15	17	16	16	10
Valine	37	38	38	38	50
PER (Casein = 2.50 ± 0.21[a])	1.87 ± 0.07[c]	2.16 ± 0.12[b]	2.14 ± 0.11[b]	2.36 ± 0.11[a]	2.36 ± 0.11[a]

1 (-) = Chemical score in parenthesis

2 (-) = Limiting amino acid with chemical score

3 Source : Food Composition Table for use in East Asia (FAO, 1972)

$$\text{Chemical score} = \frac{\text{amino acid content in protein of Kaset protein x 100}}{\text{amino acid content in FAO/WHO standard}}$$

$$\text{Protein efficiency ratio (PER)} = \frac{\text{gain in weight of albino rat}}{\text{protein intake}}$$

alone) is light brown. Its flavor is the same as the three accepted formulae but the odor is similar to fried pork fat. The texture is hard crisp, slightly puffy and a little bit porous. The three accepted soaked glandless cottonseed Kaset protein after preparation of Thai dishes such as kang - pa, kuay - teuw - pad - kee - mao and pad - prick - sod, their colors are yellowish white with good soft and elastic texture. Their taste are good salted, sweet and hot taste with spicy odor for kang-pa. In case of kuay - teuw - pad - kee mao and pad - prick sod, the taste is good salted, sweet hot and nutty with fried tofu odor. The color and taste of soaked defatted glandless cottonseed Kaset protein formula number 1 (made from defatted glandless cottonseed flour alone) after preparation of kang - pa, kuay - teuw - pad - kee - mao and pad - prick - sod is the same as the three accepted formulae. Its texture is too soft and less elasticity with cottonseed odor when compared with the three accepted formulae of defatted glandless cottonseed Kaset protein. The addition of full fat soyflour, defatted groundnut flour and defatted sesame flour into defatted glandless cottonseed flour before making Kaset protein could improve the texture by increasing their softness, elasticity, porosity and crispness of defatted glandless cottonseed Kaset protein.

CONCLUSION

The result from the preparation of 6 formulae of defatted glandless cottonseed Kaset protein from defatted glandless cottonseed flour by using village texturizer indicated that the defatted glandless cottonseed Kaset protein formula number 3, 5 and 6 were the best accepted in color, flavor, texture and acceptability. Their protein and fat contents were in the ranges of 44.44 - 45.93% and 23.19 - 25.11% on dry weight, respectively. The protein quality of the three accepted defatted glandless cottonseed Kaset protein were improved due to the chemical score of limiting amino acid lysine increasing to 73, 78 and 84%, respectively. The PER increased to 2.16 ± 0.11, 2.14 ± 0.11 and 2.36 ± 0.11, respectively while that of defatted glandless cottonseed Kaset protein formula number 1 (made from defatted glandless cottonseed flour alone) was only 69% and PER was 1.87 ± 0.07 while the PER of casein was 2.50 ± 0.21. So the adding of full fat soy flour, defatted groundnut flour, defatted sesame flour and L -methionine into defatted glandless cottonseed flour before making Kaset protein could improve the protein quality and the color and texture of the three accepted products.

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Received date : 25/06/98
Accepted date : 20/11/98