Kasetsart J. (Nat. Sci.) 30 : 400-408 (1996)

Production of High Protein Snack from Defatted Glandless Cottonseed Flour

Somchai Prabhavat, Duangchan Hengswadi, Tavidsa Lohana, and Sompoch Yai-Eiam[1]

ABSTRACT

Glandless cottonseed snacks were prepared by using village texturizer. They were prepared from defatted glandless cottonseed flour, defatted glandless cottonseed flour adding full fat soy flour, mungbean flour, defatted sesame flour, rice flour, wheat flour and cassava starch. The average score from sensory evaluation of eleven different formulations of glandless cottonseed snacks in term of color, flavor, texture and acceptability showed that four formulae of glandless cottonseed snacks which were formula number 3, 4, 9 and 11 (formula number 3 and 4 made from defatted glandless cottonseed flour adding 30 and 35% of full fat soy flour, and both adding 10% mungbean flour, 5% defatted sesame flour, 5% rice flour; formula number 9 and 11 made from defatted glandless cottonseed flour adding 30 and 40% of full fat soy flour and both adding 10% mungbean flour, 5% defatted sesame flour, 2.5% wheat flour and 2.5% cassava starch) were not significantly different and were the best accepted compared with the rest of the samples. The protein and fat contents of the best four accepted glandless cottonseed snacks ranged from 35.79-36.47% and 25.11-28.89%, respectively. The protein quality of the best four accepted glandless cottonseed snacks showed higher chemical score of lysine 76-82%, compared to 67% of snack made from defatted glandless cottonseed flour alone. These were due to the added flours such as full fat soy flour, mungbean flour which were rich in lysine, and added flour such as defatted sesame flour, rice flour and wheat flour were rich in methionine + cystine content.

Key words : glandless cottonseed snacks, defatted glandless cottonseed flour, full fat soy flour, mungbean flour, defatted sesame flour.

INTRODUCTION

The cottonseed is derived from the various kinds of the cotton plant (Gossypium), which is cultivated on a large scale in the United States, Egypt, India, South America, Russia and other countries. Undecorticated cottonseed has an oil content of 17-23% while that of kernels (meats) varies from 30 to 38% (Bernadini, 1985). The cottonseed kernel makes up about 55% of the seed's weight and contains 39% protein. The dark specks distributed over the glanded cross section are pigment glands. The major constituent of these glands is gossypol, a yellow phenolic pigment found in all parts of the cotton plant, although it is concentrated mostly in the seed. Gossypol is insoluble in water but is soluble in oil, which accounts for the dark color of extracted crude oil (Abraham and Hron, 1992). The amount of gossypol in a moisture free kernel varies for different varieties

[1] Institute of Food Research and Product Development, Kasetsart University, Bangkok 10900, Thailand.

and growing conditions generally ranging between 0.4 to 1.7% (Abraham and Hron, 1992; Bernardini, 1985). Since gossypol is toxic to non-ruminants including human (Rao and Swaminathan, 1960; Abraham and Hron, 1992; Bernardini, 1985), different methods have been employed for the detoxication of the seed as much as possible which involve wet heat processing under controlled condition or extraction by solvent or expeller processing (Bernardini, 1985; Altschul, 1974; Rao and Swaminathan, 1960). This deactivated gossypol occurring due to gossypol binds to protein e specially lysine, the quality of protein is reduced (Abraham and Hron, 1992; Lusas *et al.*, 1987; Bernardini, 1985). Therefore the cottonseed meal after oil extraction can be used for human food by making into low fat cottonseed flour and is used for the preparation of processed protein foods which is a vegetable mixture known as INCAP mixture 9 B. This food is found to be very effective in the treatment of kawashiorkor in children (Rao and Swaminathan, 1960). The high protein biscuit is also produced from this flour (Rao and Shurpalekar, 1988). The limiting amino acid of the protein of cottonseed flour is lysine (Rao and Swaminathan, 1960).

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 Hron, 1992; Simmons *et al.*, 1987; Lusas and Jividen, 1987). The kernel are used commercially in the U.S. as alternatives to nuts, confectionery products, topping, icecream, specialties snack foods, and bakery products such as bread and glandless cottonseed butter (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 interpretated 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 were 36.2 and 36.9%, respectively and in the flour were 62.6 and 0.8%, respectively (Anon, 1987; Simmons *et al.*, 1987). The amino acid lysine is deficient in the protein of defatted glandless cottonseed flour (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 are rich in lysine (but deficient in methionine + cystine) and sesame, other cereals such as rice and wheat are rich in methionine + cystine. (Rao and Swaminathan, 1960; Swaminathan and Bhagavan, 1966; Anon, 1990; Cheman *et al.*, 1992; Surendranath *et al.*, 1984). The village texturizer was developed by Meals for Millions foundation (Prabhavat, 1989) and it was originally designed for vegetable protein production at village level. The expansion of dough upon sudden release of pressure, provide porous texture with crispness after drying.

The purpose of this research is to develop the accepted low cost high protein snack from glandless cottonseed (received from the KU-

DORAS project) with improvement to protein quality by adding flour from soybean, mungbean, sesame, rice and wheat flour by using village texturizer. The accepted product not only adds the value to the low cost glandless cottonseed produced in Thailand, but also provides nutritive snack to the people for different aged group especially in the rural area and for snack food industries in the future.

MATERIALS AND METHODS

Preparation of individual flours

1. Defatted glandless cottonseed flour and defatted sesame flour.

20 Kgs of glandless cottonseed and 4 kgs of white sesame seed 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) and sesame seed were seperately washed 4 times with water until clean. Then the glandless cottonseed kernel and sesame seed were separately dried in a cabinet dryer at 50°-60°C for 10 and 5 hours, respectively. The two dried products were separately pressed with hydraulic press (Carver laboratory press, USA) at the pressure 10-11 tons for 5 times. The two pressed cakes were separately ground with pin mill into flours (80 mesh). The defatted glandless cottonseed flour and defatted sesame flour were obtained.

2. Mungbean flour, full fat soy flour and rice flour.

Each of 4 kgs of selected mungbean, soybean and rice (Khao Dawk Mali 105 variety) were used for the preparation of flours. The mungbean was cracked with a hand grinder into two parts and then the cracked mungbean, whole soybean and rice were separately washed 4 times with water until clean. The washed cracked mungbean was soaked in water at ambient temperature for 3 hours and its hull was removed by washing with water until the mungbean dhal was obtained. The washed mungbean dhal, soybean and rice were separately dried in a cabinet dryer at 50°-60° C for 12, 10 and 6 hours, respectively. The dried soybean was cracked with a hand grinder and its hull was removed by using a bamboo pan to get soybean dhal. The obtained mungbean dhal, soybean dhal and dried rice were separately ground into flours (80 mesh) using the same process as defatted glandless cottonseed flour and defatted sesame flour making.

3. Wheat flour and cassava starch.

These two kinds of flour were bought directly from the market in Bangkok.

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 cottonseed snack flours.

Eleven formulae of defatted glandless cottonseed snack flours were prepared from the individual flours 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 snacks

Thirty grams of cane sugar, four grams of pepper powder were dissolved in 100, 100, 100, 110, 120, 100, 115, 110, 115, 110 and 125 mls of water, respectively for adding into each of 500

grams of ten formulae of fortified defatted glandless cottonseed flour formula number 1-5, 7-11 and one unfortified defatted glandless cottonseed flour formula number 6, 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 140°-160° C. The lid was centered over the cup and pressed with the pressure 600-700 psi and holding time for 10-15 seconds. Then the lid was released from the cup. Moist snacks were obtained and they were cut into rectangular shapes (5x1 cm). Then they were dried in a cabinet dryer at 50°-60° C for 2 hours. The dried glandless cottonseed snacks (puffed, crisp texture) formula number 1-11 were coated with barbecue flavor in rotary octa angle coated pot (The ratio of glandless cottonseed snack: soybean oil: barbecue flavor were 20:2:1 by weight) and hot air was blown to dry the barbecue coated glandless cottonseed snack. Then 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 the snacks.

The acceptability test was done for each of the 11 formulae of glandless cottonseed snacks by 10 panalists (researchers of the Institute of Food Research and Product Development, Kasetsart University) for investigation of the different characteristics in terms of color, flavor, texture and acceptability by using Hedonic scale scoring: Score 9-the extreme like, and score 1-extreme dislike. The difference in statistics was determined by using ANOVA and DMRT at 95% significant level. The test was done for 2 times and the duration for each time was one day. The best accepted formulae of snacks were analyzed for chemical and essential amino acid compositions.

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, mungbean flour, defatted sesame flour and rice flour were 81.50, 78.50, 56.25 and 97.50% by weight of raw material, respectively. The protein contents of defatted glandless cottonseed flour, full fat soyflour, mungbean flour, defatted sesame flour, rice flour (Khao Dawk Mali 105 variety), wheat flour and cassava starch were 45.19, 45.55, 27.96, 36.96, 8.45, 12.51 and 0.02% on dry weight, respectively and the fat contents were 23.69, 25.73, 2.77, 38.15, 1.12, 0.96 and 0.00 % on dry weight, respectively as shown in Table 1.

Essential amino acid composition of each individual flour with its limiting amino acid was shown in Table 2. This indicated that the protein of different sources were incompleted. The lysine was the limiting amino acid of protein from defatted glandless cottonseed flour, defatted sesame flour, rice flour and wheat flour whose chemical scores were in the ranges of 33-69% while methionine + cystine were 86-166%. The protein of full fat soyflour and mungbean flour were rich in lysine whose chemical scores were 104 and 122%, respectively but low in methionine + cystine whose chemical scores were 69 and 66%, respectively. The essential amino acid contents of snacks from defatted glandless cottonseed flour could be

Table 1 Chemical composition of various kind of flours.

Kinds of flours	Chemical composition (% Dry weight)						
	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	Crude fiber (%)	Carbohy drate (%)	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
Mungbean flour (MBF)	9.14	2.77	27.96	3.48	1.11	64.68	395
Defatted sesame flour (DFSF)	4.09	38.15	36.96	5.08	4.95	14.86	551
Rice flour (RF)	7.67	1.12	8.45	0.02	0.00	90.41	406
Wheat flour (WF)	12.37	0.96	12.51	0.59	0.16	85.78	402
Cassava starch (CS)	11.84	0.00	0.02	0.23	0.00	99.70	399

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						
	DGCF	FFSF	MBF	DFSF	RF	WF	FAO/WHO[3]
Isoleucine	30	35	37	30	35	31	40
Leucine	57	70	77	62	78	67	70
Lysine	38(69)[2]	57(104)[1]	67(122)[1]	25(46)[2]	35(64)[2]	18(33)[2]	55
Methionine+ Cystine	30(86)[1]	24(69)[2]	23(66)[2]	50(143)[1]	58(166)[1]	52(149)[1]	35
Phenylalanine+Tyrosine	89	82	90	77	90	81	60
Threonine	31	37	33	34	34	30	40
Tryptophan	18	16	14	16	18	12	10
Valine	39	37	45	38	50	37	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).

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

improved by adding two or more flours together to make composite flours before snack making by using village texturizer as shown in Table 3.

The results of the organoleptic evaluation of glandless cottonseed snacks in term of color, flavor, texture and acceptability are shown in Table 4 and

Table 3 Composition of eleven formulae of defatted glandless cottonseed flour for the preparation of glandless cottonseed snacks.

Formula number	Composition, %						
	DGCF	FFSF	MBF	DFSF	WF	RF	CS
1	60	20	10	5	5	-	-
2	55	25	10	5	5	-	-
3	50	30	10	5	5	-	-
4	45	35	10	5	5	-	-
5	40	40	10	5	5	-	-
6	100	-	-	-	-	-	-
7	60	20	10	5	-	2.5	2.5
8	55	25	10	5	-	2.5	2.5
9	50	30	10	5	-	2.5	2.5
10	45	35	10	5	-	2.5	2.5
11	40	40	10	5	-	2.5	2.5

Table 4 Organoleptic evaluation of glandless cottonseed snack formula number 1-5 compare with formula number 6 (from defatted glandless cottonseed flour alone).

Characteristics	Glandless cottonseed snack formula number					
	1	2	3	4	5	6
Color	6.75^{a}	5.50^{c}	6.75^{a}	6.17^{b}	6.33^{ab}	5.25^{c}
Flavor	6.50^{a}	6.92^{a}	6.58^{a}	6.67^{a}	6.92^{a}	5.25^{c}
Texture	6.42^{b}	6.25^{b}	6.50^{ab}	7.17^{a}	6.67^{ab}	4.92^{c}
Acceptability	6.08^{ab}	6.42^{ab}	6.92^{a}	6.75^{ab}	6.50^{ab}	5.08^{c}
Average score	6.44^{a}	6.27^{a}	6.69^{a}	6.69^{a}	6.61^{a}	5.13^{b}

The figures on the same row with the same letter showed no significant difference in statistics at 95% level.

5. It appeared that the glandless cottonseed snack formula number 1-5 and 9-11 were more accepted than the other samples (formula number 6, 7 and 8) with significant difference in statistic at 95% level and the average scores were in the level of moderately like, while glandless cottonseed snack formula number 3, 4, 9 and 11 were the best accepted compared to the rest of samples (formula number 1, 2, 5 and 10).

The chemical composition of the best four accepted glandless cottonseed snacks (formula number 3, 4, 9 and 11) are shown in Table 6. The protein and fat content of the best four accepted glandless cottonseed snacks (formula number 3, 4, 9 and 11) were in the range of 35.77-36.47% and 25.11-28.89% on dry weight, respectively.

Table 5 Organoleptic evaluation of glandless cottonseed snack formula number 7-11 compare with formula number 6 (from defatted glandless cottonseed flour alone).

Characteristics	Glandless cottonseed snack formula number					
	6	7	8	9	10	11
Color	4.92^{c}	6.83^{ab}	6.58^{ab}	7.08^{a}	6.50^{ab}	6.25^{b}
Flavor	5.25^{c}	6.08^{ab}	5.75^{bc}	6.58^{a}	6.25^{ab}	6.58^{a}
Texture	4.83^{d}	5.50^{cd}	6.17^{bc}	7.42^{a}	6.33^{b}	7.25^{a}
Acceptability	5.08^{d}	6.17^{bc}	6.00^{c}	6.67^{b}	6.75^{b}	7.42^{a}
Average score	5.13^{d}	6.15^{b}	6.13^{b}	6.94^{a}	6.46^{ab}	6.88^{a}

The figures on the same row with the same letter showed no significant difference in statistics at 95% level.

Table 6 Chemical composition of the best four accepted glandless cottonseed snacks (formula number 3, 4, 9 and 11).

Chemical composition	Glandless cottonseed snack formula number			
(% dry weight)	3	4	9	11
Moisture, %	3.34	3.49	4.11	3.13
Fat, %	25.11	27.80	28.89	28.42
Protein, %	36.23	35.88	36.47	35.77
Ash, %	4.56	4.62	4.62	4.51
Crude fiber, %	1.19	0.86	1.66	1.49
Carbohydrate, %	32.91	30.84	28.36	29.81
Energy, cal/100 gram.	503	517	519	518

The essential amino acid composition of the best four accepted glandless cottonseed snacks are shown in Table 7. The chemical score of the limiting amino acid lysine of glandless cottonseed snack formula number 6 (made from defatted glandless cottonseed flour alone) was 67%. The chemical score of the best four accepted glandless cottonseed snacks formula number 3, 4, 9 and 11 are increased to 76-82%. These are due to high lysine but low in methionine+cystine contents of the protein of full fat soy flour, mungbean flour and high methionine+cystine content in defatted sesame flour, rice flour and wheat flour added into defatted glandless cottonseed flour before snack making to improve the protein quality of the best four accepted products.

Characteristics of the best four accepted glandless cottonseed snacks.

The color of the best four accepted glandless cottonseed snack formula number 3, 4, 9 and 11 were yellowish brown. Their flavor were optimum

Table 7 Essential amino acid composition of the best four accepted glandless cottonseed snacks formula number 3, 4, 9 and 11 compare to glandless cottonseed snack formula number 6 made from defatted glandless cottonseed flour alone.

Essential amino acid	Glandless cottonseed snack formula number					
	6	3	4	9	11	FAO/WHO[3]
Isoleueine	30	33	34	31	33	40
Leucine	50	59	61	56	59	70
Lysine	37(67)[2]	43(78)[1]	45(82)[1]	42(76)[1]	43(78)[1]	55
Methionine+ Cystine	30(86)[1]	29(83)[1]	29(83)[1]	29(83)[1]	28(80)[1]	35
Phenylalanin+ Tyrosine	74	78	79	74	74	60
Threonine	30	31	31	32	31	40
Tryptophan	16	15	15	15	15	10
Valine	38	41	42	39	40	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)

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

salty, sweet and fatty taste with barbecue odor. In terms of texture, the glandless cottonseed snack formula number, 3, 4, 9 and 11 were good soft crisp, puffy and porous. The color of glandless cottonseed snack formula number 6 (made from defatted glandless cottonseed flour alone) was greyish brown. The flavor was the same as the best four accepted formulae of glandless cottonseed snacks but a little bit astringent taste. The texture was hard crisp, slightly puffy and porous. The addition of full fat soy flour, mungbean flour, defatted sesame flour, wheat flour, rice flour and cassava starch in to defatted glandlees cottonseed flour before snack making could improve the color, taste and texture by increasing their softness, porosity and crispness of glandlees cottonseed snack.

CONCLUSIONS

The result from the preparation of 11 formulae of glandless cottonseed snacks from defatted glandless cottonseed flour by using village texturizer indicated that the glandless cottonseed snacks (formula number 3, 4, 9 and 11) were the best accepted in color, flavor, texture and acceptability. Their protein and fat contents were in the range of 35.77-36.47% and 25.11-28.89% on dry weight, respectively. The protein quality of the best four accepted glandless cottonseed snacks were improved due to the chemical score of limiting amino acid lysine increased to 76-82% while that of glandless cottonseed snack formula number 6 (made from defatted glandless cottonseed flour alone) was only 67%. So the addition of full fat soy flour, mungbean flour, defatted sesame flour, wheat flour, rice flour and cassava starch into defatted

glandless cottonseed flour before snack making could improve the protein quality and the color, taste and texture of the best four accepted products.

LITERATURE CITED

Abraham, G. and R.J. Hron. 1992. Oilseeds and their oils, pp. 1901-1910. *In* Y.H. Hui. (ed). Encyclopedia of Food Science and Technology. volume 3. John Wiley & Sons, Inc. New York.

Anonymous. 1987. Characteristics and uses of glandless cottonseed food protein ingredients. Technical News Feature. JAOCS. 64 : 973-986.

Anonymous. 1990. Amino Content of Thai Foods. Nutrition Division. Health Department. Ministry of Public Health. 39 p.

A.O.A.C. 1984. Official Methods of Analysis of the Association of Official Analytical Chemists. 14 th ed., Assoication of Official Analytical Chemists, The William Byrd Press, Inc. Arlington. Verginia. 1141 p.

Bernardini, E. 1985. Cottonseed, pp. 153-169. *In* E. Bernardini (ed). Oilseeds, oils and fats processing. Volume 1. 2nd ed., Publishing House. Rome.

Cheman, Y.B., N.B.A.K. Mohamad, and T.K. Tan. 1992. Evaluation of flour high-protein rice-soy snack formulations. J. Fd. Sci. Technol. 27 : 715-719.

FAO. 1972. Food Composition Table for Use in East Asia. FAO and US. Department of Health, Education and Welfare. 334 p.

Lusas, E.W. and G.M. Jividen. 1987. Glandless cottonseed: A review of the first 25 years of processing and utilization research. Technical News Feature. JAOCS. 64 : 839-854.

Prabhavat, S. 1989. The effect of Moisture in full fat soyflour and temperature of village texturizer on the production of kaset protein, pp. 363-373. *In* Proceeding of the 27th Kasetsart University Annual Conference. Jan 30-Feb. 1, 1989. Bangkok, Thailand.

Rao, M.N. and M. Swaminathan. 1960. Processed protein foods of vegetable origin, pp. 73-99. *In* Annual Review of Food Technology for 1959. Volume 1. Association of Food Technologists. Mysore Printing and Publishing House, Mysore. India.

Rao, P.H. and S.R. Shurpalekar. 1988. Use of unconventional protein sources in high protein biscuits. J. Fd. Sci. Technol, 25 : 31-34.

Simmons, R.G., J.T. Lawhon, J.T. Farnsworth, and K.C. Rhee. 1987. Characteristics and uses of glandless cottonseed food protein ingredients. JAOCS. 64 : 973-986.

Surendranath, M.R., N.C. Gangi Reddy, G. Azumoddin, D. A. Ramayya, and S.D. Thirumala Rao. 1984. Preparation of low-fat, high-protein sesame seed. J. Fd. Sci. Technol. 21 : 425-426.

Swaminathan, M. and R.K. Bhagavan. 1966. Our Food. Ganesh & Co. (Madras) Private LTD. Madras-17. India. 170 p.