Kasetsart J. (Nat. Sci.) 45 : 900 - 908 (2011)

Sunflower Meal Snack Production Using a Village Texturizer and its Shelf Life

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ABSTRACT

As a by-product of the oil extraction process, sunflower meal (SM) is still high in nutrients and especially fiber and protein. The study objective was to use SM in dried mixtures for snack production using a village texturizer and to study the properties and shelf life of the snack chips produced. The processing parameters using the village texturizer involved 160 °C, 6 psi and 6 sec/chip. The snack chip was 1.5–1.7 mm thick and 4–5 cm in diameter and weighed 0.5–1 g/piece. The chips were crispy having a compression force of 6.20 kg using a TA-XT2i texture analyzer (50 mm aluminum cylinder). The snack was a cream color, with water activity (a_w) of 0.28 and consisted of blended sunflower meal (12.30%), cassava starch (61.48%), all purpose wheat flour (8.20%), seaweed powder (8.18%) and refined palm olein oil (9.84%). The snack had moisture, protein, total carbohydrate, fat, ash, and dietary fiber contents of 1.89%, 6.19%, 72.18%, 13.29%, 2.82 and 3.63%, respectively, and contained 1.81×10^6 J/100 g. The overall liking preference of the product was "moderately". The shelf life of the product in an oriented polypropylene/metallic cast polypropylene laminate film bag was only 1 mth at room temperature, because the product became rancid.

Keywords: sunflower meal, snack, village texturizer

INTRODUCTION

Snacks are a popular food item and are characterized as being a small amount of food eaten between meals, or a light meal that is eaten in a hurry or in a casual manner. The snack industry continues to increase steadily in market size and globally will be worth almost $300 billion by 2010 (Staff reporter, 2008).

The main factors affecting consumer purchasing decisions include taste and flavor, price and whether the snack is considered healthy (AgriSource Co., Ltd. and Diaz 2004). Consequently, the trend in developing products should be to select healthier, more competitively priced raw materials such as sunflower (*Helianthus annuus* L.) meal (SM) that is a by-product of the oil extraction process. At present, non-dehulled or partly dehulled SM has been substituted successfully for soybean meal in isonitrogenous (equal protein) diets for ruminant animals, as well as for swine and poultry feeding (Putnam *et al.,* undated; Poland *et al.,* undated; Smith *et al.,* 2007). Compared with soybean meal, SM is higher in fiber, has a lower energy value and is lower in lysine, but higher in methionine. The protein content of SM ranges from 28% for non-dehulled seeds to 42% for completely dehulled seeds. The

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Received date : 24/12/10 Accepted date : 21/07/11

color of the meal ranges from grey to black, depending upon the extraction processes and the degree of dehulling (Putnam *et al.,* undated). SM is very rich in sulfur amino acids, (Senkoylu and Dale, 1999) unlike most other oilseed meals, and it does not contain high concentrations of anti-nutritive factors. In sunflower seeds, Milic *et al.* (1968) found 1.56% of a tannin-like chlorogenic acid compound, which inhibited the activity of digestive enzymes, including trypsin, chymotrypsin, amylase and lipase. Heating the seeds at 100 °C for 5 hr destroyed about 43% of this chlorogenic acid.

The village texturizer is a small machine for preparing texturized food products at the village level that was developed by the Meals for Millions Foundation (Prabhavat, 1989). The expansion of dough upon the sudden release of pressure provides a porous and crispy texture, similar to the extrudate from an extruder. The fat content of the raw material for this machine may be either low or high, whereas the raw material for an extruder must be low fat. There has been considerable research using this machine with kaset protein (Prabhavat and Vittavatvong, 1986; Prabhavat, 1989; Cuptapun *et al.,* 1991; Prabhavat *et al.,* 1991; Mesomya *et al.,* 1991) and snacks (Prabhavat *et al.,* 1988; Prabhavat *et al.,* 1991).

Due to the high nutritional content of SM and the use of the residue of sunflower seed to a value-added product and the lack of research into this raw material for human consumption, the objective of this study was to use SM in a dried mixture for snack production using a village texturizer and to study the properties and shelf life of the product.

MATERIALS AND METHODS

Materials

SM flakes were acquired from Sunflower Foods Ltd (40 baht.kg^{-1}). The cassava starch, all purpose wheat flour and refined palm olein oil were purchased from a local market. Seaweed-flavored powder was obtained from Globo Foods Ltd and the barbeque- and paprika-flavored powders were obtained from Flavor Plus. All ingredients were kept at 10 °C. The village texturizer machine was constructed by Mr. K. Temtrakool, Institute of Food Research and Product Development, Kasetsart University, in about 2007. Laminated bags made of oriented polypropylene/metallic cast polypropylene (OPP30u/ MCPP25u) were used to pack the snack product and were 10.8 × 18.8 cm in size, with a water vapor transmission rate of 0.10 g.m^{-2}.d^{-1} and were purchased from the local market.

Preparation of SM flour

The SM flakes were blended to flour by a pin mill (Aipine Augsburg) and examined for chemical quality using %moisture (T-CM-002, based on AOAC (2000) 925.45, %fat (T-CM-075, based on AOAC (2000) 989.05, %protein (T-CM-003, Kjeldahl method, based on AOAC (2000) 991.20, using 6.25 as the conversion factor), %crude fiber (T-CM-077, based on AOAC (2000) 978.10, %ash (T-CM-001, based on AOAC (2000) 938.08 and %carbohydrate contents (using the calculation 100 - %moisture - %fat - %protein - %ash - %crude fiber), with two replications.

Dried ingredients for chips making and processing of snack

The experiment was conducted using a randomized complete block design (RCBD) of three treatments, with two blocks. The treatments were ratio of SM and cassava starch at 10:80, 15:75 and 20:70, with 10% wheat flour by weight in every treatment. All dried ingredients were mixed together by hand and hot water (80 °C) was added (about 30% weight of the dried ingredients). The contents were mixed again and molded into round-shaped pieces with a diameter of 3 cm. The pieces were wrapped in banana leaves and steamed (97 °C) for 45 min, followed by freezing in a refrigerator (0 °C) overnight. The frozen pieces were sliced into thin chips about 1.5 mm thick and 2 cm in diameter and then dried in a hot air oven at 65 °C for 6–8 hr. The dried chips were made into the snack using the village texturizer at 160 °C and 4.14 newton.cm^{-2} for 6 sec per chip. After that, the chip was placed in a plastic bag with oil (10% by weight of chips) and flavored powder (10% by weight of chips). Twenty trained panelists (aged 22–52 yr), who were staff members of the Institute of Food Research and Product Development, evaluated the samples for sensory attributes using quantitative descriptive analysis (QDA), where on a scale of 0–7, 0 = no intensity, up to 7 = very strong intensity in color, odor, hardness and crispy texture. Twenty untrained people (aged 20–55 yr) evaluated samples for liking (STP 434, 1968), where on a hedonic scale of 1–7, 1 = dislike very much, up to 7 = like very much. Data were subjected to analysis of variance of the RBCD and Duncan's new multiple range test for inspection of mean differences at a significance level of 0.05, using the SPSS version 12 statistical software (now a part of IBM Corp.; White Plains, NY, USA).

Optimum flavors

The experiment was conducted using a RCBD with three types of flavored powder (seaweed, barbeque and paprika) at about 10% by weight of chips. An oil content of 12% by weight of chips was used to produce an improved coating. The samples were evaluated for sensory attributes using liking scores based on the hedonic scale. Data were analyzed as described earlier.

Quality of developed snack and its shelf life

The texture of the developed snack was measured by a TA-XT2i texture analyzer (50 mm aluminum cylinder) and analyzed for the moisture, fat, protein, ash and crude fiber content as above. The flavored snack was packed in OPP/MCPP laminate bags, with 50 g/pack and heat sealed and then kept in a darkened drawer at room temperature (30–33 °C). Every month, the samples were evaluated for color using the CIELAB 1976 L*(lightness, 0 = black, 100 = white), a*(-a* = greenness, a* = redness), b*(-b* = blueness, b* = yellowness) color scale (Spectraflash 600 plus, Data Color International, USA), for water activity, (a_w; Novasina, EEJA) , thiobarbituric acid (TBA; Pearson, 1976) and the microbiology of a total plate count (Maturin and Peeler, 2001) for yeast and mold (Tournas *et al.,* 2001) *Escherichia coli* (Feng *et al.,* 2002), *Staphylococcus aureus* (Bennett and Lancette, 2001) and a sensory test for liking. Analysis of the data was as described above.

RESULTS AND DISCUSSION

Preparation of SM flour

The SM flour was passed through a 70 mesh and was cream in color, but in some places had little black spots of peeled sunflower residue. The meal flour consisted of 4.77% moisture, 5.50% ash, 21.27% crude fiber, 18.84% carbohydrate, 11.80% fat and had a high protein content of 37.82%, compared with the low crude protein content (18.70%) and high crude fat (23.98%) of raw, whole sunflower seeds (Akande, 2011).

Dried ingredients for chips making and processing of snack

The flavored snack was in the form of a thin chip about 1.5–1.7 mm thick, round in shape (about 4–5 cm in diameter) and weighed 0.5–1 g/ piece. The ingredients of the three formulas all used 10% all-purpose wheat flour that has gluten proteins to make the snack tough and chewy. Cassava starch was the main ingredient to help the snack swell softly on heating. Finally, the last important factor in the formulas was the SM that replaced 10, 15 and 20% of the cassava starch. The intensity of the flavored snack is shown in

Table 1. It was found that the color and odor were not significantly different, with moderate to high color intensity and moderate intensity of odor, although as the quantity of SM increased in formulas 2 and 3, there may have been a little more obvious odor of sunflower seed. In general, the color of the flavored snack was cream in color from the creamy color of the SM and the seaweed powder, although some spots of powder had the green color of seaweed. The texture of all three formulas was not significantly different, but varied in crispness from moderate to high intensity. The hardness of formula 3 had the highest value, with a moderate score that was not significantly different from formula 2, but was significantly different from formula 1, because formula 3 had the highest quantity of SM which meant it had higher fiber as the cassava starch was reduced to its lowest level.

The sensory evaluation by liking is shown in Table 2. With increasing SM, the color liking of the snack decreased to a score of little from a score of moderate. The flavors of all formulas were considered moderate and were not significantly different, perhaps because all formulas were using the same flavor compounds. Formula 2 gained the highest texture liking, with a moderate score that was not significantly different from formula 1 but was significantly different from formula 3 that had a liking score of little (because the texture of formula 3 was considered excessively hard), which was consistent with the formula 3 score for intensity, so formula 2 was selected for the next development phase.

Optimum flavors

The liking responses for the three flavors of the snack are shown in Table 3. The color of the barbeque and paparika snacks was liked very much and received the highest score, while the color of the seaweed snack was liked a little. The odor and flavor of the seaweed snack were liked moderately and very much, respectively, and

Table 1 Intensity of flavored snack using QDA sensory evaluation.

Formula	Color	Odor	Hardness	Crispy texture
1	3.75±0.28[a]	3.00±0.27[a]	3.19±0.23[b]	4.93±0.29[a]
2	4.19±0.28[a]	3.22±0.27[a]	4.06±0.23[ab]	4.79±0.29[a]
3	4.33±0.28[a]	3.25±0.27[a]	4.47±0.23[a]	4.09±0.29[a]

Means in each formula followed by the same superscript were not significantly different at $P > 0.05$.

Table 2 Liking of flavored snack using hedonic scaling of sensory evaluation.

Formula	Color	Flavor	Texture
1	5.94±0.40[ab]	5.24±0.41[a]	6.56±0.46[a]
2	6.38±0.40[a]	5.66±0.41[a]	6.83±0.46[a]
3	4.41±0.40[b]	5.69±0.41[a]	4.92±0.46[b]

Means in each formula followed by the same superscript were not significantly different at $P > 0.05$.

Table 3 Liking of three flavored snacks using hedonic scaling from sensory evaluation.

Formula	Color	Odor	Flavor	Texture	Overall
Seaweed	5.89±0.90[b]	6.72±1.07[a]	7.33±1.08[a]	7.06±1.06[a]	7.25±1.11[a]
Barbeque	6.72±1.07[a]	5.72±1.49[b]	6.06±1.30[b]	6.56±1.29[a]	6.00±1.33[b]
Paprika	6.72±0.75[a]	6.33±1.24[ab]	6.67±1.33[ab]	6.61±1.20[a]	6.78±1.17[a]

Means in each type of flavor powder followed by the same superscript were not significantly different at $P > 0.05$.

received the highest scores, so the seaweed flavor was selected for the snack coating. The Pearson correlation coefficients for sensory evaluation between overall liking with other attributes (all at the probability level of $P \leq 0.05$) were 0.279, 0.008, 0.786 and 1 for color, odor, flavor and texture, respectively. The correlations indicated that texture was the most important attribute of the snack.

Quality of developed snack and its shelf life

The developed snack consisted of blended sunflower meal (12.30%), cassava starch (61.48%), all purpose wheat flour (8.20%), seaweed powder (8.18%) and refined palm olein oil (9.84%). The texture of the snack was crispy with 6.20 kg by TA-XT2i texture analyzer and had a moisture content of 1.89% that was very low compared with the product standard for snacks in Thailand (107/2003), which requires less than or equal to 4% moisture content. The other characteristics for the SM were 13.29% fat, 6.19% protein, 2.82% ash and 3.63% crude fiber, while the major portion of 72.18% carbohydrate came from the cassava starch and wheat flour by subtraction (100 - 1.89 - 13.29 - 6.19 - 2.82 - 3.63) and contained 1.81×10^6 J/100 g. Sensory analysis is one of the most sensitive methods available to quantify the oxidative deterioration of a product (Powers, 1984), so the present study used it to evaluate the snack shelf life. The liking score of the snack packed in OPP3/MCPP bags and stored for 2 mth is shown in Table 4 The scores of all attribute decreased as the storage time increased, except for the color which did not change. The scores for odor, flavor and overall after 2 mth decreased markedly, to the extent that the panelists rated the product as "not like very much", commenting that it was rancid, with the values for a_w and TBA (Table 5) increasing by about 0.28–0.33 and 0.858–1.69 mg malonaldehyde.kg^{-1}, respectively, as the storage time increased. However, this sample had a_w less than 0.50 so the products could be classified as shelf stable because no microorganism could proliferate at such a low a_w value (Beuchat, 1981). Water activity is an important factor in fungal spoilage and the production of mycotoxins (Magan and Aldred, 2007). Katz and Labuza (1981) studied the effect of a_w on the sensory crispness and mechanical deformation of snack food products and found that the critical a_w level where the products became organoleptically unacceptable was 0.35–0.50. Lavelli *et al*. (2007) studied the stability of

Table 4 Liking of flavored snack with increasing storage time.

Time (mth)	Color	Odor	Flavor	Texture	Overall
0	5.89±0.90^a	6.72±1.07^a	7.33±1.08^a	7.06±1.06^a	7.25±1.11^a
1	5.80±1.07^a	5.90±1.49^b	5.74±1.30^b	6.96±1.29^a	5.67±1.33^b
2	5.81±0.75^a	2.23±1.24^c	2.54±1.33^c	6.55±1.20^b	2.38±1.17^c

Means in each type of flavor powder followed by the same superscript were not significantly different at $P > 0.05$.

Table 5 TBA*, a_w, L* a* and b* color values of flavored snack with increasing storage time.

Time	a_W	TBA	Color		
(mth)		(mg malonaldehyde.kg^{-1})	L*	a*	b*
0	0.28±2.41^a	0.858±0.74^a	80.08±0.25^a	3.72±0.05^a	18.95±0.07^a
1	0.29±0.92^a	1.09 ±0.33^a	81.89±0.61^a	3.36±0.08^a	18.64±0.20^a
2	0.33±1.05^b	1.69 ±0.58^b	82.95±0.10^b	2.54±0.26^b	18.62±0.25^b

Means in each column followed by the same superscript were not significantly different at $P > 0.05$.

carotenoids in dehydrated carrots and found that carotenoid had maximum stability at a_w values of 0.31–0.54 (6–11% of moisture on wet weight basis) and within this a_w range, microbial growth was halted and enzymatic activity and non-enzymatic browning were at a minimum. The TBA level is a measure of the malondialdehyde present in the oxidized fat (Allen and Hamilton, 1983). Many studies of snack have used TBA to monitor the oxidized fat (Bock *et al.,* 2008; Yamsaengsung *et al.,* 2011). Charunuch *et al.* (2008) studied an extruded rice snack and found that it had retained good characteristics when packed in metalized bags that were kept at room temperature for more than 4 mth with an increase of 0.2–0.325 a_w and 1.5–3 mg malonaldehyde.kg^{-1} TBA.

The color measurement of the snack is shown in Table 5. In general, the color changed little, as the lightness (L*) increased, but a* and b* decreased. Based on the sensory evaluation, the shelf life of this product in this packaging at room temperature (30–33 °C) should not be more than 1 mth with 0.29 a_w and 1.09 mg malonaldehyde.kg^{-1} TBA, even though the microbial organism levels (Table 6) were still within the safe ranges set down in the product standard for Thai snacks (107/2003; total plate count (TPC) ≤ 1 × 10^4 colony forming units per gram (cfu.g^{-1}); *Escherichia coli* < 3 most probable numbers (MPN) per gram; zero levels of *Staphylococcus aureus;* and yeast and mold < 100 cfu.g^{-1}). There was a trend of increasing microbial activity with time. The low shelf life of the snack may have been due to the OPP/MCPP bags (Hernandez and Giacin, 1997), as the low quality packaging provided low barrier protection against UV lighting. In addition, this snack was moisture sensitive and had a high fat content from the meal of the sunflower seed oil. Commercial sunflower oil contains high amounts (69.2%) of linoleic acid, which is a polyunsaturated omega-6 fatty acid (Jasso de Rodriguez *et al.,* 2002), so it may have been readily susceptible to oxidation. Lipid oxidation produces rancid odors, unpleasant flavors and discoloration, and can also decrease nutritional quality and safety, resulting in harmful effects to human health (Esterbauer *et al.,* 1991; Lercker and Rodriguez-Estrada, 2002). The shelf life of snack foods may be prolonged by storing them in an argon-rich environment (100% argon or a mix with other gases, such as carbon dioxide or nitrogen) and using a gas-impermeable container (Humphreys and Spencer, 1999).

Table 6 Microbial sampling of flavored snack from shelf life study.

Time (mth)	Microorganism	Result
0	Total plate count, cfu[1].g^{-1}	< 10 (None)
	Yeast, cfu.g^{-1}	< 10 (None)
	Mold, cfu.g^{-1}	< 10 (None)
	Escherichia coli, MPN[2].g^{-1}	< 3
	Staphylococcus aureus, cfu.g^{-1}	None
1	Total plate count, cfu.g^{-1}	1.8 × 10^2
	Yeast, cfu.g^{-1}	55
	Mold, cfu.g^{-1}	< 10 (None)
	Escherichia coli, MPN.g^{-1}	< 3
	Staphylococcus aureus, cfu.g^{-1}	None

[1]Cfu.g^{-1} = Colony forming units per gram

[2]MPN = Most probable numbers.

CONCLUSION

Sunflower meal can be used as a raw material for snack production using a village texturizer. However, in order to improve the texture of the products and gain consumer acceptability, the sunflower meal should be limited to no more than 15% by weight of dried ingredients for chip making. The shelf life of the snack in OPP/MCPP laminate film bags was only 1 mth at room temperature. This study was undertaken at a pilot scale with the snack being produced only one chip at a time, so an improved product would be expected if the village texturizer was used in a continuous process.

ACKNOWLEDGEMENTS

The authors wish to thank Research Net Work (Upper Middle Part of Thailand), Commisssion on Higher Education for financial support.

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