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Formula optimization for garlic and pepper-flavoured puffed snacks

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Abstract

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Herbs show high potential as functional ingredients in Thai snacks. Garlic was the most preferred herb in snacks, followed by holy basil, and pepper. This study was to determine the amount of spices such as garlic and pepper to be added to the products to beneficially improve the health status of the consumer without detrimental effect on the flavour and taste. The Box-Behnken ($k = 3$, $n_c = 3$) response surface design was used to create a model to determine the optimum garlic and pepper flavour for puffed snacks. Specified quantities of salt (1-2 %(w/w)), garlic (0-4 %(w/w)), and pepper (0-4 %(w/w)) were used in the design. Fifteen spiced snacks were evaluated by 30 Thai panelists. The model showed the optimum pepper quantity of 0.7 %(w/w) and salt and garlic of no more than 1.10 and 2.80 %(w/w), respectively. If 25 g of the puffed snacks were eaten daily the consumer would get enough garlic to satisfy its daily requirements, but not enough pepper to get its purported health benefits. However, as the Thais use copious quantities of pepper in most other dishes, it is likely that eating 25 g of the proposed functional snack with their other dishes would more than likely provide enough pepper to give them the health benefits from this herb.

Key words : puffed snacks, functional snacks, garlic, pepper

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Snacks have become a rapid food solution for consumers. A number of global trends and lifestyle factors are currently driving the snack industry. For examples, more women are working, changing and extended working hours, increasing number of single person households, different eating times and food choices by individual family members, kids' buying power, consumer's need for indulgence, and increasing perception of food as a reward (Promar International, 1997; Euromonitor, 2002). In 2004, the value of the savoury snack market in Thailand was expected to be worth Bt 10-12 billion. This market consists of puffed snacks (40%), potato chips (30%), puffed rice (9%), prawn crackers (8-9%), fish snacks (8%), and others such as nuts and popcorn (Tansattakij, 2004). However, health concerns have caused many consumers to reduce their consumption of processed snacks. A key marketing opportunity exists for the development of functional snacks that will meet both the increasing demand for snacks and their need to be "healthy" (Euromonitor, 2002). Snacks have become one of the major groups of the functional food products (Roberts, 2002). A good evidence of this market opportunity is the functional snack food market in the U.S., estimated to be $1.6 billion by the end of 2001, $2.8 billion by 2005, and $4.8 billion in 2010. Snack food, which represents 7% of the total U.S. functional food market, is the fastest growing segment, up by 30% in 1999, 20% in 2000, and an estimated 18% in 2001 (Sloan, 2001).

Herbs have been added to foods throughout history for preservation and flavour. Creative use of herbs can make it easier to enjoy foods while maintaining a healthful diet because of their negligible calories and excellent replacement for fat and salt (Dole Food Company, 2002). Moreover, the pharmacological properties of Thai herbs have been well documented (Farnsworth and Bunyapraphatara, 1992; Primary Health Care, 1998). Flavours and seasonings are important considerations for snacks (Williams, 1999) and herbs could be used as both flavouring (Williams, 1999; Nordmark, 1999) and functional ingredients (Pszczola, 1999) in snack products. Therefore, using herbs as functional ingredients to improve the health benefits of snacks is an interesting alternative.

Wangcharoen *et al*. (2002a) showed that 47.3% of Thai respondents in urban areas ate snacks on a daily basis. Their main reasons for consuming snacks were their taste, their ability to stop hunger, and they are fun to eat. Good snacks should be convenient to consume, inexpensive, nutritious, low in fat, and have long shelf life. About half of the respondents said they probably or definitely would buy snacks containing Thai herbs with medicinal or health properties. Ngarmsak *et al*. (2002) showed that garlic was the most preferred herb in snacks, followed by holy basil and pepper. Wangcharoen *et al*. (2002b) also found that pepper, garlic, and holy basil were compatible herbs for puffed snacks. The preference for these herbs by Thai consumers may be due to their familiarity with the herbs. They have been widely used as culinary herbs and have been known as medicinal plants in Thai traditional medicine. Garlic is now commonly used for reducing cholesterol, and cardiovascular risk. The effectiveness is thought to be due to active substances in garlic such as allicin and other breakdown products (Koch and Lawson, 1996). Randomized clinical trials showed that garlic could significantly reduce total cholesterol levels in the subjects as compared with placebo (Warshafsky *et al*., 1993; Silagy and Neil, 1994; Stevinson *et al*., 2000; Ackermann *et al*., 2001). Preliminary studies on holy basil have shown that its leaf and seed may help people with type 2 diabetes control their blood sugar levels (Agrawal *et al*., 1996; Rai *et al*., 1997). Active compounds in holy basil are terpenoids, particularly eugenol, thymol, and estragole (de Vasconcelos Silva *et al*., 1999). Pepper has long been recognized as a carminative, (a substance that helps prevent the formation of intestinal gas), a property likely due to its beneficial effect of stimulating gastric acid secretion by piperine, an alkaloid found in pepper (Ononiwu *et al*., 2002). Other researchers have shown that pepper demonstrated impressive antioxidant (Karthikeyan and Rani, 2003; Vijayakumar *et al*., 2004; D'Souza *et al*., 2004) and

anti-inflammatory effects (Mujumdar *et al*., 1990; Pratibha *et al*., 2004).

The difficulty in formulating any spice blend is in deciding how much of each spice to add to achieve a desired flavour. The original aim of this study was to determine how much each spice should be added to beneficially improve consumer health. The recommended daily doses are 600-900 mg (Brown, 1996; Blumental *et al*., 1998) and 400-1,200 mg (Fisher and Painter, 1996) for garlic powder, 4,000 mg for dried holy basil, and 500-1,000 mg for dried pepper (Primary Health Care, 1998). These spice levels were then compared with the levels of the respective spices that are used in other Thai dishes and it became clear that it would be impossible to add the recommended level of holy basil without having a detrimental effect on the flavour of the spice blend. It would, however, be possible to add the suggested levels of the other two spices so that a normal pack size of puffed snacks would provide all the daily nutrient requirements for garlic and pepper.

Therefore, the objective of this study was to establish the optimum levels of garlic and pepper in puffed snacks, where optimum level was defined as being the level that met the dual needs of being well-liked and imparting health benefits to the consumer. The product used in this study was a puffed potato snack flavoured with garlic and pepper to provide health benefits to consumers 12 years of age or older who had preference for strong and hot flavour of garlic and pepper.

Materials and Methods

An extruder-cooker was used to produce extruded pellets from 100% potato starch using minimum water feed, screw speed of 220 rpm, and cooking temperature of 110ºC for 30-45 s. The pellets were then dried at 95ºC to reduce their moisture to 10% (w/w) and held at least one more day before deep frying at 180-190ºC for 30 s to produce puffed snack. The Box-Behnken (k = 3, n_c = 3) response surface design (Myers and Montgomery, 1995) was used to create a model for determining the optimum flavouring of garlic and pepper for the puffed snack. Fifteen separate runs were conducted to determine the optimum levels of the flavouring ingredients from among the three levels of the three ingredients: salt, garlic powder, and pepper powder. The detail of the experimental design is shown below:

Variable	Level (%w/w)		
	Low (-1)	Medium (0)	High (1)
Salt	1	1.5	2
Garlic powder	0	2	4
Pepper powder	0	2	4

The resulting products from the experimental design were evaluated by a group of consumer panelists. Thirty Thai students in Palmerston North, New Zealand, aged 18-42 years, who ate snacks regularly and liked the strong and hot flavour of garlic and pepper, were recruited for 1-h sample evaluation. All panelists were advised on how to evaluate the samples before the test. Five grams of each sample was served in a transparent plastic bag. The panelists were asked to evaluate 5 sets of 3 samples, with a 10-min break between the sets. A 9-point hedonic scale (1 = Dislike extremely, 5 = Neither like nor dislike, 9 = Like extremely) was used as a measuring tool for sample evaluation. The taste testing was done without replication, since it was an acceptance test.

Sensory responses of the 30 panelists were computed as standard scores (Z-score) and were averaged for each trial run. The scores for each ingredient were then used as independent variables in the equation for estimating the degree of consumer preference. The original estimating model was:

$$\begin{aligned}\text{Liking score} = {} & \text{constant} + a\,[\text{Salt}] + b\,[\text{Garlic}] \\ & + c\,[\text{Pepper}] + d\,[\text{Salt}^2] + e\,[\text{Garlic}^2] \\ & + f\,[\text{Pepper}^2] + g\,[\text{Salt}][\text{Garlic}] \\ & + h\,[\text{Salt}][\text{Pepper}] + i\,[\text{Garlic}] \\ & [\text{Pepper}]\end{aligned}$$

Analysis of variance was done to obtain a working model, which was then optimized by

calculating the first derivative of function and finding a maximum point to define the appropriate value of the variable (either salt, garlic powder, or pepper powder). This value was then substituted into the working model to estimate values of other variables. All values were translated into the optimum quantities of salt, garlic powder, and pepper powder that should be used to flavour the new puffed snack. With the estimated optimum values for salt, garlic and pepper powder the new product was produced and evaluated for acceptance by the same 30 panelists. All data analysis was done by SPSS 10.0 for Windows.

Results and Discussion

The standardization (Z score) of sensory responses was done to solve the difference of using the scale area from the panels. Z-score means of each trial run are shown in Table 1 and were used to create a model for optimizing the quantities of the three flavouring ingredients. Results of the analysis of variance and coefficients for each independent variable of the original model are shown in Tables 2 and 3, respectively, and the resulting model is as in equation 1.

$$\text{Z-score mean} = -0.182\,[\text{Salt}] + 0.130\,[\text{Garlic}] - 0.227\,[\text{Pepper}] - 0.179\,[\text{Pepper}^2] + 0.199\,[\text{Salt}]\,[\text{Garlic}] \quad (1)$$

$R^2 = 0.904$; Adjusted $R^2 = 0.731$
Standard error of the estimate = 0.15

From equation 1, the optimum quantity of pepper powder could be estimated by calculating the first derivative with respect to "Pepper", and solving this derivative equation to find the value of "Pepper" which makes the first derivative value equal to zero. The optimum pepper quantity was subsequently found to be -0.634 (or 0.73% (w/w)) as shown below.

d [Z-score mean]/d [Pepper]
= - 0.227 - (2*0.179) [Pepper]
0 = - 0.227 - 0.358 [Pepper]
[Pepper] = 0.227 / (-0.358) = -0.634

The above optimum value was substituted into equation 1 to obtain equation 2, as shown below:

$$\text{Z-score mean} = 0.072 - 0.182[\text{Salt}] + 0.130\,[\text{Garlic}] + 0.199\,[\text{Salt}][\text{Garlic}] \quad (2)$$

Figure 1 shows a plot of equation 2 with the optimum quantities of salt and garlic powder. The optimum quantity of salt was no more than -0.8 (or 1.1%(w/w)) and that of garlic powder was no more than 0.4 (or 2.80% (w/w)). To validate these

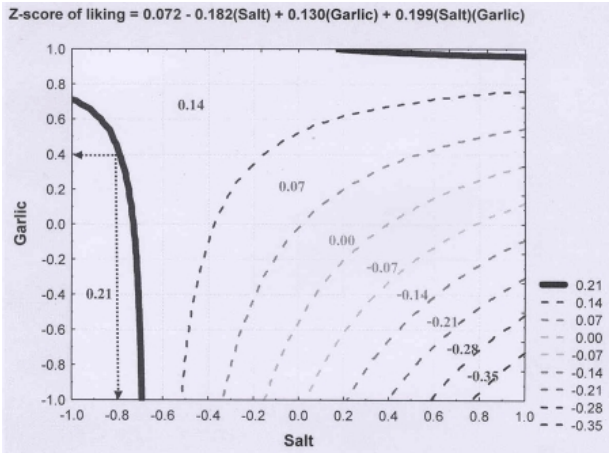

Figure 1. A plot of the model (equation 2) when the value of pepper = -0.634 (0.73 %(w/w)).

Table 1. The Z-score means of consumer panels' sensory responses.

Trial Run	Salt	Garlic	Pepper	Mean of Z-score
1	-1	-1	0	0.441
2	+1	-1	0	-0.428
3	-1	+1	0	0.219
4	+1	+1	0	0.147
5	-1	0	-1	0.281
6	+1	0	-1	-0.138
7	-1	0	+1	-0.158
8	+1	0	+1	-0.236
9	0	-1	-1	0.049
10	0	+1	-1	0.382
11	0	-1	+1	-0.593
12	0	+1	+1	-0.236
13	0	0	0	0.121
14	0	0	0	0.162
15	0	0	0	0.004

Table 2. Analysis of variance for the original estimating model.

	Sum of Squares	df	Mean Square	F	Significance
Regression	1.1048	9	0.1228	5.2183	0.0418
Residual	0.1176	5	0.0235		
Lack of fit	0.0134	3	0.0045	0.0860	0.9614
Pure error	0.1042	2	0.0521		
Total	1.2225	14			

Table 3. Un-standardized coefficients for each independent variable of the original estimating model.

	Un-standardized Coefficients	Std. Error	t	Significance
Constant	0.096	0.089	1.080	0.329
Salt	-0.182	0.054	-3.315	0.021
Garlic	0.130	0.054	2.404	0.061
Pepper	-0.227	0.054	-4.142	0.009
$Salt^2$	0.018	0.080	0.224	0.831
$Garlic^2$	-0.019	0.080	-0.236	0.823
$Pepper^2$	-0.179	0.080	-2.209	0.078
Salt*Garlic	0.199	0.077	2.598	0.048
Salt*pepper	0.085	0.077	1.112	0.317
Garlic*Pepper	0.006	0.077	0.078	0.941

findings, puffed snack with 0.73% (w/w) pepper powder, 1.10% (w/w) salt, and 2.80% (w/w) garlic powder were produced and evaluated by the same 30 panelists. The results showed that all of them accepted this product. If a consumer consumed 25 g of the snack with these optimum spice concen-

trations, they would consume about 700 mg of garlic powder and about 182.5 mg of pepper powder. If 25 g of the snack were eaten on a daily basis, consumers would get enough garlic to satisfy the recommended daily requirements for garlic but not enough pepper to get its purported health benefits. However, as pepper is a common condiment in Thai cooking the amount of pepper in the snack would be more than likely supplemented by other foods the Thais consume. Therefore, the consumption of the puffed snack will provide adequate amount of garlic and increase the amount of pepper consumed to derive health benefits from both. The therapeutic effects of garlic are hypolipidemic, anti-thrombotic, anti-hypertensive, anti-hyperglycemic, anti-hypercholesterolemic and immuno-modulatory (Krishnaraj, 1997; Block, 1998). For pepper, therapeutic uses are as carminative, antipyretic, diaphoretic and diuretic agents (Primary Health Care, 1998).

The bioactive components responsible for health benefits of garlic are assumed to be allylic sulfur compounds. These compounds are offensive in sufficiently high dosage but are much less offensive than piperine, the burning aftertaste which is the bioactive compound of pepper belonging to the vanilloid family of compounds as capsaicins, the hot burning note of chili. Allylic sulfur compounds are reasonably stable in most food systems and can be delivered more easily than compounds in capsaicin family (Reineccius, 2000).

Conclusion

The sensory evaluation results from the experimental design to obtain the optimal spice blend of salt, garlic powder, and pepper powder showed that the optimum quantity of pepper powder that could be added to a puffed snack was 0.73% (w/w). At this level of pepper added, the salt and garlic concentrations should be no more than 1.1 and 2.8% (w/w), respectively. Daily consumption of 25 g of the puffed snack would meet the recommended daily garlic requirements, but not the pepper. However, as the Thais use copious quantities of pepper in most other dishes it is likely that, together with the snack, they would more than likely ingest enough pepper to get the health benefit from this spice as well.

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