CHAPTER 4

Results and Discussion

4.1 Phase 1: Identification of enhanced saltiness perception odors

This phase was conducted to investigate food names associated with saltiness perception. Within the previous studies suggested that odor selection evoked saltiness on the basis of their names so well selected odors could effective on enhances saltiness perception. Each food name evidenced significant differences in saltiness (Lawrence *et al.,* 2009). In this study, identification suitable odors that can enhance saltiness perception by 2 steps, including;

4.1.1 Gathering information of food and food ingredients related to salty perception

1) Literature reviews

Previous studies expressed many odors that used to study effect on enhancing the saltiness perception in various models such as water solution (Djordjevic et al., 2004), salt solution (Djordjevic et al., 2004) and real food products (Nasri et al., 2013; Batenburg and van der Velden, 2011). Some studies also indicated that many food items were used to study the relationship with salty perception (Lawrence et al., 2009). Table 4.1 illustrates all odor/ food and food ingredient items were used to study the association with salty perception.

Table 4.1 List of odor, food and food ingredients were used to study the relationship with saltiness perception from previous studies

Literature reviews	Food/food ingredients/odors names
Batenburg and van der Velden (2011)	beef flavor, chicken flavor, sotolon, abhexon, furfuryl thiol, 2-me-3-tetrahydrofuranthiol
Cerf-Ducastel and Murphy (2004)	citral, ethyl butyrate
Cook et al. (2003)	Garlic
Djordjevic et al. (2004)	soy sauce
Gillan (1983)	citral, anethole
Lawrence et al. (2009)	anchovy, bacon, carrot, chicken, comté cheese, tomato, concentrated cheese, goat cheese, ham, peanuts, roquefort cheese, sardine, soy sauce, sotolona, tuna, caviar, camember, garlic, butter, sauerkraut, capre, lemon, clove, cucumber, scallop, coriander, crab, cream, shrimp, meat stock, cumin, curry powder, shallot, emmental, chicory, tarragon, foie gras, meat powders, chanterelle, lobster, oyster, spiny lobster, laurel, morel, hazelnut, cashew nut, nutmeg, onion, orange, olive, origano, sorel, sea urchin, bread, parsley, pea, pistachio, leek, fish, black pepper, four spices, hot pepper, dry sausage, smoked salmon, truffle, vanilla, meat roast, meat sauce, viennosery, vinegar, milk chocolate, cinnamon, dill, artichoke, mushroom, chive, celery
Lawrence et al. (2011)	sardine, comté cheese
Nasri et al. (2011)	Sardine
Nasri et al. (2013)	Sardine
Niimi et al. (2014)	chesses aroma (2-butanone, 2-heptanone, 2-nonanone, diacetyl, ethyl butyrate, butyric acid, methional, 3-methyl butanal, ethyl hexanoate, 3-methylbutanoic acid)

All these items were used to support with data from focus group interviewing for finding suitable odor enhanced saltiness.

2) Focus group interviewing

Another methodology for finding odor related saltiness in this study was focus group interviewing. A focus group interview is one of several qualitative methodologies that can be used to obtain knowledge, attitude and habits. The benefit of focus group discussion is less time-consuming and cost effective for data collection, requires a smaller sample, but provides a rich array of data (Aldag and Tinsley, 1994). It has been used to obtain knowledge, attitude and eating habits about salt intake of human (Smith et al., 2006). Some reports have expressed facts about individual's attitude, knowledge and behavior of sodium/salt consumption which could be used to enhance understanding of factors that impact consumer awareness and behavior relative to sodium reduction (Smith et al., 2006; North and Neale, 1995; Claro et al., 2012; Kim et al., 2012). Demonstration of sodium content on food label and health claim on food packaging was one important way to help consumer reduce their salt consumption (Claro et al., 2012; Kim et al., 2012). Nonetheless, recent data show that a large number of consumers in many countries were likely to exceed the daily recommended salt intake (Smith et al., 2006; Claro et al., 2012; Kim et al., 2012). For this study, the purpose was to use a focus group interview technique to assess Thai consumer's knowledge and attitude toward sodium reduction in food products, development of reduced sodium salts using OISE approach, and some critical factors affecting such development.

Demographic characteristics of participants

All 48 participants were equally assigned into 6 groups by age: 18-30 years old (group 1 and 2), 31-45 years old (group 3 and 4) and 46-65 years old (group 5 and 6), with the odd-numbered groups having no preference for salty taste/foods while the even-numbered groups having preference for salty taste/foods. The majority of participants (75%) were females. For their occupations, 29% of them were students, 27% housewives, 21% farmers and vendors, 19% government and office clarks, and 4% others. The mixed taste with dominant saltiness was preferred by 42% of participants. Eighty seven percent (29% always and 58% sometimes) of participants added table salt in foods prior to consume.

Attitude of sodium reduction in food products

The summarized focus group responses for attitudes of sodium reduction in food products are shown in Table 4.2. Participants were aware of the sources of salty taste in foods, including salt fish sauce, soy sauce, some condiments and seasonings, and Thai traditional salty foods such as dried salted fish and pickled fish. An interesting observation was that the “consumers not preferring salty taste/foods” groups could identify more sources of salty taste in foods than the “Consumers preferring salty taste/foods” groups. In order to implement appropriate sodium reduction programs, the main source of sodium consumption in the target population for each country should be defined (He and MacGregor, 2010).

For Thai population, the averaged salt consumption is 10.9 ± 2.6 g/ day/person, of which approximately 80% is from condiments (fish sauce, soy sauce, salt, shrimp paste and oyster sauce) used for food preparation (Food and Drug Administration Thailand, 2012). This is similar to some Asian countries in that the main source of sodium intake is from salt added during cooking and in condiments (e.g., pickles), rather than from prepackaged processed foods. For example, most dietary sodium (76%) for People’s Republic of China came from salt added in home cooking, while in Japan, most dietary sodium (63%) came from soy sauce (20%), commercially processed fish/seafood (15%), salted soups (15%), and preserved vegetables (13%) (Anderson et al., 2010). In contrary to some European and Northern American countries, approximately 80% of the main source of sodium intake comes from processed food (He and MacGregor, 2010). Anderson et al. (2010) stated that processed foods, including breads/ cereals/grains, contributed heavily to sodium intake in the United Kingdom (95%) and the United States (for methodological reasons, underestimated at 71%).

Table 4.2 Summarized focus group responses for attitudes of sodium reduction in food products

Group*	Where does salty taste in food products come from?	What is sodium?	What is the importance of salt/sodium reduction in food products?	How would you reduce salt/sodium in food products/in your diets?
1	salt, fish sauce, other condiments, ingredients, sauces, soy sauce & seasoning powder	salt, found in meats, one of nutrients which combines with others	excessive sodium intake causes renal failure, cardiovascular disease, hypertension	using salt substitute and other condiments, avoid seafoods and salted butter, adding less salt in foods
2	salt, fish sauce, soy sauce, seasoning powder, sea salt, fermented fish	not sure,salt, salt solution, salt compounds	no idea,excessive sodium intake causes hypertension	no idea, control salt consumption, using salt substitute, adding less salt in foods
3	salt, fish sauce, sauce, soy sauce, bouillon cubes, seasoning powder, fermented fish	salt powder, salt compounds used in food products, salt compounds, mineral	excessive sodium intake causes renal failure, cardio-vascular disease, hypertension	using salt substitute, adding less salt in foods
4	salt, fish sauce, sauce, soy sauce, seasoning powder, fermented fish	not sure, salt	no idea, excessive sodium intake causes renal failure, hypertension	no idea, using other condiments, control added salt, adding less salt in foods
5	salt, fish sauce, soy sauce, seasoning powder, dried/salted fish	not sure, salt compounds as condiments and soy sauce	excessive sodium intake causes renal failure, cardio-vascular disease, hypertension	reduce added condiments, fish sauce and soy sauce, salted food intake reduction
6	salt, fish sauce, fermented fish	not sure, salt	no idea, excessive sodium intake causes renal failure, hypertension	adding less salt in foods, reduce saltiness in foods

* Group 1 vs. 2 (18-30 years old) =Consumers not preferring vs. preferring salty taste/foods.
Group 3 vs. 4 (31-45 years old) = Consumers not preferring vs. preferring salty taste/foods.
Group 5 vs. 6 (46-65 years old) = Consumers not preferring vs. preferring salty taste/foods

A few participants in each focus group could not accurately define "sodium". Some said that sodium is salt, salt solution or salt compounds, and it is used in food products as condiments and soy sauce. Only one participant stated that sodium appears in natural food such as meat. Similarly, Grimes et al. (2009) studied that consumer knowledge of health risks of high salt intake and frequency of use and understanding of labelled salt information by a cross-sectional survey in shopping centers within Metropolitan Melbourne, Australia. They reported that 65% of participants (N = 475) were unable to correctly identify the relationship between salt and sodium, and 40% stated that salt and sodium were the same substance. Gilbey and Fifield (2006) also reported that over 58% of participants (N = 226) surveyed in multiple locations of a small city in the North Island of New Zealand appeared to believe that salt and sodium are interchangeable terms, and almost 98% were unable to identify the amount of salt present in the product (Wattie's Baked Beans). Subsequently, they suggested that the sodium information on packaged foods in New Zealand was not easily understood by the target population. Furthermore, the use of the word "sodium" on food labels can cause some confusion for conversion of sodium to salt (McLean et al., 2011). In Thailand, the main source of sodium intake of Thai people comes from salty taste condiments such as fish sauce, soy sauce and other sauces. So, the words "salt" and "sodium" are not exactly the same for consumers to understand the relationship between salt, sodium and health risk from excess sodium intake (Food and Drug Administration Thailand, 2012).

Regarding concern of high salt intake on health, all "consumers who not preferred salty taste/foods" participants were aware of the health issues such as hypertension, renal failure and cardiovascular disease that are linked to high salt intake (Table 4.2). Some participants in the "consumers who preferred salty taste/foods" groups were not sure of the adverse health effect of high salt intake. Claro et al. (2012) reported that almost 90 % of participants (N = approximately 400 from each country; Argentina, Canada, Chile, Costa Rica, and Ecuador) (approximately 400 from each country) associated excessive intake of salt with the occurrence of adverse health. Grimes et al. (2009) showed that most (88%)

participants (N = 475) knew of the relationship between salt intake and high blood pressure.

Recently, many countries have voluntarily participated in the salt reduction programs (He and MacGregor, 2010; Legetic and Campbell, 2011). In Thailand health media, salt consumption checklist, and a new food labeling have been used to increase knowledge and awareness of salt reduction (Bureau of Nutrition, Department of Health, 2011). In this study, when further asked "how would you reduce salt/sodium in foods/diet?," a few participants in the "consumers who preferred salty taste/foods" groups had no concept. The majority reported the followings: adding less salt, not adding salt, using salt substitute and other condiments such as lemon, spice and herbs (Table 4.2). A few "consumers who not preferred salty taste/foods" participants said that an easy method for reducing sodium in foods was "not adding salt" but other participants did not agree because food with no added salt was not delicious. To alleviate their concerns, we referred them to two manuals: reduced sweet, fat, salt, overweight/obesity and diseases for Thai people (Bureau of Nutrition, Department of Health, 2011) and reduced sodium prolong the life book (Food and Drug Administration Thailand, 2012).

Reduced sodium salt products by odor-induced saltiness enhancement

After information/explanation regarding sodium reduction in foods and development of reduced sodium salt using OISE had been given, some examples of reduced sodium products were given to the participants. The concept of reduced sodium salt was well received by participants, and could provide alternatives or more choices of salts currently available in the market. However, a few participants raised their safety concern of the odor to be used for reduced sodium salt production. In addition, they were concerned of the overall taste of foods prepared with reduced sodium salts. It is known that reduced and low sodium diets are considered bland in flavor by consumers which may decrease consumer acceptance. Many consumers have grown accustomed to common salt through processed foods; a barrier to limiting sodium intake and new reduced sodium product development (Gibson et al., 2000; World Health Organization, 2010). In Thailand, only a few reduced or low sodium products are available in the market. On the other hand, several reduced sodium products are available in the market in some countries such as United States and Finland. More than half Americans regularly purchase reduced or lower sodium foods and the most food items include canned soup, snacks, and canned vegetable (International Food Information Council Foundation, 2011). In Finland consumers have been encouraged to use partial salt substitute products for home use (Legetic and Campbell, 2011).

In this study, sixty seven food items associated with salty taste/flavor were listed by participants (Table 4.3). During discussion, many traditional food names associated with salty taste/flavor were mentioned by all panelists, including traditional condiments (fish sauce, soy sauce, fermented fish, and shrimp paste), traditional food (spicy soup, Thai noodle soup, and various Thai style salads), etc. A few food items were similar to those of previous studies (Djordjevic et al., 2004; Lawrence et al., 2009; Nasri et al., 2011) including, anchovy, chicken, cheese, ham and soy sauce. For future research on OISE, some tasteless odors were selected to be incorporated into salt, resulting in a salt product with saltier taste perception due to psychological effect. Specifically as odor and saltiness interaction combinations may be specific to cultures, knowledge and experience (Salles, 2006; Lawrence et al., 2009), most mentioned odors such as fish sauce and soy sauce should be used.

Factors affecting development of reduced sodium salts by odor-induced saltiness enhancement

Some desirable attributes and packaging of reduced sodium salt were listed in Table 4.4. The participants thought that characteristics of the reduced sodium salt product should be similar to those of existing salt products in the market. It should be white color, small particles or fine powder and packed in transparent plastic or glass bottle (Table 4.4). An interesting observation was that many participants thought that odor is in a liquid form so they suggested that this product should be liquid packed in a transparent bottle (similar to fish sauce). In addition, the product may be mixed other ingredients such as herbs and spices for good health and food flavor enhancement.

All participants expressed that the price of this product was important to purchase decision. They preferred a low price but would consider if the price is not more than twice the price of current salt products available in the market. In addition to price, the product should be readily available for purchase in various stores or supermarket (Table 4.4). Participants suggested that information about salt reduction should be provided on the product label, and a certification of safety and quality of this product from governmental authorities is desirable.

Table 4.3 A summary of food and ingredient items associated with salty taste

Type	Food/Ingredient items
Condiments	*Sauce* (chili sauce, oyster sauce, tomato ketchup), bouillon cubes, sesame oil, seasoning powder
Local condiments	*Soy* (fermented soybeans, soy molasses**,** soy sauce**);** *Fish and meat* (fish sauce, fermented fish, shrimp paste); *Herb and spice powder* (Hunglay curry powder**,** Chinese five spices powder**,** curry powder)
Meat	*Salted meat* products (crab, fish, beef, chicken, pork, seafoods, egg); *Dried* meat (dried shrimp, dried squid)
Dessert	coconut cream, butter cake
Fruits	salted plum, salted mango
International food	mayonnaise, milk, cheese, salted butter, anchovy, ham, fried chicken, steak, sausage, smoked salmon, canned fish, gravy, yellow curry, ten vegetable stews, pasta, pizza, potato chip
Local food	*Thai soup* (fish organs sour soup, spicy soup, Thai noodle soup, various salad (Thai style), papaya salad, various chili paste, pork/beef fried rice with basil leaf paste, pork sa-tay, Thai omelet with minced pork, sweet and sour pork, stewed pork leg, chicken stir-fried with ginger, various stir-fried meat, whole crispy fish with chili sauce, stir-fried spicy chicken, green chicken curry, *Various curry* (northern style pork curry with garlic, light yellow curry, morning glory curry, northern mixed curry, bamboo shoot curry, chicken drum stick curry and potato, roasted duck in curry sauce, pa-nang curry)

Table 4.4 Summarized focus group responses for factors affecting development of reduced sodium salt by OISE

Group*	Desirable attributes of reduced sodium salt	Desirable package of reduced sodium salt	Price of this product	Type of stores and promotion of this product
1	Powder	packaging must not affect product, plastic bottle, new packaging	less or more expensive than regular salt	everywhere, superstore not promotion, healthy advertisement, booth event, health effects of product, buy 1 get 1 free
2	powder, small particle, liquid, mixed with spices, odor, similar characteristic with existing salt product	plastic or glass bottle	less or more expensive than regular salt	shop, village shop supermarket, retail shop, short TV advertisement, healthy advertisement, brochure
3	powder, small particle, liquid, white color, no other color, mixed with spices, natural odor	transparent plastic or glass bottle	less or more expensive than regular salt, willing to pay	market, supermarket, everywhere, healthy advertisement, brochure, cooking show, give free sample, radio advertisement , using details on label
4	powder, small particle, liquid, white color, mixed with spices, pure salt	transparent plastic or glass bottle	less or more expensive than regular salt, willing to pay	retail shop, market, supermarket healthy advertisement, booth event, give free sample
5	powder, small particle, liquid	glass bottle	less or more expensive than regular salt	everywhere, shop, supermarket, restaurant, market healthy advertisement
6	powder, small particle, liquid, white color, mixed with spices, pure salt	transparent glass bottle	less or more expensive than regular salt, willing to pay	retail shop healthy advertisement

* Group 1 vs. 2 (18-30 years old) =Consumers who not preferred vs. preferred salty taste/foods.
Group 3 vs. 4 (31-45 years old) = Consumers not preferred g vs. preferred salty taste/foods.
Group 5 vs. 6 (46-65 years old) = Consumers not preferred vs. preferred salty taste/foods

Claro et al. (2012) reported more than half of participants would like food labeling to indicate high, medium, and low levels of salt or sodium and would like to see a clear warning label on packages of foods high in salt. Grimes et al. (2009) suggested that increasing consumer awareness of the health risks associated with high salt intake may increase salt label usage and purchases of low salt foods. International Food Information Council Foundation (2011) demonstrated that many factors influence on foods purchasing selection, including, taste (87%), Price (79%), healthfulness (66%), convenience (58%) and sustainability (52%). Therefore, the development of reduce sodium salt products should concern these factors for product success.

4.1.2 Selection of odor on saltiness enhancement by salty intensity rating

Several research issues also shown that different sensory evaluation methodologies were used in order to determine specific odor induce taste enhancement and utilized knowledge about odor induced taste enhancement as a basis for utilization to sugar, salt reduction in food product strategies (Batenburg and van der Velden, 2011) and to improve product palatability (Mukai, et al., 2009). The most method widely used for determining taste-odor interaction is taste rating intensity of aqueous solution model (Djordjevic et al., 2004; Frank et al.,1989; Lawrence et al., 2009) and few have studied taste-odor interaction in real food model such as nutritional products, soup, beverage and cheese (Mukai et al., 2009; Batenburg and van der Velden, 2011). One research has demonstrated the differences in saltiness perception among international food names by taste intensity rating method. They indicated that rating taste intensity perception or expectations of odors depend on names of their food source. Taste rating by using food names was easy and fast to select odor induced taste enhancement (Lawrence et al., 2009). Other sensory evaluation methods for determination of taste-odor interaction were matching and time intensity test (Clark and Lawless, 1994; Djordjevic et al., 2004). The suitable methods were a particularly important factor that these methods were used to prove the hypothesized odor–taste interaction model and study potential applications of taste-odor interaction in the food industry. This part of research was designed to examine the differences in salty intensity rating of food odor items among Thai consumers.

Consumer's Demographic Data

The characteristic of four hundred consumers by age, gender and occupations showed in Table 4.5. As can also be seen in Table 4.5, there were more female (56.59 %) participating than male (43.41 %). The age of participants ranged from 18-65 years old (The mean age of the study sample was 41.1 years). A large proportion of participants (33.41 %) identified themselves as agriculturist, the rest of respondents were comprised of housekeeper (25.37 %), student (22.20 %), corporate officer (5.61 %), government officer (3.41 %), businessman (2.20 %) and state enterprise employee (1.46 %).

Table 4.5 Demographic characteristic of respondents in this research

Demographic question	Response option	Respondent	
		Number	%
What is your age (years)?	18-30 years old	148	36.10
	31-45 years old	146	35.61
	46-65 years old	116	28.29
Gender?	Female	232	56.59
	Male	178	43.41
What is your job?	Agriculturist	137	33.41
	housekeeper	104	25.37
	student	91	22.20
	others (temporary employee)	26	6.34
	corporate officer	23	5.61
	government officer	14	3.41
	businessman	9	2.20
	state enterprise employee	6	1.46

Saltiness intensity rating

The participants were asked to indicate the saltiness intensity of food items name on a ten point scales from "0=unknown" to "9=extremely salty". A total score was calculated for each participant by summing and averaging their scores in each food names. The rated salty intensity was compared within each food item. The results of the top ten average highest salty intensity scores among food odor names are shown in Table 4.6.

Table 4.6 Summary of salt intensity data for each top ten food items in this experiment

No	Food items	Number	Mean*	Standard deviation
1	fish sauce	410	6.33 [a]	1.97
2	fermented fish	410	5.48 [b]	1.96
3	salted fish	410	5.45 [b]	1.99
4	salted crab	410	5.35 [b]	1.90
5	soy sauce	410	5.12 [c]	1.93
6	sea foods	410	4.60 [d]	1.97
7	salted plum	410	4.32 [e]	1.99
8	dried shrimp	410	4.29 [e]	1.92
9	Lime	410	3.98 [f]	1.96
10	salted egg	410	3.95 [f]	1.98

***** The different letters in the same column mean significantly different ($P < 0.05$)

A significant different in salt intensity score was found among fifty seven food odor names used ANOVAs ($P<0.05$). The means for salt intensity score of food items varied within the range of 0.82 scores (unknown to not salty) and 6.33 scores (moderately – much salty to extremely salty) which is in the higher end of the 9-point scale. Fish sauce had the highest saltiness intensity score (6.33 scores) followed by fermented fish (5.48 scores) and salted fish (5.45 scores). The other most highly rated food items in top ten were salt crab, soy sauce, sea foods, salted plum, dried shrimp, lime and salted egg. The ten lowest rated food items included shallot, sesame oil, finger root, lemongrass, kitchen mint, carrot, Chinese kale, anchovy, tree basil and clove. However, only thirteen food items had the means for salt intensity score in range little salty to moderately - much salty (3.23-6.33 scores). The rest of the food items were rated in unknown to not salty-little salty (0.82-2.82).

The findings were in line with earlier research showing that food odor names effect on saltiness intensity rating (Lawrence et al., 2009). With respect to effect of food odor names on human perception, some studies have demonstrated that many factors play a role in human perception of food odor names (Lawrence et al., 2009; Severiano-pérez et al., 2012). Many previous studies showed effect food name label (food identity information) on human perception, for instance, odor intensity, taste intensity, liking and familiarity (Herz and von Clef, 2001; Bensafi et al., 2007; Djordjevic et al., 2008; Okamoto et al., 2009; Shanker et al., 2009). Herz and von Clef (2001) used odor with name labels, including, cucumber, cheese, and mint. The participants sniffed odor and were rated pleasantness, familiarity and intensity on 9-point hedonic scale. Okamoto et al. (2009) presented four food names, including, lemon, coffee jelly, caramel candy and consomme soup with ten taste solutions consisting of 2–3 of the 5 basic tastes in different ratios. Lemon, caramel candy and consomme soup were selected to use in solution with sodium chloride. The participants rated each sample on the labeled magnitude scale of intensity, a 201-point scale of liking and familiarity. Moreover, there are many the other researches showing effect name label on odor perception using hedonic scale (Bensafi et al., 2007; Herz, 2003; Djordjevic et al., 2008). Previous researches suggested that variation of responses in experiment rely on methodology condition, for example, using scales, sample conditions and instructions (Schifferstein, 1996; Salles, 2006; Okamoto et al., 2009). For odor and taste interaction study, some studied used multiple and appropriate scales for preventing the bias (dumping effect). In case, subjects are unable to rate sensory favor qualities of odor in a sample, they 'dump' these qualities onto ratings of other qualities that are rated (such as sweetness, saltiness), thereby producing apparent enhancement (Frank, 2002; Nasri et al., 2011).

It was interesting to note many food items in condiment group had higher saltiness intensity scores than other groups such as fish sauce, fermented fish, salted crab, soy sauce, soup cube, oyster sauce, tomato ketchup, chili sauce and curry powder. Other food name had high salty intensity scores that it was meat group such as salted fish, sea foods, dried shrimp and salted egg. Our result indicated that most food items in condiment group were recorded in the consumption behavior of Thai people study. This research demonstrated that the most salt consumption of Thai people come from condiments (80.3% of total salt consumption). The top five condiments were fish sauce, soy sauce, salt, shrimp paste and oyster sauce that were most consumption in Thai. Some food items were the most popular high salt food for Thai people, including, potato chip and salted egg (Food and Drug Administration Thailand, 2012). Vegetables names, on the other hand, were over-represented in the lowest saltiness rated items. Some vegetable names, such as carrot, were compared to enhance saltiness perception in odor induce saltiness enhancement model (Nasri et al., 2011).

Odor type plays an important role for saltiness perception in odor- induced taste enhancement study similar to previous studies (Djordjevic et al., 2004; Lawrence et al., 2009; Batenburg and van der Velden, 2011). One odor was unable to enhance all basic tastes, for instance, soy sauce aroma did not enhance perceived sweetness but it enhance only perceived saltiness (Djordjevic et al., 2004), the non-salty-related carrot aroma showed no significant saltiness enhancement in sodium chloride solution (Nasri et al., 2011). Batenburg and van der Velden (2011) indicated that anchovy or Roquefort aromas may increase the saltiness perception of chicken bouillon but most consumers cannot accept undesirable flavor profile of these aroma added chicken bouillon. In meat odor group, Batenburg and van der Velden (2011) established that chicken flavor was used in beef bouillons to enhance saltiness perception due to reduced sodium in food products. Furthermore, they utilized single odor compound to enhance salty perception in beef bouillons, for instance, brothy, meaty and roasted compounds.

In this study, the highest salty intensity of food name was fish sauce due to the fact that most Thai people have been familiar with fish sauce smell and the good taste it provides when blended with some local food preparations or when simply used as a sauce. Furthermore, fish sauce is widely used in most country of

Southeast Asia including Thailand (Peralta et al., 1996). It was not similar to previous studies. In case of Lawrence et al. (2009) used eighty–one panelists to rate taste intensity (bitter, sour, sweet and salty) on linear scales from 0 to 10. They showed that anchovy, bacon, smoked salmon, dry sausage, peanuts, ‘‘bouillon cube” and sardine items were the most saltiness associate food name and they suggested salty intensity rating of food names depended on consumer’s knowledge and experience factors. On the contrary, anchovy item were rated in the ten lowest saltiness food items. This item has lower salty scores (1.16 scores) in our research owing to most Thai participants are not familiar with anchovy odor and some Thai participants do not know anchovy. More than half of Thai participants (58.29%) indicated “0=unknown” for this item and only one percent of Thai participants rated “9=extremely salty” (data not shown).

Soy sauce odor was widely chosen to enhance perceived salty taste in water, salt solution and real food for OISE researches (Djordjevic et al., 2004; Lawrence et al., 2009; Batenburg and van der Velden, 2011; Lawrence et al., 2011). Djordjevic et al. (2004) showed imagined soy sauce in weak sodium chloride solutions to enhanced perceived salty taste. Soy sauce was extensively used in solution model of odor induced taste enhancement. For consumers in areas such as United States and Europe, they have not developed tolerance to fish sauce characteristic odor. Fish sauce has not become as popular as soy sauce. In this study, soy sauce name was associated salty intensity at 5.12 (moderately – more salty) and was in top five of salty intensity ranking. Other factors also affected the result of perception in previous studies. Subject’s environmental factors were one factor to influencing the olfactory or gestation function. Some studies have focused on the experience of participants influencing perception response (Batenburg and van der Velden, 2011; Boakes and Hemberger, 2012). Severiano-pérez et al., 2012 supported their research with previous studies (Chrea et al., 2004; Ferdenzi et al., 2013) which culture and specific culture may have influence odor liking and perception. Culture has been proven to influence the olfactory or gestation perception in odor and taste interaction model (Salles, 2006). Moreover, Severiano-pérez et al., 2012 illustrated that scent familiarity showing a significant difference among odor names as different demographic variables including age, gender, occupation and region. Many researches also indicated that women performed significantly better than men in olfactory tasks. The explanation was reported in previous studies to support this result that females have more attentive attitude toward olfaction than males (Seo et al., 2011). Other experiments also reported that differences in the sensitivity between women and men to identify and recognize odors (Öberg et al., 2002; Hummel et al., 2007). Tastes intensity perception of man and woman have different pattern that depend on each basic taste. Hyde and Feller (1981) showed that gender effects for citric acid. The young women rated the sourness higher than the elderly men. On the other hand, some previous studies reported that gender had no effect on some studied response, for example, detection or identification of olfactory information (Larsson et al., 2000), odor familiarity and pleasantness ratings (Ferdenzi et al., 2013) and taste threshold measurement (Akal et al., 2003). The relationship between genders and salty intensity of food items in this study, the results revealed no significant relationship between the salt intensity scores of many food items and gender of respondents. Nevertheless, saltiness intensity showing a significant difference among some food odor names as different men and women. Saltiness intensity of these food odor items was higher for male than female. This is consistent with previous findings that man performed more intense feelings to odors. Particularly, they had stronger feelings related to happiness/well-being, sensuality/desire, and energy (Ferdenzi et al., 2013).

Relationship between gender and age with saltiness intensity rating

Prior to examining different between gender and salty intensity of food odor names, there were no significant difference salt intensity ratings of almost each food odor item between male and female. Less than half of the food odor items (15 food items, 26.79 %) had difference salt intensity scores between male and female. All saltiness intensity scores for these food items were higher for male than female (Figure 4.1).

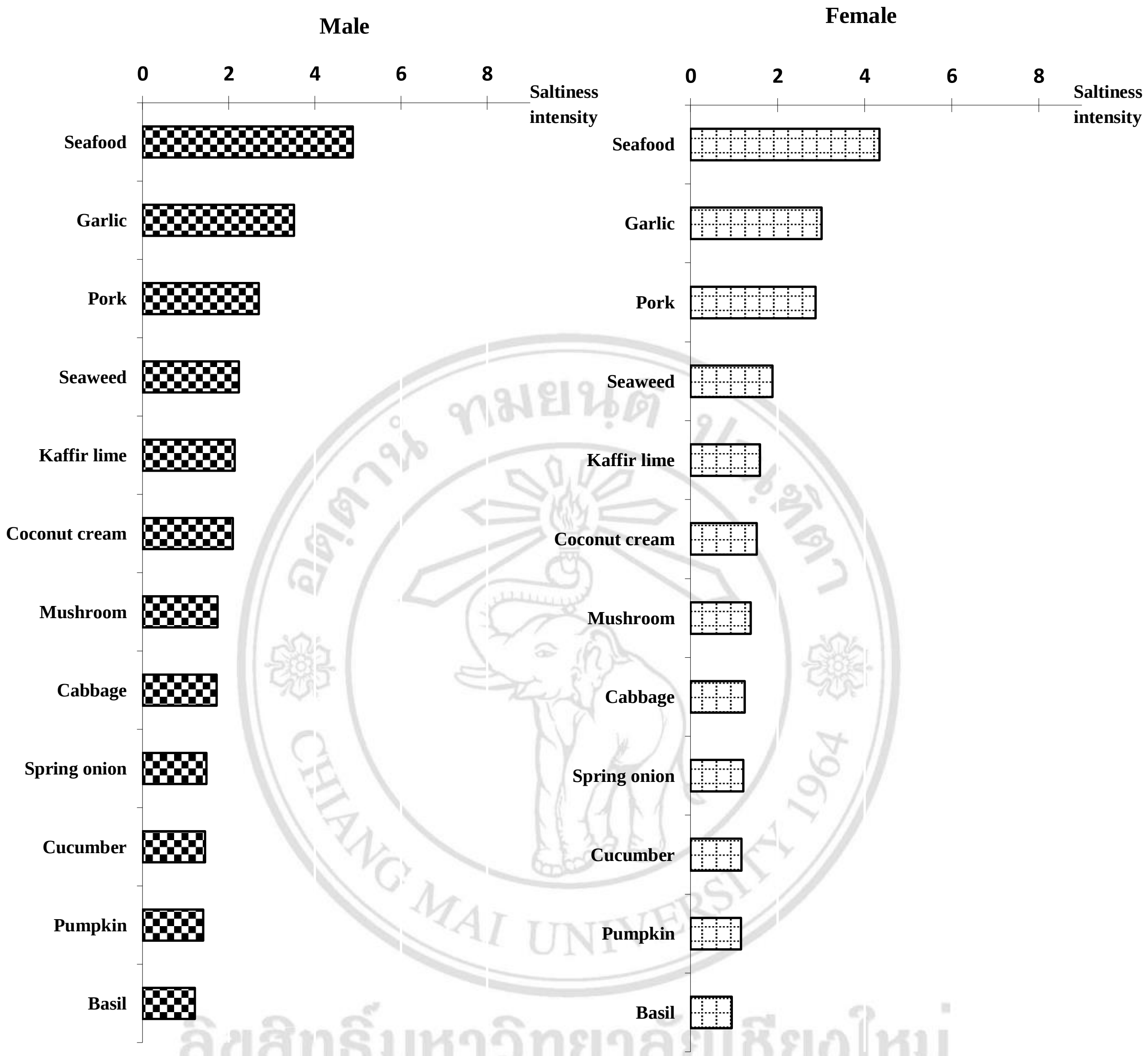

Figure 4.1 Salty intensity of some food odor items showing a significant difference as a function of gender

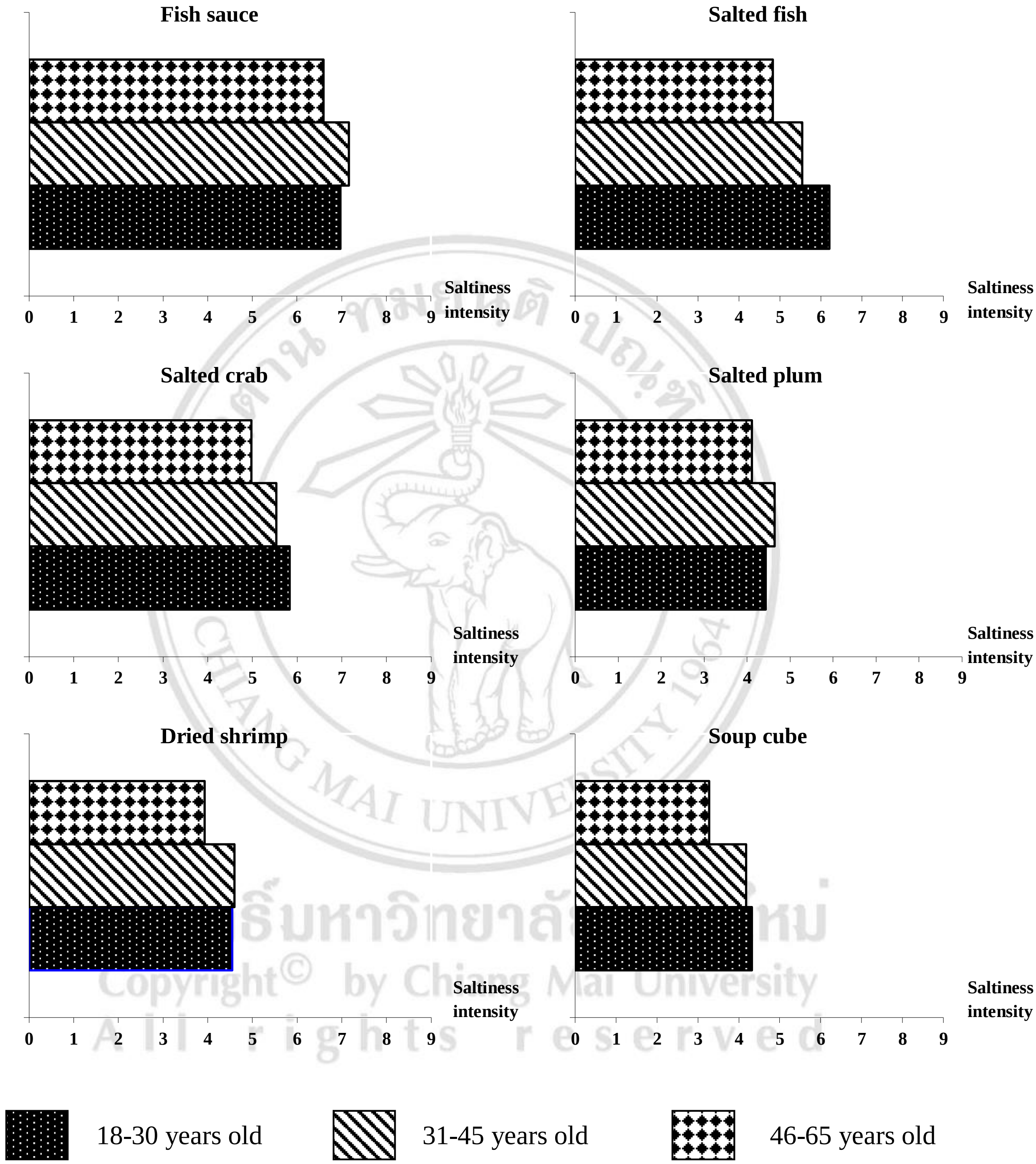

Figure 4.2 Salty intensity showing a significant difference as a function of ages

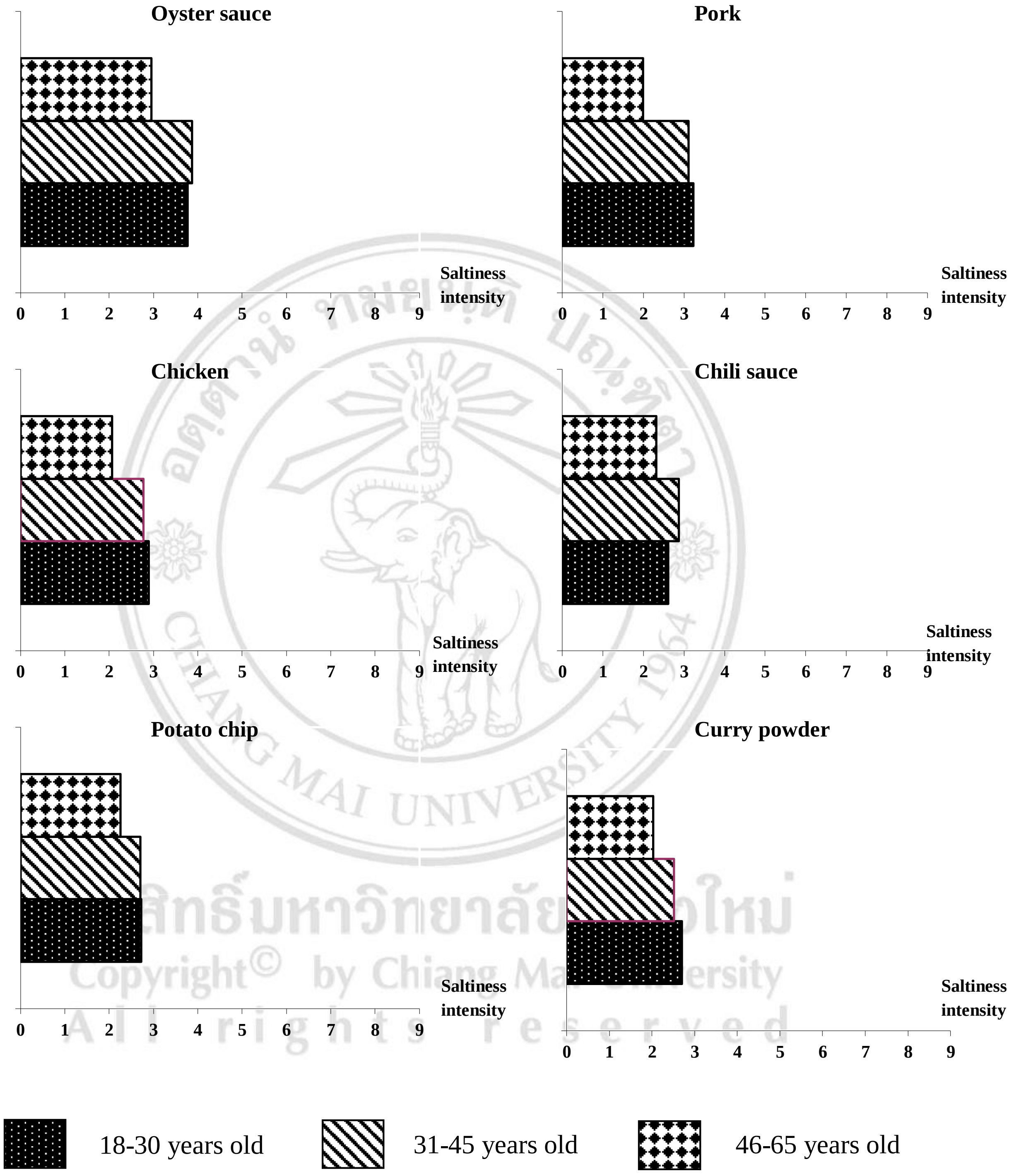

Figure 4.2 Salty intensity showing a significant difference as a function of ages (continued)

In order to examine the influence of age group on the salty intensity rating among food odor items related salty perception, three age groupings were used in this study: young adult, 18-30 years olds (n=148), middle adult, 31-45 years olds (n=146) and old adult, 46-65 years olds (n= 116). This result revealed that the salty intensity scores of most food item were significantly across ages (Figure 4.2). A comparison across age groups found that the old adult (46-65 years) tend to rate salty intensity lower than other ages for almost every food odor item and The high salty intensity for almost every food item was young adult (18-30 years) and middle adult (31-45 years). Gender-by-age interaction effects on saltiness intensity were observed in a few food names such as salted fish, salted crab, tomato ketchup, chili sauce and sesame oil.

There were significant differences between salty intensity scores of many food items in term depend on age groups. The result indicated that saltiness intensity of food odor names decreased with old subjects (46-65 years old). This finding confirmed earlier researches that the odor and taste perception can be affected by age differences. The decline of the olfactory and gestation sense increases with age (Larsson et al., 2000; Mojet et al., 2003; Hummel et al., 2007). Larsson et al. (2000) reported that age differences were related to affects as reported with both detection and identification of olfactory information. The old adults (66–87 years) group detected the odorants less than young-old adults (45–65 years). As in case of odor name familiarity study, Severiano-pérez et al., 2012 showed that leather, spice and herbal odor names were more familiar to the elderly (over 60-years old) and plastic names were more familiar to young people. Within tastes evaluation, the absolute taste perception (intensity rating) decreased with age for all tastants (NaCl, KCl, sucrose, aspartame, acetic acid, citric acid, caffeine, quinine HCl, monosodium glutamate (MSG) and inosine 5′-monophosphate (IMP))in water for all tastants in water (Mojet et al., 2003).

For this research, interaction between gender and age in saltiness intensity were observed in some food odor names. Larsson et al. (2000) pointed out that no evidence of age by gender interactions in odor detection or odor identification abilities. Generally, many investigations reported effect of age and gender difference on odor or taste perception separately. Few investigations showed effect of age and gender difference on odor-taste interaction. This result from our studies concurs with the results gained by other research that exhibit age groups different on odor-taste interaction such as Lavin and Lawless (1998) examined the effects of an added vanilla flavor on judgments of sweetness, creaminess and liking of milk product. The result showed the different between children and adult on the enhancement of rated sweetness by added vanilla favor in milk.

4.2 Phase 2: Investigation of odor induced saltiness enhancement in solution model

Within the result from experiment 4.1 (1), soy sauce odorant were selected to use in phase 2 within criteria; No. 5 rank in salty intensity from experiment 4.1(2), available, suitable, popularity in western and eastern culture. Soy sauce odor have been use to enhance perceived saltiness in water and low salty solution for odor-induced saltiness enhancement (Djordjevic et al., 2004; Lawrence et al., 2009). In soy sauce products, many earlier researches were interested in researching how to develop low/reduced sodium soy sauce and effect on health (Luo et al., 2009, Muangthai et al., 2009; Nakamura et al., 2003). Moreover, natural soy sauce condiment was replaced table salt for reduce sodium in food product (Kremer et al., 2009; Goh et al., 2011).

4.2.1 Odor tasteless testing

The triangle method with nose clip was carried out to confirm tasteless of the soy sauce odor. The thirty assessors were used to find taste difference sample. For the result of odor tasteless testing, Figure 4.3 illustrates the results of the triangle taste test conducted. For a significant difference at $P<0.05$; 15 out of the 30 panelists needed to correctly distinguish between water and odor solution (Meilgaard et al., 2007). For both 2 replications of triangle test, there was no significant difference ($P<0.05$) between water and odor solution. So this tasteless soy sauce odor can be used as representation of other odor to prove saltiness enhancement in next experiment.

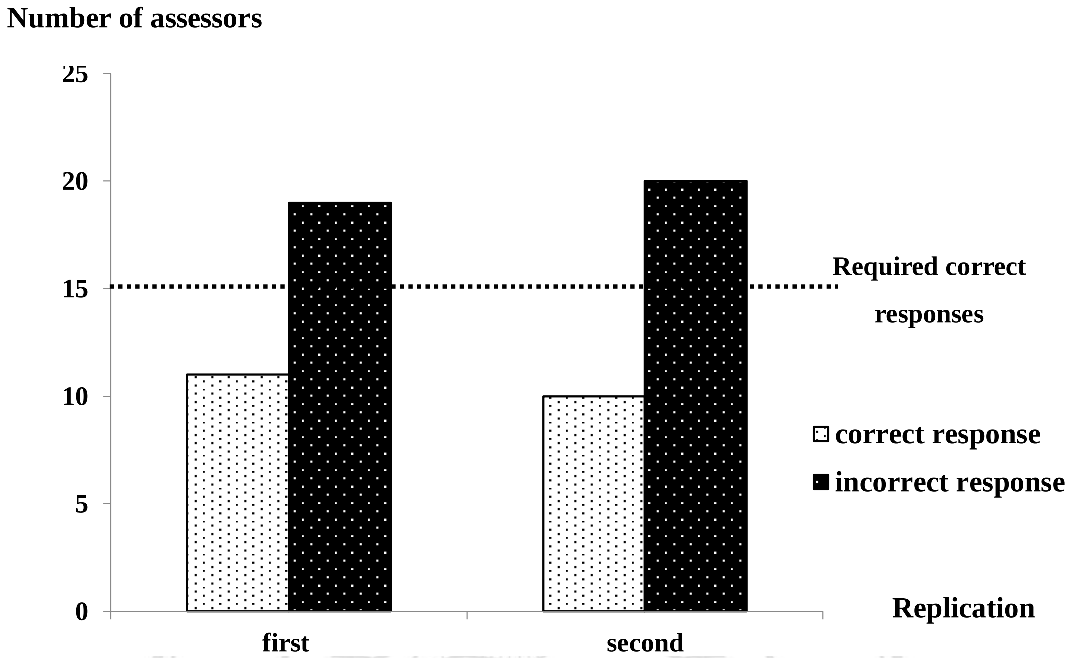

Figure 4.3 Odor tasteless checking of soy sauce odor in water

4.2.2 Determination of odor concentration threshold and odor induced saltiness enhancement in solution model

To our knowledge, this is the first study reporting absolute, saltiness recognition and saltiness difference threshold values of soy sauce odor in water and NaCl solutions (Figure 4.4). The averaged absolute and saltiness recognition GBET values of soy sauce odor in distilled water were 4.35 ppb and 28.45 ppb, respectively. The percentage of panelists recognising salty taste in the midrange of soy sauce odor concentrations (40, 400 and 4,000 ppb) in water was 70%, 80%, and 96.67%, respectively. The averaged difference GBET value of soy sauce odor in 0.02M NaCl solution was 122.71 ppb. In this study, the relative standard deviation (%RSD) for absolute, saltiness recognition and saltiness difference threshold values from three independent replications were 13.8%, 36.4%, and 9.5 %, respectively. According to Meilgaard et al. (2007), the ASTM E679-04 method provides a very approximate (±200%) BET value of each panelist's threshold.

In all the threshold studies, the nose clips were not used to allow the influence of soy sauce odor on salty taste perception. The averaged absolute GBET value of soy sauce odor in distilled water was 4.35 ppb (Figure 4.4), meaning that panelists were able to differentiate distilled water with soy sauce odor from distilled water starting at 4.35 ppb soy sauce odor but they could not identify specific discriminating taste quality. This concentration is much lower than 40,000 ppb in a triangle test with nose clips, providing an evidence that soy sauce odor imparted taste perception.

The averaged saltiness recognition GBET value of soy sauce odor in distilled water was 28.45 ppb (Figure 4.4), meaning that panelists were able to differentiate distilled water with soy sauce odor from distilled water starting at 28.45 ppb soy sauce odor, and they were able to identify specific discriminating taste quality. The percentage of panelists recognizing salty taste in the midrange of soy sauce odor concentrations (40, 400 and 4,000 ppb) in water was 70%, 80%, and 96.67%, respectively. This provides an evidence that soy sauce odor imparted salty taste perception in water, and that increasing soy sauce odor concentrations increased recognizable salty taste perception. Lawrence et al. (2009) reported a higher ($P<0.05$) mean saltiness intensity rating of water containing 0.6g/L (approximately 600,000 ppb) soy sauce odor than water without soy sauce odor. The soy sauce odor concentration (28.45 ppb) from this threshold study was much lower than reported by Lawrence et al. (2009). This finding substantiated OISE, which takes place via multisensory-integration mechanisms at the brain and not in the mouth (Salles, 2006; Lawrence et al., 2009). However, some of the panelists (5.7%) occasionally identified a sweet taste in the water solutions with soy sauce odor. This may be due to the possibility that OISE causes panelists to detect other taste qualities such as sweetness (Djordjevic et al., 2004). Nasri et al. (2011) reported that, in water and salt solution samples containing carrot odor, panelists detected sweet taste, which was higher when compared with samples containing sardine odor and no odor. On the other hand, samples with carrot odor were less salty than samples without odor.

The averaged difference GBET value of soy sauce odor in 0.02M NaCl solution was 122.71 ppb (Figure 4.4), meaning that panelists began to notice the difference in saltiness perception starting at 122.71 ppb soy sauce odor. Although Djordjevic et al. (2004) reported an enhancement of saltiness by soy sauce odor, they did not specify the concentration of soy sauce odor used in their study. The predetermined concentration of soy sauce odor at 0.6 g/L (approximately 600,000 ppb) was used in the study of Lawrence et al. (2009) where the panelists rated a slightly higher (but not significant, $P \geq 0.05$) saltiness intensity of 0.02M salt solution with soy sauce odor compared with 0.02M salt solution without odor. Using the same salt concentration in water, the soy sauce odor concentration (122.71 ppb) from this threshold study was, however, much lower than reported by Lawrence et al. (2009).

The saltiness recognition BET (in water with no NaCl) of the soy sauce odor was much lower than the saltiness difference BET (in 0.02M NaCl solution) (28.45 vs. 122.71; Figure 4.4). Hence, the effect of soy sauce odor on saltiness perception likely depends on salt concentration. In other words, OISE was less effective at a higher salt concentration, thus requiring a higher concentration of soy sauce odor. Nasri et al. (2011) reported that OISE induced by sardine odor was high at a low salt concentration (0.01 and 0.02 M NaCl) but at 0.04 M, OISE was not significant. Subsequently, some limitations do exist when utilizing OISE in development of low-sodium food products. For products containing a high salt content, the tasteless soy sauce odor may be less effective in enhancing the salty taste perception in an effort to reduce sodium.

Table 4.7 Sample calculation of the individual best-estimate threshold (BET) and group BET of soy sauce odor (ppb) in water from one independent replication (absolute threshold).

Panelists	Soy sauce odor concentration (ppb)							Absolute BET	log_{10}BET
	0.4	**4**	**40**	**400**	**4000**	**40000**	**400000**		
1	0 Sw	0 Sa	+ Sa	+ Sa	+ Sa	+ Sa	+ Sa	12.65	1.10
2	0 No	0 Sw	+ No	+ Sa	+ Sa	+ No	+ Sa	12.65	1.10
3	+ Sa	+ Sa	+ Sa	+ Sa	+ Sa	+ Sa	+ Sa	0.13	-0.90
4	0 Sa	0 No	+ Sa	+ Sa	+ Sa	+ Sa	+ Sa	12.65	1.10
5	+ B	0 B	+ Sa	+ Sa	+ Sa	+ Sa	+ Sa	12.65	1.10
6	+ B	+ Sa	+ Sa	+ Sa	+ No	+ Sw	+ Sw	0.13	-0.90
7	0 No	0 No	+ No	+ No	+ Sa	+ Sa	+ Sa	12.65	1.10
8	0 So	0 Sa	+ Sa	+Sa	+ Sa	+ Sa	+ Sw	12.65	1.10
9	0 No	0 No	+ So	+ No	+ Sa	+ Sa	+ Sa	12.65	1.10
10	0 B	0 Sw	+Sw	+Sa	+ Sa	+ Sa	+ Sa	12.65	1.10

Group BET geometric mean = 5.01

Log standard deviation = 0.84

''0'' indicates incorrect responses; ''+'' indicates correct responses.

Taste identification: "No" = unknown; "Sa" = Salty; "Sw" = Sweet; "So" = Sour; "B" = Bitter.

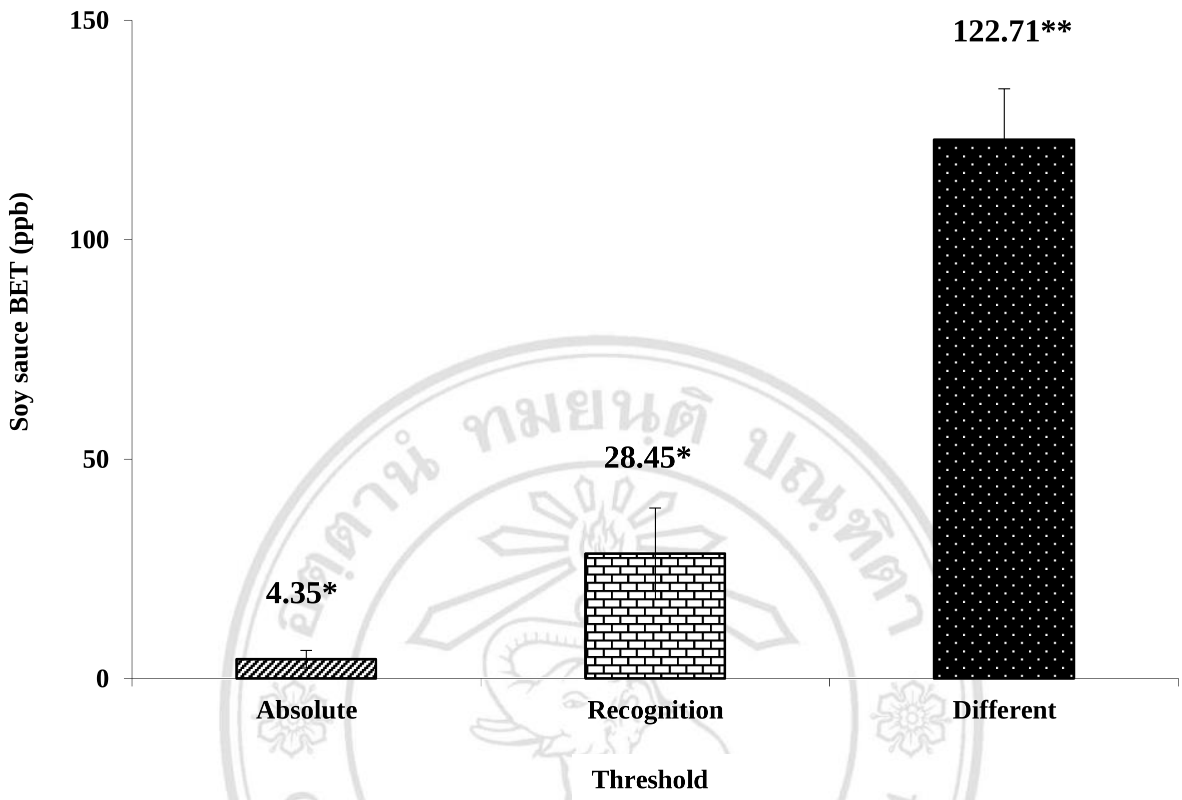

Figure 4.4 The group best-estimate (GBET) absolute and saltiness recognition thresholds in water and GBET saltiness difference threshold in 0.02M NaCl solution, reported as ppb of soy sauce odor concentration. The averages and standard deviations of 3 independent replications.

***** The averages (3 repetitions) of the group best estimate absolute and recognition thresholds (GBET) of soy sauce odor in water solutions

** The average and standard deviation (3 repetitions) of the group best estimate different threshold (GBET) of soy sauce odor in 0.02 M salt (NaCl) solutions

4.3 Phase 3: Study of using odor-induced saltiness enhancement with modified salt particle and its utilization in roasted peanut

This study was set to investigate OISE from experiment 4.2 comparing with using a modified salt particle by various processing. Soy sauce odor power was chosen as representation odor with spray dried salt and foam mat salt to apply in oil roasted peanut, 3 steps were conducted as follows:

4.3.1 Suitable of odor concentration for modified salt particle

The main purpose of this part study was to find the suitable concentration of soy sauce odor powder in order to use as saltiness enhancement with modified salt particles. Commercial salt was used in this study. The roasted peanut samples with different salt and soy sauce odor powder content were evaluated on saltiness intensity by trained panelists and also submitted to consumer acceptance testing. The result of saltiness intensity and sodium content of roasted peanut with different salt and soy sauce odor content is presented in Table 4.8. The saltiness intensity reduced in roasted peanut with lower salt content. Normally, reduced salt in food product resulted in decreased perceived saltiness in food (Ruusunen et al., 2005). In Table 4.8, it can be seen that there were different salty intensity between oil roasted peanut different salt and odor content. The full salted peanut sample (100% salt content) had the highest salty intensity. All oil roasted peanut with lower salt content replacing soy sauce odor were significantly more salty than oil roasted peanut with lower salt at the same salt content. However, the level of salty intensity of the samples with soy sauce odor slightly increased when compare with low salt samples at the same salt content. Previous public data also shown odor enhanced saltiness perception slightly increased perceived saltiness in solution and food model (Lawrence et al., 2009; Batenburg et al., 2010)

In addition, lowering the level of salt used in diet may be a good choice for decreasing sodium content in food products without decreasing consumer acceptance. Example, in case of reducing the sodium content in dishes (beef stew and vegetable soup) with a complex composition by about 30% without significantly changing acceptability (Malherbe et al., 2003). Base on the result of consumer acceptance evaluation of roasted peanut with different salt and soy sauce odor content in Table 4.9, consumer liking scores also decreased further when salt content in product decreased. There were significant difference (P<0.05) in mean values for overall liking, overall flavor and saltiness among the different salt content in roasted peanut samples. However, liking scores in all attributes were similar for the normal sample (100% salt) and samples with soy sauce odor at 30and 50%. These consequences indicated a potential for using soy sauce odor in reduced salt products.

Table 4.8 Saltiness intensity and sodium content of oil roasted peanut with different salt and soy sauce odor content (trained panelist, N=10)

Salt (%)	**Soy sauce odor powder (%)**	**Saltiness intensity (mm)*,****	**Sodium content * (mg/100 g peanut sample)**
100	0	50.21±3.71[a]	310.54±20.97
70	30	47.36±3.96[b]	219.54±13.78
70	0	44.36±3.56[c]	213.35±5.16
50	50	39.10±3.49[d]	166.91±8.81
50	0	36.62±3.17[e]	157.86±4.02
30	70	34.96±3.04[e]	88.91±12.85
30	0	32.22±2.06[f]	80.10±0.42

* Values are mean ± standard deviation.

** Salty intensity was examined by 10 trained panelists on 150 mm line scales.

Slightly effect on enhance saltiness perception of OISE is the constraint of using this approach to reduce sodium in food products. Sample of OISE in liquid food, salt reduction that could be compensated in savoury products like soups and sauces remain limited to approximately 15-20%. By the way, using sotolon (4,5-dimethyl-3-hydroxy-2(5*H*)-furanone) aroma in beef bouillon that combine KCl-based salt replacer and sotolon (4,5-dimethyl-3-hydroxy-2(5*H*)-furanone) aroma was found to compensate approximately 30% sodium reduction without significant change of the flavor profile (Batenburg et al., 2011). Nasri et al. (2011) also suggested that the high saltiness of the food product could be combine different compensation strategies such as the use of salt substitutes or flavor enhancers in additional to use saltiness-inducing aromas. Since in this study used the commercial salt, therefore, the application odor enhanced saltiness perception in conjunction with modified salt particle was obtained in next experiment.

Table 4.9 The hedonic scores of sensory evaluation of oil roasted peanut with different salt and soy sauce odor content (consumers, N= 218)

Salt (%)	**Soy sauce odor (%)**	**Sensory Attributes*,****		
		Overall liking	**Overall flavor**	**Saltiness**
30	70	6.0±1.6[b]	5.9±1.7[b]	5.4±1.6[b]
50	50	6.4±1.5[a]	6.3±1.5[a]	6.0±1.2[a]
70	30	6.5±1.4[a]	6.4±1.4[a]	6.3±1.2[a]
100	0	6.6±1.5[a]	6.6±1.5[a]	6.3±1.3[a]

* 9-point hedonic scale where 1 = dislike very much, 5 = neither like nor dislike and 9 = like extremely

** a,b Mean ± standard deviation in same column with different latters are significant different (p<0.05).

4.3.2 Modification salt particle using different process with odor-induced saltiness enhancement

This section was performed in order to investigate the effect of using modified salt particle from two different drying processes: spray drying and foam-mat drying. The physical and chemical properties of two different salts were expressed in Table 4.10. The foam-mat salt had the significant higher moisture content than the other. The moisture contents of all salt were in the range of Thai Industrial Standard: edible common salt (Thai Industrial Standard Institute, 2544). Both modified salt: spray dried salt and foam-mat salt showed that the L value was significantly higher (*P*<0.05) than that of commercial salt. The commercial salt had the highest value of bulk density and average size. The structures of commercial salt, spray dried salt and foam-mat salt particles were shown in Figure 4.5, 4.6 and 4.7, respectively. Most of spray dried salt in this research was typically small cubic shaped crystal with smooth surface and some parts of particles were irregular shaped. Size of this spray dried salt analyzed by mastersizer tests varied in range 6.42-27.04 µm. Foam-mat salt particles showed different size and shape from spray dried salt. The crystals of foam-mat salt were somewhat irregular flake-type particle. The foam-mat salt powder showed larger particle in range 34.94-265.07 µm when compared with those of spray dried salt. The structure of this spray dried salt like smaller cubic shaped salt from previous study. Tang et al. (2006) prepared dry powders of salt by an ultrasound-mediated precipitation process followed by spray drying. In inhalation delivery require rather small particle size of salt at mass median diameter, 2.12±0.35 µm for ultrasound-mediated precipitation and spray drying method. Figure 4.8 illustrate the SEM image of final salt product for inhalation.

Table 4.10 Physical and chemical properties of different salt types

Physical and chemical properties	**Commercial salt**	**Spray dried salt**	**Foam-mat salt**
Moisture content (%)	0.022 ± 0.010^{b}	0.028 ± 0.007^{b}	0.079 ± 0.010^{a}
a_w	0.666 ± 0.015^{ns}	0.651 ± 0.003^{ns}	0.657 ± 0.004^{ns}
Color L*	87.52 ± 1.02^{b}	94.62 ± 0.59^{a}	94.60 ± 0.54^{a}
a*	-0.20 ± 0.03^{ns}	-0.29 ± 0.04^{ns}	-0.26 ± 0.03^{ns}
b*	0.10 ± 0.06^{b}	1.78 ± 0.29^{a}	1.69 ± 0.20^{a}
Bulk density (g/ml)	1.29 ± 0.05^{a}	0.74 ± 0.03^{b}	0.65 ± 0.03^{c}
Average particle size (µm)	338.17 ± 2.72^{a}	15.40 ± 0.07^{c}	133.80 ± 0.66^{b}

* a,b Mean ± standard deviation in same row with different latters are significant different (*P*<0.05).

** ns: not significant different

Dissimilarly, the shape of microsalt and submicro salt were obtained in recently research (Reyes, 2014). Microsalt particles had more irregular in shape and sizes; non spherical, irregular squares and different dimensions and submicrosalt also show mostly irregular shapes and with slight agglomeration (Figure 2.5). The size particles of microsalt and submicrosalt ranged from 3-75 μm and 520-1300 nm, respectively.

The characteristics of salt particles from both produced salt methods were also confirmed to be crystalline by X-ray diffraction method (XRD) in Figure 4.9. Both samples had more crystalline compare with normal salt. The XRD pattern of both samples showed line of larger intensity than normal salt sample. This finding was similar to the data from Tang et al. (2006). They found the spray dried salt particles were highly crystalline, as expressed by X-ray diffraction.

Several parameters that caused dissimilarity of salt size and shape were different salt production methods (namely, spay dry, centrifugation, filtration, evaporation, milling and encapsulation), condition method (such as material concentration, inlet/outlet air temperature in spray dry method, recrystallization, the volume of the antisolvent, sonification time, sonic waves output power and frequency, and stirring rate (Langrish, 2009; Reyes, 2014; Tang et al., 2006).

Encapsulation method was used to produce modified salt (Noort et al., 2012). The process of encapsulation salt included the two salt fractions obtained by pan sieving (1000 mm and 2000 mm) were encapsulated with the encapsulation fat using a rotating drum. The melted encapsulation fats (70 °C) were sprayed on batches of 35 g salt crystals and it were kept moving in the rotating drum with a manual spraying pump. This structure of encapsulated salt by drum dryer is illustrated in Figure 2.5.

Application of two salt particles in roasted peanut with soy sauce odor is presented in Table 4.11. No significant ($P \geq 0.5$) in saltiness intensity between two samples were observed by using train panel. The result from acceptability study did not find difference in overall liking, overall flavor and salty of both spray dried salt and foam-mat salt.

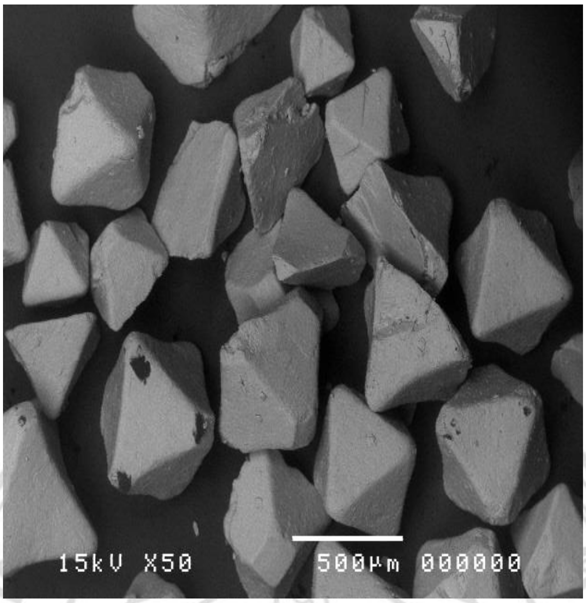

Figure 4.5 A scanning electron microscope (SEM) photo of commercial salt

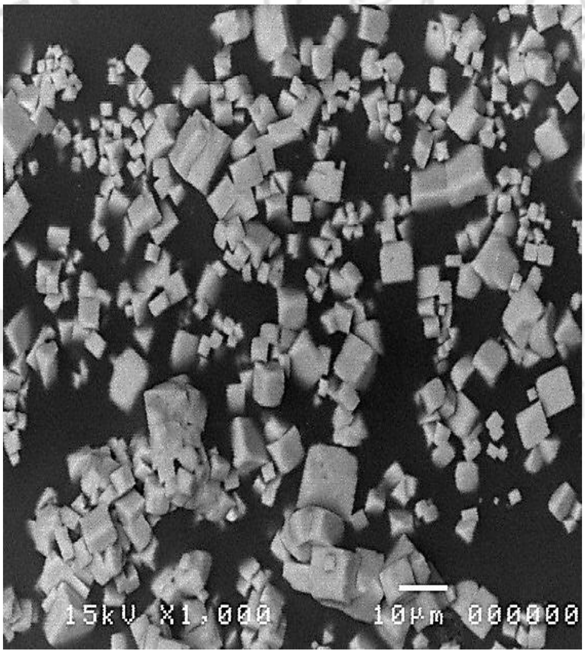

Figure 4.6 A scanning electron microscope (SEM) photo of spray dried salt

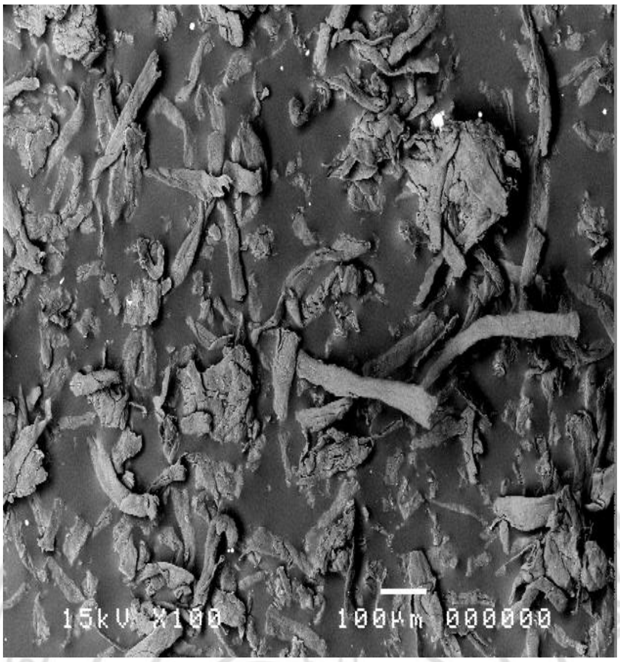

Figure 4.7 A scanning electron microscope (SEM) of foam-mat salt

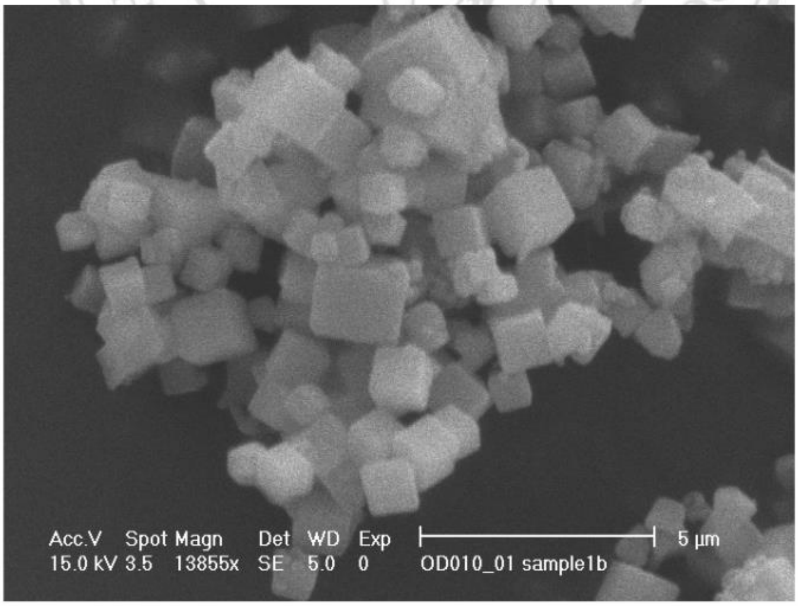

Figure 4.8 A scanning electron microscope (SEM) of salt for inhalation delivery

Source: Tang et al. (2006)

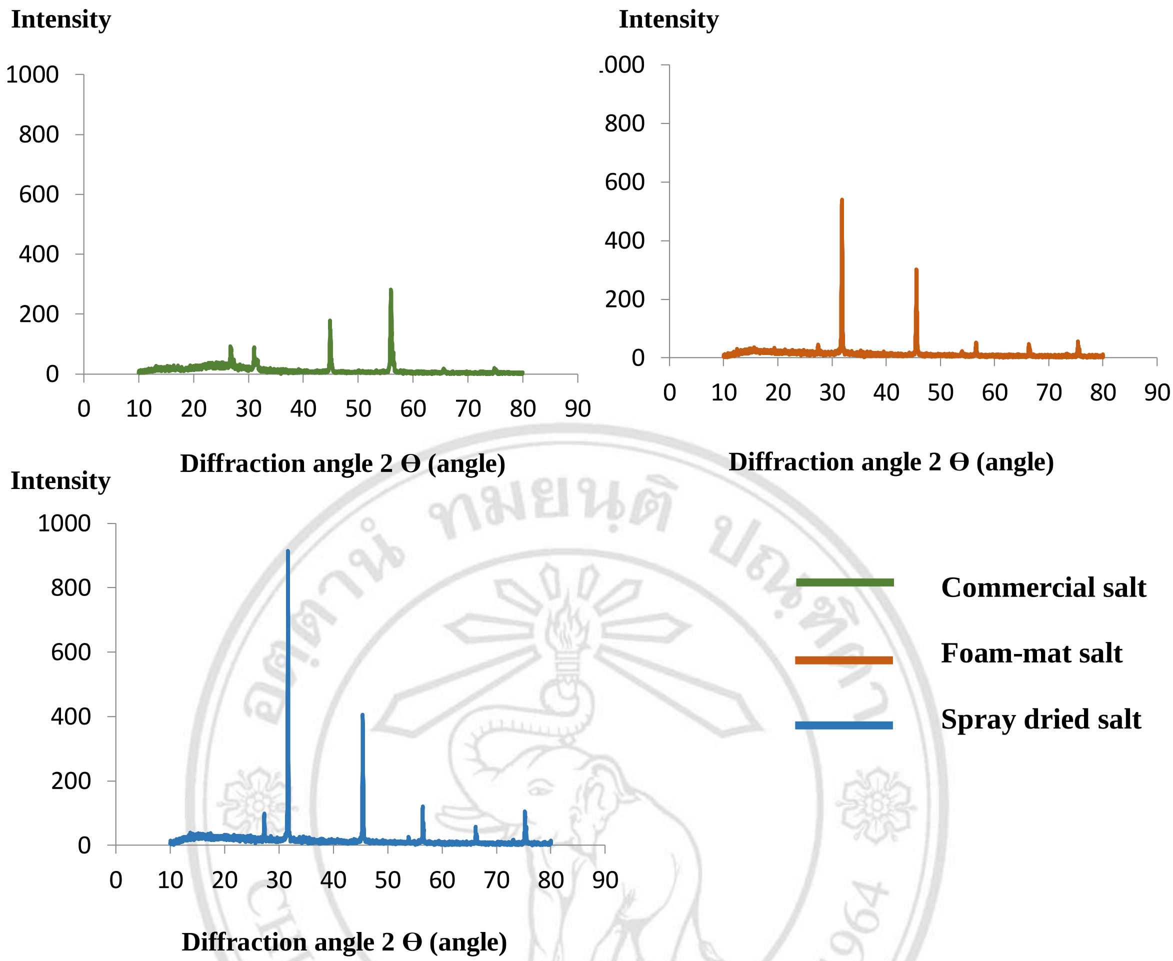

Figure 4.9 X-ray diffraction pattern of sodium chloride with different process

Earlier research had studied about various modified sodium salt methods (Tang et al., 2006; Langrish, 2009) and influence on application modified them to decease or replace salt in products (Reyes, 2014; Noort et al., 2012; Rama et al., 2013). Changing the physical form of salt particle was the one reduced sodium strategy. Size of salt particle affects flavor perception (Reyes, 2014; Noort et al., 2012; Rama et al., 2013; Sa-Uram, 2004). The optimum size of salt particles is rapid dissolution and faster perceived saltiness. In case, reforming shape of salt also affects flavor perception that it was produced by various processes such as making granule with a core composition comprising a non-sweetener carbohydrate and a coating on the core comprising sodium chloride (Bunick et al., 1992), controlling drying parameters of spray dry includes the inlet temperature, pump speed, air flow and compressor of spray dryer for suitable size of crystal salt. The ingredients of salt particle with reducing size included sodium chloride and carrier such as carbohydrate maltodextrin hydrocolloids protein, etc. (Wang and Patil, 2011). Foam-mat drying is one of drying method with the advantage of lower temperature, shorter drying time and more rapid reconstitution. Earlier studies indicated that foam-mat drying technique has been used to increase solubility and dissolution rates of drug (Seakow et al., 2012).

Table 4.11 Saltiness intensity, hedonic score and sodium content of roasted peanut using different salt with soy sauce odor

Type of salt	**Commercial salt**	**Spray dried salt***	**Foam-mat salt***
Soy sauce odor (%)	**50**	**50**	**50**
Saltiness intensity (mm)	39.10±3.49	43.99±4.24	42.95±3.18
Hedonic scores			
Overall liking	6.4±1.5	6.6±1.4	6.4±1.2
Overall flavor	6.3±1.5	6.5±1.5	6.4±1.4
Salty	6.0±1.2	6.3±1.6	6.2±1.1
Sodium content (mg/100 g peanut sample)	166.91±8.81	152.01±10.28	156.40±20.37

* Values are mean ± standard deviation.
9-point hedonic scale where 1 = dislike very much, 5 = neither like nor dislike and 9 = like extremely
No significant ($P \geq 0.5$) between spray dried salt and foam-mat salt on all parameters

Sa-Uram (2004) studied influence of particle size of seasoning powder on sensory perception of fried potato chips. The size of sodium chloride particles were in the ranged of 75-300 µm. Size of sodium chloride affected on taste perception. Increasing sodium chloride particle size resulted in diminishing salty taste intensity. Similarly, Rama et al. (2013) supported sodium chloride crystal size modification is one of approach to reduce sodium in crisp snacks. They showed that the particle size of sodium salt utilized to fried potato crisps resulted in a significant impact on the delivery rate of sodium into the saliva, the maximum concentration of sodium in the saliva, the maximum saltiness perception and the saltiness onset time. Moreover, they expressed smaller crystals of salt presented a faster, more salty delivery of sodium per unit sodium. However, Reyes (2014) studied on the effect of using sodium chloride crystal with reducing the particle size (regular, microsalt and submicrosalt) on salt perception of surface salted cheese crackers. The result shown the utilization microsalt at 2, 1.5 and 1% (particles size were 3-75 μm) did not increase salty taste perception of surface salted cheese crackers. As submicrosalt (reduction in salt particle size at 520-1,300 nm) can increased salty taste perception. Moreover, application of submicrosalt to reduce salt content at 25 and 50% in cheese cracker had more advantage: sustain low counts in yeasts, no counts in molds and did not adversely affect sensory scores in each attribute, including, color, aroma, crunchiness, overall liking and acceptability.

While result from the application of encapsulated sodium chloride to decrease sodium content in bread showed varying sizes of encapsulated salt may lead to difference in saltiness perception and acceptability by trained panels and consumers (Noort et al., 2012). They indicated that an appropriate particle size of encapsulated sodium chloride can enhance saltiness in reduced sodium product. The small and medium encapsulated salt particle sizes at 500 mm and 1,000 mm did not express explicit influences on salty taste perception, even though the result appear to present a small trend of saltiness enhancement. The reason may be the concentration contrast created by these smaller encapsulates was not a large sufficient to cause in influence on saltiness intensity perception. The largest encapsulated particle size at 2,000 mm exhibited a substantial enhancement of saltiness intensity at 1.0% and 1.5% of total salt. For consumer liking result in their experiment, the encapsulated salt particle size at 1,000 mm to apply in level of 1.5% salt concentration of bread exhibited result to enhance the salty taste perception and at enhance liking of consumers. Application of large encapsulated salt particles (2,000 mm) in bread trended to decrease consumer liking. It was too large to induce sensory liking by the large salty spots. The encapsulated salt particles at 500 mm and 1,000 mm were not preferred significantly different than the reference. So the size of the encapsulated salt requires to be equalized in such a way that a significant taste contrast is created which enhances saltiness intensity, but does not affect consumer liking. They indicated that the proper particle size of encapsulated salt is between 1,000 and 2,000 mm for reduced sodium bread.

From the result of this study, applying two modified salts in samples (spray dried salt and foam-mat salt) also had the same outcome. It showed that no significant between two modified salt on perceived saltiness and consumers preferring. However, the perceived saltiness intensity and consumers preference slightly increased more than the samples with foam-mat salt. Moreover, procedure for making foam-mat salt had difficult to control foaming ability before drying in hot air oven, for example, the foam of salt solution with methocel sometime were unstable. It showed leak water layer from the foam before finish drying process. Within these all reasons, spay dry salt was utilized as model representation to study cooperative influence with OISE in oil roasted peanut.

4.3.3 Comparison the effect of using spray dried salt and odor-induced saltiness enhancement

A two-level factorial design with a confidence level of 95% was analyzed in order to determine the effects of the two variables tested (type of salt and the amount of soy sauce odor powder). The salty intensity and liking scores of each attributes obtained in each treatment of factorial design were shown in Table 4.12.

In factorial experiment design, analysis of variance (ANOVA) is often utilized to find out the influence size for each of the factors in addition to a measure to identify the factors that have a statistically significant effect on response. However, for finding out the optimal levels for each factor, the most useful tools were graphical plots of the data, such as main effects plots and interaction plots.

Table 4.12 The hedonic scores of sensory evaluation of oil roasted peanut with different salt and soy sauce odor content (consumers, N= 200)

Treatment	Type of salt (%)	Soy sauce odor (%)	Saltiness intensity (mm)	Sensory Attributes*		
				Overall liking	Overall flavor	Saltiness
1	C salt	0	36.49 ± 2.66^{c}	5.8 ± 1.7^{b}	5.7 ± 1.7^{b}	5.4 ± 1.8^{b}
2	C salt	50	39.43 ± 2.86^{b}	6.6 ± 1.4^{a}	6.4 ± 1.6^{a}	6.2 ± 1.6^{a}
3	S salt	0	42.49 ± 3.78^{a}	6.5 ± 1.3^{a}	6.4 ± 1.5^{a}	6.2 ± 1.7^{a}
4	S salt	50	43.72 ± 3.58^{a}	6.6 ± 1.4^{a}	6.5 ± 1.4^{a}	6.5 ± 1.6^{a}

* C salt : commercial salt, S salt : spray dried salt, a,b Mean ± standard deviation in same column with different latters are significant different (*P*<0.05).
9-point hedonic scale where 1 = dislike very much, 5 = neither like nor dislike and 9 = like extremely

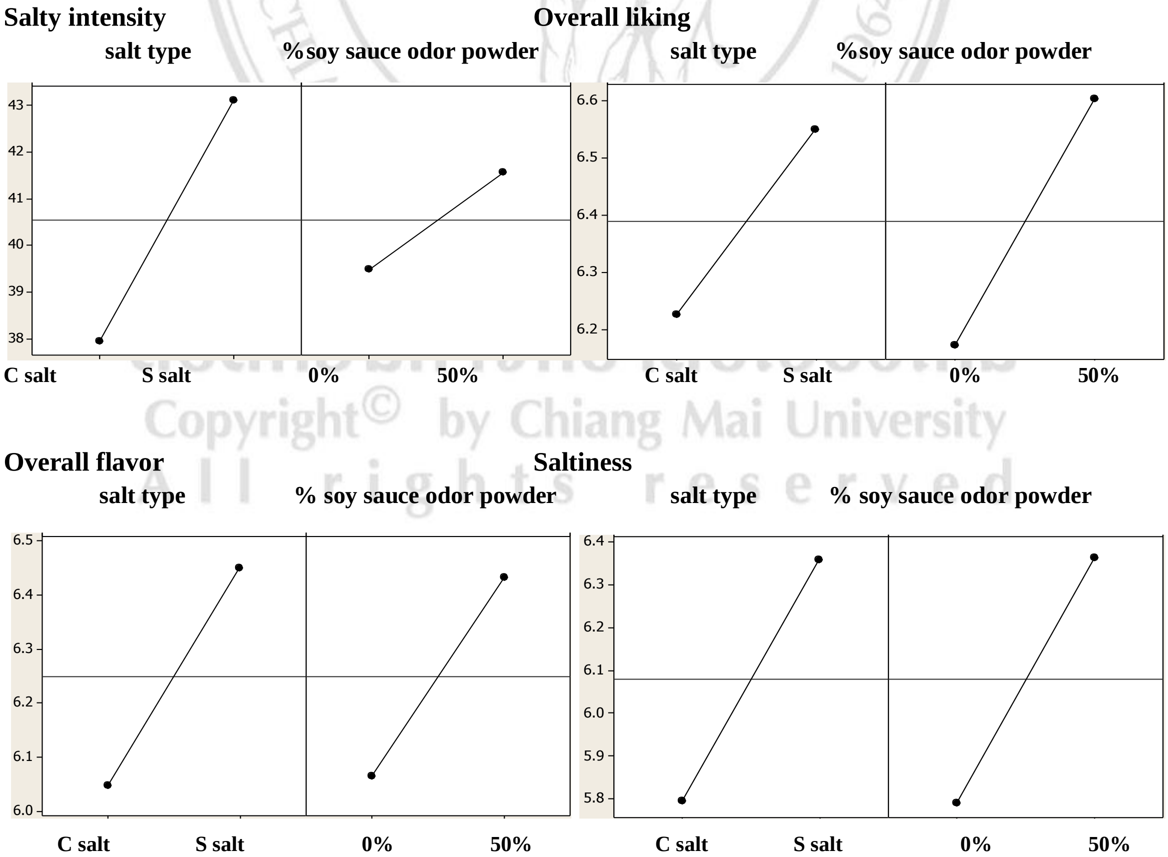

Figure 4.10 Main effect plots for this 2x2 factorial design experiment

For main effect, it was found that all the parameters were significant within the 95% confidence interval ($P<0.05$) for each factor: type of salt and the amount of soy sauce powder. The main effect graphs (Figure 4.10) can be used to compare the relative strength of the effects across factors. The x-axis represents the levels for each factor and the y-axis represents the response (saltiness intensity and consumer acceptability scores). The saltiness intensity and hedonic liking scores of all attributes tend to increase in treatments using spray dray salt and 50% soy sauce odor.

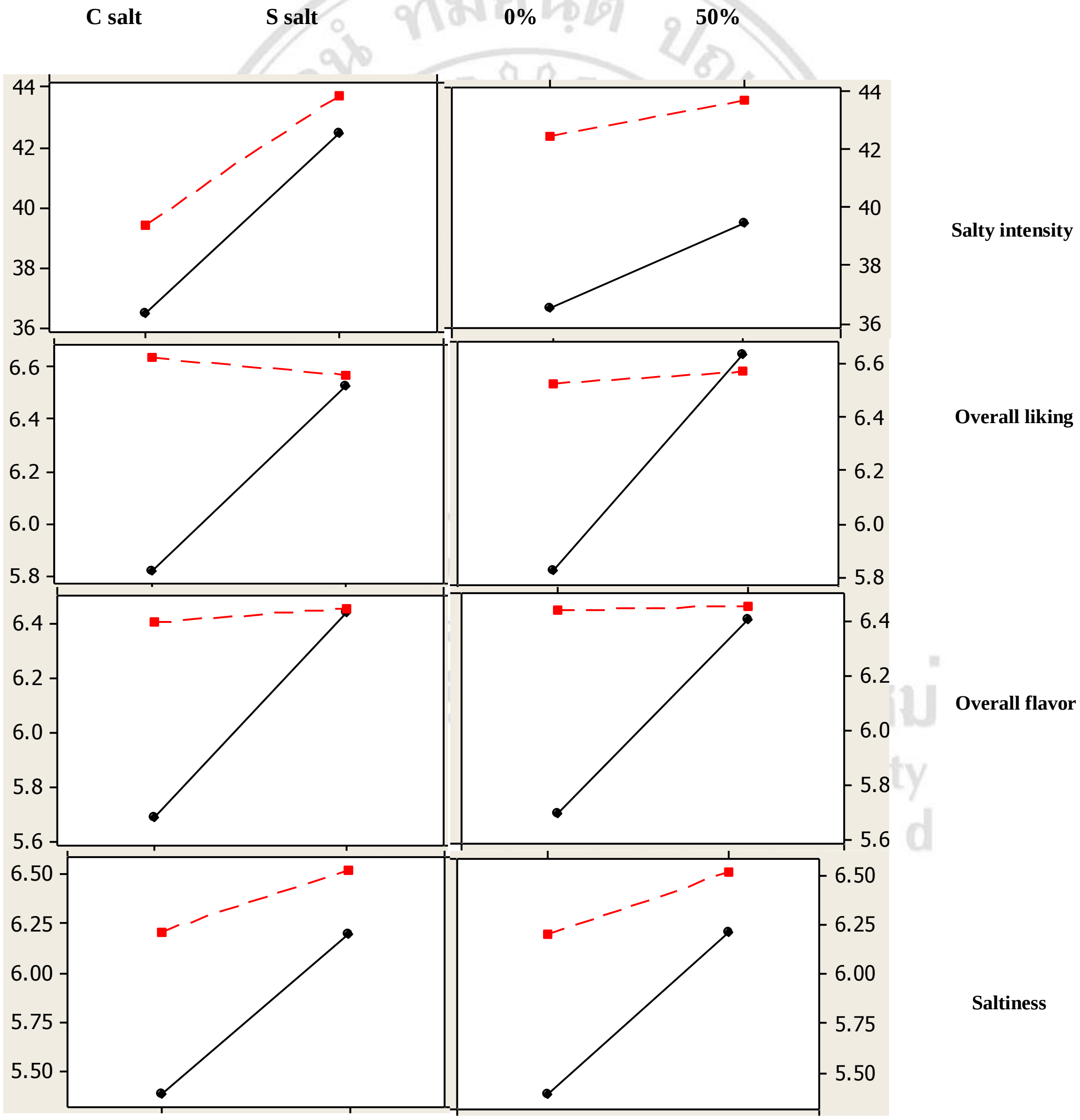

Figure 4.11 Interaction effect plots for this 2x2 factorial design experiment

In addition, the interaction plot depicted using data means is given in Figure 4.11. Some of the lines in type of salt versus percent of soy sauce odor powder plot were approximately parallel, pointing to an insufficiency of interaction between the two factors. In other hand, some lines on the plot do not cross each other or some lines on the plot cross each other, so they lack of parallelism of the lines exhibit significant interaction between type of salt and percent of soy sauce odor powder.

Based on the result of using 50% soy sauce odor powder, there was significant difference between using this odor with commercial salt and using only commercial salt. Application soy sauce odor in reduced sodium oil roasted peanut trend to increase saltiness perception and consumer preference as compared to the commercial salt sample without this odor. However, the perceived salty intensity and consumer liking were slightly increase in samples using soy sauce odor powder with spray dried salt so it was no significantly difference in all observed results between sample with only using spray dried salt. This cause may be low efficiency of OISE. The tasteless odor can slightly enhance salty perception in all solution model and real food products (Batenburg et al., 2011; Lawrence et al., 2009; Nasri et al., 2011). Most of the application of OISE with other reduced sodium approaches has been studied due to increase effect on salt reduction (Batenburg et al., 2011; Lawrence et al., 2011).

Properties of spray dried salt with soy sauce odor

The appropriate type of modified salt and the amount of soy sauce odor from this study result was spray dried salt and ratio of spray dried salt: soy sauce odor at 1:1. The properties result of spray dried salt with soy sauce odor in this research show as Table 4.13 and 4.14. This spray dried salt with soy sauce odor contained 7.11 % moisture, 0.656 water activity and 0.63 g/ml bulk density. Sensory evaluation of oil roasted peanut with spray dried salt: soy sauce odor at 1:1using label affective magnitude scale evaluated by 200 consumers reveals in Table 4.13. For using spray dried salt with soy sauce odor at 1:1 in roasted peanut, mean hedonic scores of all attributes were between like moderately and like very much (72.9-75.0).

Table 4.13 Physical and chemical properties of final product (spray dried salt with soy sauce odor)

Properties	Spray dried salt : Soy sauce odor Ratio 1 : 1*
Moisture (%)	7.11±0.10
a_w	0.656±0.015
Color L*	88.95±0.41
a*	0.82±0.10
b*	7.73±0.34
Bulk density (g/mL)	0.63±0.02

***** Mean ± standard deviation

Table 4.14 The label affective magnitude scores of sensory evaluation of roasted peanut with spray dried salt and soy sauce odor content (consumers, N= 200)

Salt ratio	Soy sauce odor ratio	Scores of sensory attributes*		
		Overall liking	Overall flavor	Saltiness
1	1	75.0±12.4	74.4±12.7	72.9±14.5

* Label affective magnitude score mean ± standard deviation

A line scale includes two additional anchors: 'greatest imaginable like = 100' and 'greatest imaginable dislike = 0' (Cardello and Schutz, 2004).