

**FORMULATION OF INULIN-ENRICHED INSTANT RICE
PORRIDGE**

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entitled
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PORRIDGE**

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FORMULATION OF INULIN-ENRICHED INSTANT RICE PORRIDGE

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At present, instant rice porridge is becoming more popular as a breakfast item in Thai society because of the time constraint in the morning. However, the nutrition labeling of the existing products show that they contain less than 1 g of dietary fiber/serving size. Inulin is an interesting functional food ingredient because it provides the benefit of soluble dietary fiber and acts as a prebiotic. Kaentawan is a tuberous crop presently cultivated in Thailand. Moreover, it is a good source of inulin. This study aimed to formulate inulin-enriched instant rice porridge using commercial inulin, and Kaentawan tuber as a source of inulin, to improve the nutritive value and increase the choice of food fiber sources for consumers. The target level of commercial inulin and Kaentawan addition was 10%, 15% and 20% of Thai RDI per serving.

The results showed that the optimum time for drying Kaentawan pieces, which was chopped using a food processor, was 4 h at 70°C with 4.1% moisture content, 0.41 A_w , and quite light in color. Addition of commercial inulin significantly decreased ($p \leq 0.05$) the viscosity of products whereas the viscosity of Kaentawan added to instant rice porridge significantly increased ($p \leq 0.05$). A_w values of all formulas were still lower than the value that can support the growth of microorganisms. From a sensory screening test, 15% commercial inulin and 20% Kaentawan supplemented products were selected as the optimum levels with the highest scores of overall acceptability. The in-house consumer test showed that the overall acceptability score of 15% commercial inulin and 20% Kaentawan enriched products were 7.36 (like moderately) and 6.10 (like slightly), respectively. The storage test showed that the formulated products could be kept for at least for 2 months. Nutritionally, one serving (35 g) of commercial inulin and Kaentawan enriched products provide 21% and 27% of the Thai RDI for dietary fiber, respectively. Both formulated products are excellent sources of dietary fiber and can be introduced as an alternative food fiber source for consumers.

**KEY WORDS: INULIN/ KAENTAWAN/ DIETARY FIBER/
INSTANT RICE PORRIDGE**

81 pages

การพัฒนาสูตร โจ๊กกึ่งสำเร็จรูปเสริมอินนูลิน

FORMULATION OF INULIN-ENRICHED INSTANT RICE PORRIDGE

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บทคัดย่อ

เนื่องจากปัจจุบันชีวิตของคนในสังคมไทยต้องเร่งรีบในตอนเช้า ทำให้เวลาที่ใช้ในการรับประทานอาหารเช้าลดน้อยลง โจ๊กกึ่งสำเร็จรูปจึงเป็นอาหารเช้าที่กำลังได้รับการนิยมในสังคมไทย อย่างไรก็ตามฉลากโภชนาการของโจ๊กกึ่งสำเร็จรูประบุว่าผลิตภัณฑ์มีใยอาหารน้อยกว่า 1 กรัมต่อหนึ่งหน่วยบริโภค อินนูลินเป็น functional ingredient ที่ได้รับความนิยมมากขึ้น เพราะมีประโยชน์ในแง่ของใยอาหารที่ละลายน้ำและมีคุณสมบัติเป็นพรีไบโอติก แก่นตะวันเป็นพืชหัวที่มีอินนูลินสูง ดังนั้นจุดประสงค์ของการทดลองนี้ คือเพื่อพัฒนาสูตรโจ๊กกึ่งสำเร็จรูปเสริมอินนูลินโดยใช้ผงอินนูลินและแก่นตะวัน เพื่อเพิ่มคุณค่าทางอาหารและเพิ่มทางเลือกให้กับผู้บริโภค โดยเสริมผงอินนูลินและแก่นตะวันในปริมาณร้อยละ 10, 15 และ 20 ของThai RDI ต่อหนึ่งหน่วยบริโภค

ผลการทดลองพบว่า ระยะเวลาที่เหมาะสมในการอบขึ้นแก่นตะวัน ซึ่งถูกปั่นโดยใช้ food processor อยู่ที่ 70 องศาเซลเซียส 4 ชั่วโมง ซึ่งจะมีค่าความชื้นร้อยละ 4.08 ค่า Aw 0.406 และสีของขึ้นแก่นตะวันค่อนข้างขาว การเติมผงอินนูลินมีผลทำให้ค่าความหนืดของโจ๊กลดลง ($p \leq 0.05$) ในขณะที่การเติมแก่นตะวันจะทำให้ความหนืดเพิ่มขึ้น ($p \leq 0.05$) อย่างไรก็ตาม Aw ของทุกสูตรมีค่าต่ำกว่าที่จุลินทรีย์จะใช้ในการเจริญเติบโต ผลจาก sensory screening test พบว่า การเติมผงอินนูลินและแก่นตะวันที่ระดับร้อยละ 15 และ 20 ตามลำดับ เป็นระดับที่เหมาะสมที่สุด และใน In-house consumer test พบว่า การเติมผงอินนูลินและแก่นตะวันที่ระดับร้อยละ 15 และ 20 ได้คะแนนความชอบโดยรวม 7.36 (ชอบปานกลาง) และ 6.10 (ชอบเล็กน้อย) ตามลำดับ ผลการทดลองอายุการเก็บรักษาพบว่าผลิตภัณฑ์ที่พัฒนานี้สามารถเก็บได้อย่างน้อย 2 เดือน หนึ่งหน่วยบริโภค (35 กรัม) ของโจ๊กกึ่งสำเร็จรูปเสริมผงอินนูลินและแก่นตะวันมีใยอาหารร้อยละ 21 และ 27 ของThai RDI ตามลำดับ ดังนั้นผลิตภัณฑ์ที่พัฒนาขึ้นทั้งสองสูตรสามารถอ้างได้ว่าเป็นแหล่งที่ดีของใยอาหาร

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LIST OF ABBREVIATIONS

AACC	American Association of Cereal Chemists
kcal	kilocalories
g	gram
CRC	Codex Alimentarius Commission
CHD	coronary heart disease
GI tract	gastrointestinal tract
LDL	<i>low density lipoprotein</i>
RDI	Recommended Daily Intake
DP	degree of polymerization
SCFA	short chain fatty acids
USDA	the Americans based on <i>the United States- Department of Agriculture</i>
GRAS	Generally Recognized as Safe
m	meter
cm	centimeter
JA	Jerusalem artichoke
mg	milligram
µg	microgram
IU	International Unit
°C	degree Celsius
Aw	water activity
cps	centipoises
h	hours
ml	milliliter
min	minute
mm	millimeter
s	second
BAM	Bacteriological Analytical Manual

LIST OF ABBREVIATIONS (cont.)

ANOVA	analysis of variance
PPO	polyphenol oxidase
MPN	Most probable number of coliform organisms
Thai RDI	Thai Recommended Daily Intakes

CHAPTER I

INTRODUCTION

According to the American Association of Cereal Chemists or AACCC (2001), dietary fiber is the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine. Dietary fiber includes polysaccharides, oligosaccharides, lignin, and associated plant substances. It promotes beneficial physiological effects including laxation, blood cholesterol attenuation, and blood glucose attenuation. Dietary fiber can be classified by its solubility in water into soluble and insoluble dietary fiber (1). The common dietary sources of dietary fiber are whole grains, vegetables, fruits, legumes and products. However, inadequate consumption of vegetables and fruits is now considered as a risk factors of global diseases such as cancer and cardiovascular disease (2), partly due to the lack of dietary fiber. The International Health Policy Program (IHPP) Thailand (2007-2011) reported that more than 75% of Thai people consume fruits and vegetables less than 400 grams per day, which is the minimum standard required by the World Health Organization (WHO) (3). Therefore, dietary fiber-enriched products become a product of interest among consumers and food manufacturers to increase the dietary intake of fiber for health promotion and reduction of disease risk.

Inulin is a group of carbohydrate substances namely polysaccharides known as fructans which is a soluble dietary fiber. The structure of inulin is both linear and branch fructose polymers, usually having a glucose unit at the end of the chain. Inulin has a degree of polymerization between 2-60 and each monosaccharide unit links together by β -(1-2) glycosidic bond. It occurs in a variety of plants as plant storage carbohydrates such as Kaentawan, chicory, onions and garlic. Inulin provides the benefit of dietary fiber with low caloric value (about 1.5 kcal /g) (4). It has been shown to improve some physiological functions in humans such as relieving constipation, decreasing total blood cholesterol and low density lipoprotein (LDL)

cholesterol and increasing high density lipoprotein (HDL) cholesterol (5), and decreasing the risk of osteoporosis (by increasing mineral absorption, especially calcium) (6). Moreover, inulin not only provides the benefit of dietary fiber but also acts as a prebiotic which stimulates the immune system of the body by stimulating the growth of beneficial bacteria including Bifidobacteria and Lactobacilli. In the colon, inulin is rapidly fermented to produce short chain fatty acids by beneficial bacteria (4) which take part in the maintenance of gut health. Hence, several physiological properties of inulin help to lower the risk of many diseases and provide healthful benefits. Beside its health benefits, inulin is also considered to have functional properties such fat replacer and sweetener without adversely affecting flavor in several products like yoghurt, cheese, and ice cream (7). Finally, it may provide an interesting alternative to increase dietary fiber content as well as improve quality of prepared foods.

Jerusalem artichoke (*Helianthus tuberosus L.*) or Kaentawan is a tuberous annual crop originated from North America. It is presently cultivated in Thailand. Recent studies show that tuber of Kaentawan can be used as an ingredient substitutes for antibiotic growth promoters in animal feed and used as a raw material for sugar and ethanol production (8). Kaentawan tuber contains high level of inulin so it is a good source of inulin (19.4 ± 1.04 g/100g fresh weight) (9), similar to chicory roots (10) that are commonly used in the commercial production of inulin. Hence, Kaentawan can be a good choice of food raw material for use as an inulin source in dietary fiber-enriched products. However for Thailand, using Kaentawan tuber as a food ingredient is not widespread even though it has many advantages for health.

Instant rice porridge is processed rice product that is cooked and dried into small flakes. It is mixed together with seasoning, dried meats and dried vegetables. It is prepared by adding hot water in a short time, less than 10 minutes (11) and consumed. At present, instant rice porridge is becoming more popular as a breakfast item in the Thai society because of the time constraint in the morning. However, the nutrition labeling of the product shows that instant rice porridge has low amount of dietary fiber (less than 1 gram of dietary fiber/serving size). Therefore, this study aims to formulate inulin-enriched instant rice porridge using commercial inulin and Kaentawan tuber as a source of soluble dietary fiber in order to improve the nutritive

value of instant rice porridge product and increase the choices of food fiber source for consumers.

CHAPTER II

OBJECTIVES

General objective

To formulate a dietary fiber-enriched instant rice porridge containing inulin

Specific objectives

1. To determine the optimum amount of commercial inulin suitable for adding to instant rice porridge.
2. To determine the optimum amount of Kaentawan suitable for adding to instant rice porridge.
3. To determine the sensory acceptability of inulin-enriched instant rice porridge.
4. To evaluate the physical, nutritional and microbiological properties of inulin-enriched instant rice porridge.

CHAPTER III

LITERATURE REVIEW

3.1 Dietary fiber

3.1.1 Definition

The term of dietary fiber was firstly used by Hipsley in 1953. He described that dietary fiber is the non-digestible constituents that make up the plant cell wall. These constituents were known to include cellulose, hemicellulose, and lignin (12). This definition was later amended and extended by other researchers.

According to the American Association of Cereal Chemists or AACCC (2001), dietary fiber is the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine. Dietary fiber includes polysaccharides, oligosaccharides, lignin, and associated plant substances. Dietary fibers promote beneficial physiological effects including laxation, and/or blood cholesterol attenuation, and/or blood glucose attenuation (1).

In 2009, Codex Alimentarius Commission or CRC define dietary fiber definition as carbohydrate polymers with ten or more monomeric units, which are not hydrolysed by the endogenous enzymes in the small intestine of humans and belong to the following categories:

- Edible carbohydrate polymers naturally occurring in the food as consumed,
- carbohydrate polymers, which have been obtained from food raw material by physical, enzymatic or chemical means and which have been shown to have a physiological effect of benefit to health as demonstrated by generally accepted scientific evidence to competent authorities,

- synthetic carbohydrate polymers which have been shown to have a physiological effect of benefit to health as demonstrated by generally accepted scientific evidence to competent authorities (13)

3.1.2 Classification of dietary fiber and its components

Dietary fiber can be divided into two general groups of soluble and insoluble fiber based on chemical, physical, and functional properties (14). Soluble dietary fibers can be dissolved in water and formed viscous gels such as pectin, gums, inulin, β -glucans, and mucilage. They are readily fermented by the microflora of the large intestine and led to building up of beneficial microflora. Therefore, they act as a prebiotic and improve host health. Insoluble dietary fibers are not soluble in water such as cellulose, hemicelluloses, lignin, and wax. They promote the movement of materials in the digestive system, increase fecal bulk, and help soften feces (15). The proportion of different dietary fiber constituents found in plant foods depends on the type and maturity of the plants. In mature typical plant cell walls, the percentage of cellulose, lignin, and ash tend to be higher than that in immature plants. Conversely, the percentage of noncellulosic polysaccharides, waxes, and protein tend to be higher in immature than in mature plants. The portion of the plant consumed as well as storage and ripening conditions also influence the dietary fiber composition of plant foods. Moreover food-processing techniques may alter the native fiber composition (15). In general, Wong and Jenkins (2007) reported that most dietary fiber containing foods contain approximately one-third soluble and two-third insoluble fiber (16).

3.1.3 Sources of dietary fiber

Dietary fiber occurs in a wide variety of food sources and is available in human food stuff. The majority of dietary fiber comes from plants such as cereals, legumes, whole grains, vegetables, and fruits. Whole grains provide more dietary fiber than fruits and vegetables per weight because of their lower water content. The sources and varieties of dietary fiber are shown in **Table 3.1**

Table 3.1 Sources of dietary fiber

Dietary fiber	Sources	Major polymers
Soluble fiber		
Pectin	Whole grains, legumes, apple, cabbage, and root vegetables	Galacturonic acid, Rhamnose, Arabinose
Gums	Legumes, oatmeal, and haricot bean	Galactomannans
Inulin and Fructooligosaccharides	Chicory, garlic, banana, and Kaentawan	Fructans
Insoluble fiber		
Cellulose	Whole grains, bran, peas, root vegetables, apple, and beans family of cruciferous	Glucose monomers
Hemicellulose	Bran and whole grains	Glucose, Arabinose, Mannose, Xylose, and Galacturonic acid
Lignin	Vegetables and flour	Phenylpropanoid unit

Source: Adapted from Yangilar, 2013 (17)

3.1.4 Physiochemical properties

Dietary fiber is a complex mixture of polysaccharides and other minor components with different functions and activities during passage through the gastrointestinal tract. Hence, they would provide a wide range of physiochemical properties.

Solubility and viscosity

The solubility of dietary fiber depends on the structural characteristics. Dietary fiber solubility is determined mainly by the charged groups of polysaccharide molecules. Water soluble polysaccharides produce viscous solutions which due to the physical interactions between polysaccharide molecules in solution. The viscosity of

dietary fiber depends on the molecular weight of the polysaccharides, the capacity to interact in solution, and their volume (18).

Water holding capacity

The water holding capacity refers to the ability of polysaccharides to retain water in the matrix. The water holding capacity of dietary fiber depends on the shape of the molecules, their ability to pack closely, and solubility (18). Studies have shown a direct relationship between water holding capacity and stool output. Dietary fibers with high water holding capacity are likely to have a high stool bulking property (19).

Chemical binding capacity

The binding capacity depends on the shape of molecules, the chemistry of the surface, and the total area capable for binding which vary with the particle size (18). Polysaccharides have the ability to bind polar molecules. Many substances such as bile acids and certain minerals can bind to dietary fiber and thus their availability would be reduced.

Cation exchange capacity

The cation exchange capacity depends on physiological state and development stage of plant because the ionic groups change with the chemical and physical properties of each stage. In general, plant cell walls have negatively charged groups so they have a strong cation binding capacity, particularly from phenolic residues, uronic acid, and phytates. This property affects the absorption of minerals because of the presence of phytates.

3.1.5 Health benefits

An adequate amount of daily dietary fiber intake is recommended to reduce the risk of global diseases such as cancer, coronary heart disease (20), and improves some physiological functions in humans such as relieving constipation, decreasing blood cholesterol (5). Therefore, dietary fiber intake has been recognized by its association with health promotion and reduction of disease risk.

Colon cancer

Fermentation of dietary fiber in the bowel is an important determinant of its physiological effect. The process of fermentation of dietary fiber in the colon produces short chain fatty acid that sustains the integrity of the gut (21). Moreover, dietary fiber acts as a protective factor in bowel by reducing transit time of the food mass which reduces the formation and action time of carcinogens in bowel. A high dietary fiber intake was associated with a reduced risk of colon cancer, particularly dietary fiber from cereals and whole grains (22).

Coronary heart disease (CHD)

Dietary fiber intake has been shown to reduce the risk of CHD by way of various mechanisms such as lowering blood cholesterol and blood pressure (23). Dietary fiber has been reported to inversely associate with CHD and mortality risk (reduced 19% of CHD mortality risk) (20). Whole grains intake is protective against cardiovascular diseases especially the bran component of whole grains which is an important factor in the protection.

Obesity

Consumption of dietary fiber promotes effective weight management. Larry and Kathryn (2009) (24) evaluated the effect of dietary fiber and body weight. They reported that increasing dietary fiber intake significantly decreased the risk of weight gain and obesity in women. Soluble dietary fiber prolongs gastric emptying, which enhances a feeling fullness. Thus it helps prevent overeating and decrease the overall energy intake. In contrast, insoluble dietary fiber provides the opposite effect of soluble dietary fiber. Its mode of action may be due to the fact that insoluble dietary fiber increases the rate of passage of food through the GI tract. This would be expected to result in diminished digestion and absorption of energy and fat (25).

Diabetes

Cereal fiber intake was associated with a decreased risk of type II diabetes independent of other compounding factors (26). Low glycemic index foods reduce the insulin demand during digestion and absorption. Consumption of whole grain cereals

with low glycemic index could help to reduce energy intake by increasing satiety. It could be helpful in the type II diabetes management. Besides it might be particularly beneficial with respect to insulin resistance syndrome (27).

Hypercholesterolemia

Soluble dietary fiber intake can delay gastric emptying and reduce the uptake rate of glucose. Moreover, the fermentation products of soluble dietary fibers (short-chain fatty acids such as acetate, butyrate, propionate) could have a role in reducing plasma cholesterol by inhibiting hepatic synthesis (28). Consumption of soluble fibers about 2-10 g/day has been shown to reduce total and LDL cholesterol. Some evidence suggests that soluble dietary fibers could bind with bile acids or cholesterol during the micelles formation and increase their rate of excretion along with the fibers (29).

3.1.6 Recommendation for dietary fiber consumption

An adequate dietary fiber intake is essential for proper functioning of the gut and is related to reduction of the risk of diseases such as cancers, diabetes, and coronary heart disease. Recommendations for dietary fiber intake in adults among countries which have developed guidelines for intake range from 21 to 40 g/day. In Thailand, the Thai Recommended Daily Intake (Thai RDI), stated that healthy people (> 6 years old) should consume 25 g dietary fiber per day, based on 2000 kcal per day intake.

3.2 Inulin

3.2.1 Definition

Inulin is a type of fructans. It is a polymer of fructose linked by β (2-1) glycosidic bonds with a chain length of fructose monomers ranging from 2 to 60 units (degree of polymerization; DP) and usually with glucose at the terminal unit of the chain (30). The DP depends on the plant species, weather conditions during growth,

and harvest time. The DP of inulin is an important property that affects its functions. Chemically, inulin formation can be divided in two classes; fructosyl-fructose linkage with glucose unit (GF_n -type) and only fructosyl-fructose linkage (F_n -type). Their structure are shown in **Figure 3.1** where G is a glucose moiety, F is a fructose moiety and n is the number of fructose molecules (4).

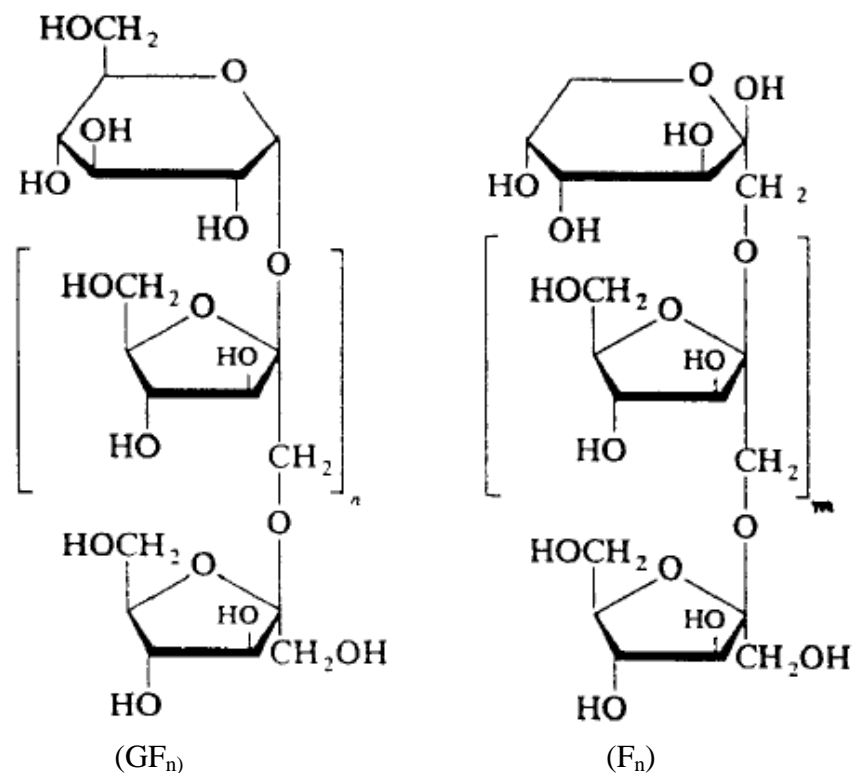


Figure 3.1 Chemical structure of inulin (GF_n -type and F_n -type) (31)

3.2.2 Source of inulin

Inulin is found in several varieties of fruits and vegetables as a plant storage carbohydrate. The level of inulin in plants varies depending on types of plant, cultivation conditions, and harvest time. **Table 3.2** shows inulin content in some plants.

Table 3.2 Inulin content of some plants

Plant source	Inulin (g/100g)
Chicory	35.7-47.6
Kaentawan	16.0-20.0
Dandelion	12.0-15.0
Garlic	9.0-16.0
Leek	3.0-10.0
Onion	1.1-7.5
Asparagus	2.0-3.0
Wheat	1.0-4.0
Banana	0.3-0.7
Barley	0.5-1.0
Rye	0.5-0.9

Source: Adapted from Van Loo *et al.*, 1995 (32)

3.2.3 Physiological effects and health benefits

Inulin is classified as a soluble dietary fiber that cannot be digested by the enzymes in the human small intestine because of the inability to hydrolyze the glycosidic bonds in inulin (30). Thus it has various beneficial effects similar to soluble dietary fibers as follows;

Low caloric value

Inulin is classified as a non-digestible carbohydrate that cannot be digested in the stomach or small intestine by human enzyme. Thus the caloric value of inulin is lower than the digestible carbohydrates. Inulin provides the energy of only 1.5 kcal per g (33). Hence, it is suitable for weight control diet. For food industry, inulin is used as a fat replacer in several products such as drinking yoghurt, milk, and coffee.

Low glycemic index

Inulin is a non-digestible carbohydrate which cannot be hydrolyzed and broken down into simple sugars by the human digestion system. Therefore, it does not

increase blood sugars and is designated as creating a low glycemic response. Jackson *et al.* (1999) (34) reported that the consumption of diet added with 10 g of inulin significantly reduced fasting insulin concentrations. Besides, some evidence showed that low glycemic index diet can prevent obesity (35). Thus, addition of inulin in daily diet is interested in the prevention and treatment of obesity and diabetes.

Improvement of calcium bioavailability

Inulin is a type of dietary fiber which can be fermented in the colon by colonic microflora. The fermentation of inulin produces short chain fatty acids (SCFA) and contributes to a lower pH in the large intestine. This condition enhanced the solubility and absorption of calcium, so the bioavailability of calcium is increased (36). Souza *et al.* (2010) (37) reported the effect of inulin on calcium metabolism. They found that it could increase the bone mass of adolescents. Moreover inulin consumption may decrease the risk of osteoporosis resulting from the stimulation of calcium absorption.

Improvement of lipid metabolism

Inulin is completely fermented by colonic microflora. The resulting short chain fatty acids, especially propionate and acetate, can reduce blood lipids by decreasing biosynthesis and absorption and increasing catabolism of lipids (38). A clinical trial by Guo *et al.* (2012) (39) found a reduction of total cholesterol and triglyceride concentrations in the serum with consumption of inulin. The mechanism of the cholesterol and triglyceride lowering effect by inulin was described by Ooi and Liong (2010) (40). They found that there are 2 mechanisms; first, inulin is a soluble and viscous compound that can coat and increase the thickness of the small intestine so it decreases and inhibits the absorption of cholesterol and second, the fermentation product of inulin such as propionate and acetate can inhibit the synthesis of fatty acids.

Reduction of colon cancer

Several studies revealed that the fermentation products of inulin have an anti-tumor cell properties that can reduce the risk of colon cancer (41, 42). The

production of short chain fatty acids from fermentation of inulin may help to suppress colon cancer.

Prebiotics

A prebiotic is a selectively fermented ingredient that stimulates the growth and activity of beneficial bacteria in the colon, and improves the host health (43). Inulin cannot be digested in the small intestine so it passes down into the colon and its selective fermentation by the human colonic microflora leads to a shift in the composition of the indigenous bacterial ecosystem and promotes the growth of Bifidobacteria. By increasing the Bifidobacteria, it could help improve the host resistance to invasion from pathogens (44). Consequently, the immune function of the host could be enhanced.

3.2.4 Recommendation of inulin intake and possible side effects

Inulin is natural food ingredients from edible plants. An estimate of daily inulin intake ranges between 1 to 4 g/day in the Americans based on the United States Department of Agriculture (USDA) and 3 to 11 g/day in the Europeans (32). However, the recommended daily intake of inulin has not been established. In practice, inulin is added to various food products to allow a specific nutritional claim, such as improvement of beneficial microflora, at the level of 3-8 g per portion (45). According to Coussement (1999) (45), he suggested that a formulation dose of inulin is about 10 g or more for non-sensitive persons without side effects.

The possible side effects of inulin include gastrointestinal discomfort, bloating, cramping, diarrhea, and flatulence. These are common symptoms that can occur along with dietary fiber consumption, particularly at high levels. Bruhwylter *et al.* (2009) (46) reported that the maximum dose was 20 g/day without gastrointestinal symptoms. Nevertheless, inulin has been certified as a Generally Recognized as Safe (GRAS) food ingredient in 1992 (47).

3.2.5 Food applications of inulin

In the food industry, inulin is used for dietary fiber supplementation because of its beneficial effect on health. It provides not only the important functions of soluble dietary fiber but also the prebiotic properties that make inulin useful in developing functional foods. Inulin is available commercially in a dry powder form, which does not have any odor and flavor. The color can vary from white to gray depending on the purification degree. Commercial inulin is obtained and purified from chicory roots using hot water extraction. The functional properties of inulin depend on chain length distribution or degree of polymerization. Long chain (high DP) inulin is lower in the sweetness than short chain inulin. Besides, long chain inulin is less water soluble and yields greater viscosity in solution than short chain inulin (30). It is also considered to give functional properties such as fat replacer, sweetener, and texture modifier without adversely affecting flavor in several products like yoghurt, cheese, and ice cream (7, 48). For example, when inulin replaced fat in reduced fat cookies formulations the crispness was increased. Moreover, cookies with 50% fat replacement by inulin presented a higher sensory acceptability and similar physical characteristics to the cookies made from the standard formula (49). Although inulin replacement of fat in ice cream formulas affected the physical properties of the final products, the level of 5% inulin replacement of fat gave a product that was accepted by the consumers (50).

3.3 Kaentawan

3.3.1 General information

Kaentawan or Jerusalem artichoke (*Heliantus tuberosus L.*) is a tuberous annual crop. The plant is a herbaceous perennial plant growing to 1.5–3 m tall. The flowers are yellow and the part that is consumed is the tubers as root vegetable as shown in **Figure 3.2**. It is originated in the North America. Over the past 300 years, Kaentawan has been used widely during the times of crop failure and food shortage such as potato famine and after World War II. Recently, Kaentawan has been

interested because of its potential health benefits and as the raw material of biofuel production (51).

The origin of the name of Kaentawan; Jerusalem artichoke, is not related to Jerusalem city but it was converted from “girasole artichoke”, which is the Italian name. This is due to the difficulty of the pronunciation in English. The meaning of “girasole” is sunflower because Kaentawan is similar to sunflower. The word “artichoke” came from the Arabic word that means rough skin. Furthermore, Kaentawan can be called by other names such as sunchoke, sunroot, earth apple and topinambur (51). Kaentawan can grow to 3 m or more height with 1.6-2.4 cm stem diameter. The leaves are lanceolate shape with 10-20 cm length and 5-10 cm width.



(A)



(B)



(C)

Figure 3.2 Kaentawan: (A) flower (B) tubers (C) peeled tubers

The morphology depends on variety and cultivation conditions. Flowers are bright yellow color. Its stem and flower look like Mexican sunflower (*Tithonia*

rotundifolia). The edible underground tubers are similar to ginger. The skin of tubers has light brown color. The internal appearance of tubers is white or light brown color. The tubers contain high level of inulin instead of starch (52). Kaentawan can be grown in a wide range of environmental conditions especially in tropical climate. It exhibits good resistance to diseases and pests. At present Kaentawan is cultivated in Thailand (53). It is known in Thai language as “kaentawan”. Originally it is used as an ingredient in the industries such as a component for promoting the growth of probiotics and a raw material for ethanol and sugar production. In Thailand, the use of Kaentawan tuber as a food ingredient is still not widespread even it has many advantages for health.

3.3.2 Nutritive value of Kaentawan

The tubers of Kaentawan generally consist of about 80% water, 18% carbohydrates, 2% protein, and 2% dietary fiber. It is very low in fat and contains no cholesterol (**Table 3.3**). Carbohydrates in Kaentawan tubers has only a small amount of starch but it has high level of inulin (about 20% in raw Kaentawan) (9), similar to chicory roots (10) that are commonly used in the commercial production of inulin. Hence, Kaentawan tubers can be a good source of inulin.

Table 3.3 Composition of Kaentawan tubers (per 100 g fresh weight)

Nutrient	Value
Water (%)	78.0
Energy (kcal)	73
Carbohydrate (g)	17.4
Protein (g)	2.0
Fat (g)	0.01
Total dietary fiber (g)	1.6
Cholesterol (mg)	0
Minerals	
Calcium (mg)	14
Iron (mg)	3.4

Magnesium (mg)	17
Phosphorus (mg)	78
Potassium (mg)	429
Sodium (mg)	4
Zinc (mg)	0.12
Vitamins	
Vitamin A (IU)	20
Vitamin C (mg)	4
Vitamin E (mg)	0.19
Vitamin K (μg)	0.1
Vitamin B6 (mg)	0.077
Folate (μg)	13
Niacin (mg)	1.3
Thiamin (mg)	0.2
Riboflavin (mg)	0.06

Source: Adapted from USDA National Nutrient data base (54)

3.3.3 Utilization of Kaentawan

Kaentawan can be grown for various ways of utilization such as human consumption, animal feed, and alcohol and fructose production (55).

Human diet

As a food, Kaentawan is a type of vegetables that is similar to potatoes, except the carbohydrate content of the tubers is inulin in place of starch. Inulin can be converted to fructose so the tubers may exhibit some sweetness. Inulin provides various benefits for health as described in section 3.2.3. Therefore, Kaentawan tubers become of interest for applications in the human diet. The tubers can be eaten both fresh and cooked. Several recipes have been developed to prepare common dishes containing Kaentawan. For example, tubers can be sliced and mixed in salads, boiled into cream soups, prepared deep-fried chips, and mashed (56). Moreover, a Kaentawan juice can also be produced (57).

Alcohol production

Because Kaentawan is a polysaccharide-containing root, its tubers can be utilized as a raw material for ethanol production with high quantity at low cost. Fermentation of tubers has been used in spirit, beer, and wine production. Inulin in tubers can be converted to sugar by enzymatic or acidic hydrolysis. Then fermentable sugars are fermented by yeast and the resulting product is distilled to recover the ethanol. However, at the present time the cost of ethanol production from this process is not competitive with gasoline prices. Therefore, the production of bioethanol from Kaentawan tubers is still limited and not used in widespread situation (58).

Fructose production

Kaentawan tubers are raw material of fructose production. Inulin is an excellent substrate for producing high fructose syrup. It can be hydrolyzed by acid or enzyme. The syrup from Kaentawan tubers acts as a sweetener because it provides a sweet taste with a low caloric value (59). Furthermore, to add value to Kaentawan, the tubers can be a raw material of flour production. The Kaentawan flour provides prebiotics properties and low energy. It is used as a food additive in several products for instant, yoghurt, snack, juice, coffee, and powdered milk.

Animal feed

Kaentawan is not only consumed as a human diet, but it can also be utilized as an animal feed. The leaves of Kaentawan contain a high level of protein, especially a high level of the amino acid lysine (60). Thus the leaves are a good source of protein for animal feed. Moreover, it has been used in animal feed as prebiotics supplements. The addition of prebiotics can help promoting the growth and activity of beneficial bacteria which work against pathogenic bacteria. The expecting benefits include improving the immune system and balancing the gut microflora of animals (56).

3.4 Instant rice porridge

Instant rice porridge is a processed rice product that is cooked and dried into small flakes. It can be mixed together with seasoning, dried meats and dried vegetables. The final product can be prepared by adding hot water in a short time, usually less than 5 minutes. According to the Thai standard, instant rice porridge is required to have moisture content lower than 7% and protein higher than 8% (11). Moreover, the presence of microorganisms should not be greater than the criteria as shown in **Table 3.4**.

Table 3.4 Microbiological criteria of an instant rice porridge

Microorganism	Criteria
Total plate count (per g of sample)	$< 1 \times 10^5$
Yeast and mold (per g of sample)	< 100
<i>Clostridium perfringens</i> (per 0.01 g of sample)	0
<i>Escherichia coli</i> (per g of sample)	< 3
<i>Staphylococcus aureus</i> (per 0.01 g of sample)	0
<i>Salmonella</i> (per 25 g of sample)	0

Source: Adapted from Thai Industrial Standard, 2005 (11)

At present, instant rice porridge is becoming more popular as a breakfast meal in the Thai society because of the time constraint for food preparation in the morning. Thus, consumers are interested in the products that can be conveniently prepared and consumed. The market of instant rice porridge in Thailand reached a value of 500 million baht in 2005. Furthermore, Kasikorn Research Center estimated that the market of instant rice porridge will be continue to increase annually (61). In response to the consumers' interest and preference toward healthy and functional foods, the manufacturers have formulated and developed more choices of instant rice porridge products to offer greater product varieties for consumers. They included for example, instant rice porridge with dehydrated corn, carrot, cabbage, broccoli, egg, and mushroom-seaweed flavor. However, the nutrition label of most existing

commercial instant rice porridge products shows that it contains only a small amount of dietary fiber (less than 1 g of dietary fiber/serving size).

CHAPTER IV

MATERIALS AND METHODS

4.1 Materials

4.1.1 Instant rice porridge ingredients

Instant rice porridge (chicken-flavored) was provided from Unilever Thai Service Limited. (supplied from Unilever Thai Holdings Limited., Chachoengsao, Thailand)

4.1.2 Inulin powder

Commercial inulin, Fibruline® S20, was provided by the Nutrition SC Co.,Ltd., Thailand (supplied from Cosucra Groupe Warcoing S.A., Belgium)

4.1.3 Kaentawan

Kaentawan (variety HEL 65, number 2) tubers were purchased from Raipiriya, Nakhon Ratchasima, Thailand. Upon receipt, they were stored in a cold room at 4° C until further use.

4.1.4 Analytical chemicals

All chemicals used in the chemical and microbiological analyses were analytical grade.

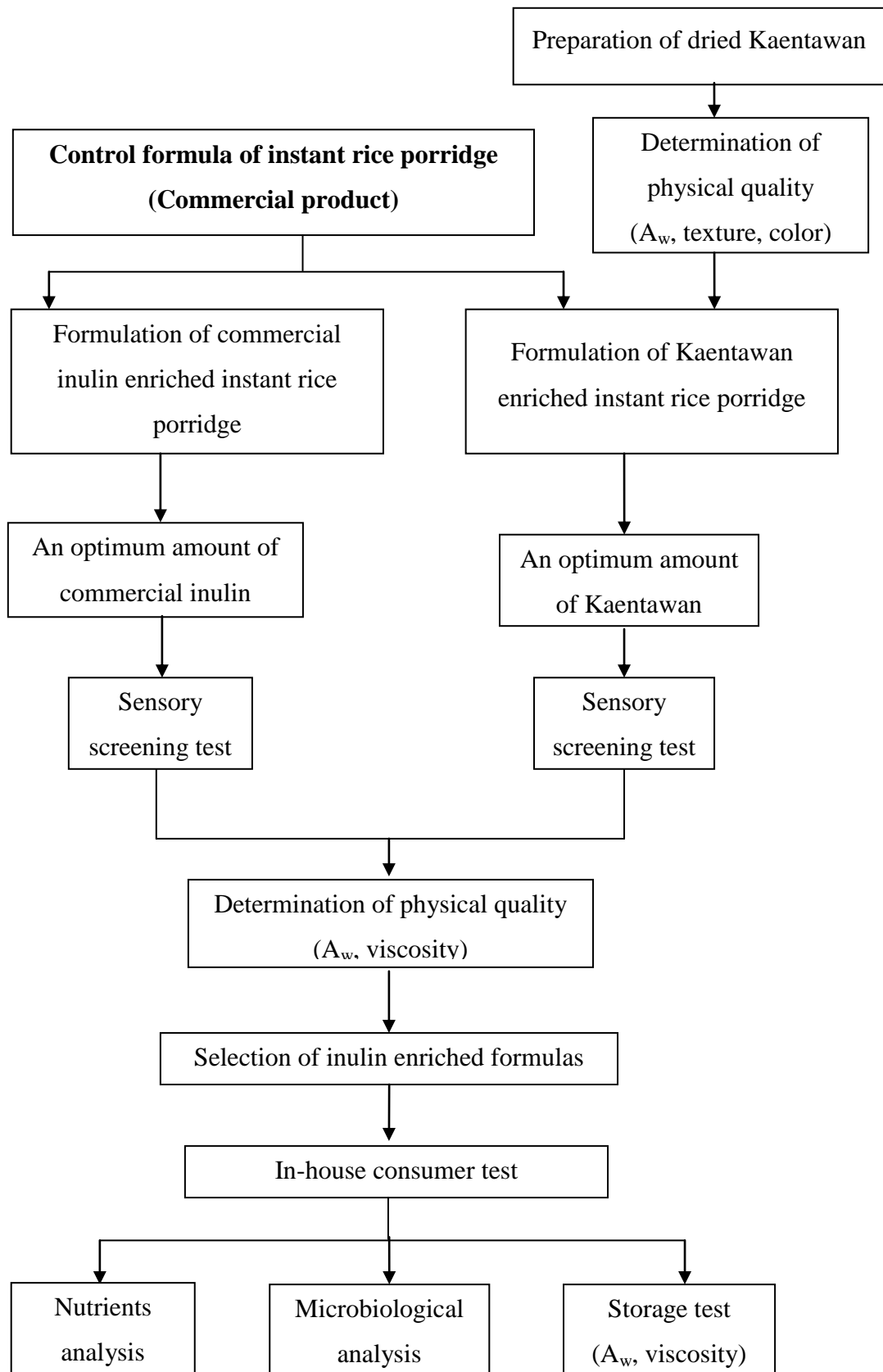


Figure 4.1 Experimental schematic

4.2 Formulation of commercial inulin added instant rice porridge

An instant rice porridge was added with commercial inulin powder to formulate a dietary fiber-enriched product. A commercial instant rice porridge, chicken-flavored was used as a base product for the formulation.

4.2.1 Determination of an optimum amount of commercial inulin added to instant rice porridge

Different levels of commercial dry inulin powder were added to instant rice porridge according to the recommendation for daily dietary fiber intake. The target level of addition included 10%, 15% and 20% of Thai Recommended Dairy Intakes (Thai RDI) per serving. The dry components were mixed together at a determined amount and kept in laminated bags until further testing. The optimum level of commercial inulin was selected by sensory evaluation and physical properties determination including viscosity and water activity in order to achieve the level of inulin addition that was feasible to add to instant rice porridge and was as close to the maximum target as possible. The acceptability of the selected product was confirmed in an in-house consumer test.

4.2.2 Sensory screening test

The sensory screening test was performed in order to identify the optimum level of commercial inulin in the formulated products from 4.2.1. The products were prepared by adding hot water at $85\pm 3^{\circ}\text{C}$ (35 g instant porridge: 250 ml hot water), stirred and allowed to stand for 2 min before serving. Sensory characteristics were evaluated by 25 panelists who are staff and graduate students at the Institute of Nutrition, Mahidol University. The sensory evaluation was performed in testing booths at Sensory Science Laboratory, Food Science Unit, under daylight fluorescent lamp, air conditioned and free from cooking odor and noise. The panelists were not allowed to communicate with each other.

Approximately 45 g of sample was served each time to the panelists. The order of sample preparation and presentation was randomized. Panelists were asked to

rinse their mouth with water between samples. Nine-point hedonic tests were used to measure the preference for appearance, flavor, taste, and overall acceptability, where 1 means “dislike extremely”, 5 means “neither like nor dislike”, and 9 means “like extremely”. Specific characteristics of the products were evaluated by 5-point “just-about-right” scales. The score ranged from 1 to 5 where 1 means “much too weak”, 3 means “just-about-right”, and 5 means “much too strong”. The questionnaire used in this experiment is shown in Appendix E.

In addition, a comment column will be provided on each ballot. A formula with the overall acceptability score more than 5 was considered for an in-house consumer test compared to the control formula.

4.2.3. Physical properties determination

4.2.3.1 Water activity: water activity of the dry instant rice porridge sample was measured using a water activity analyzer (Novasina MB-MIK 3000, Switzerland) at room temperature (approximately 25°C). Five gram of sample were weighed into a sample container and placed in the measuring chamber until the relative humidity reached equilibrium inside the analyzer. The water activity value was then recorded. The measurement was carried out in three replicates of each sample.

4.2.3.2 Viscosity: viscosity of the prepared rice porridge sample was measured using a Brookfield digital viscometer model RVT DV-II (Brookfield Engineering Laboratories, Inc., MA, USA). All measurements were performed at room temperature (27-30°C), 4 min after hydration in three replicates of each sample, using spindle no. 2 at a speed of 20 rpm. The values were expressed in centipoise (cps) unit.

4.3 Preparation of dehydrated Kaentawan

Dehydrated Kaentawan was prepared from the fresh tubers by drying in a hot air oven. The dehydrated product was determined for the physical and chemical properties. The most suitable sample was later used to add to the instant rice porridge.

4.3.1 Determination of an optimum condition for drying Kaentawan

Kaentawan tubers were manually peeled using a knife. Then the tubers were diced into 5×5×5 mm pieces. Diced Kaentawan pieces were dried in a hot air oven at 50° C for 8, 9, and 10 h (62). An optimum time for drying diced Kaentawan was determined by physical and chemical qualities of the dried product including moisture content, water activity, color, texture of the dried sample after rehydration and sensory screening test.

4.3.2 Physical and chemical properties determination

4.3.2.1 Moisture content: moisture content of sample was determined by drying the sample in a hot air oven at 105°C until a constant weight was obtained (AOAC 990.19 and 925.23, 2005).

4.3.2.2 Water activity: water activity of the dry instant rice porridge sample was measured using a water activity analyzer (Novasina MB-MIK 3000, Switzerland) at room temperature (approximately 25°C) with the same measurement method as in 4.2.3.1. Three replicate determinations were carried out for each sample.

4.3.2.3 Color: rehydration of dried Kaentawan was carried out by soaking the dried sample in hot water at 85±3°C (10 g sample/ 70 ml water) for 2 min and drained out the water.

The color of fresh and rehydrated dried Kaentawan was measured using a Chromameter CR-400. The values were expressed as L*, a* and b*. The maximum L* value is 100, which represents the most diffusion while the minimum value is 0, which represents the black color. Positive a* value represents redness and negative value represents greenness. Positive and negative b* values represent yellowness and blueness respectively. Three replicates of measurement were performed for each sample.

4.3.2.4 Texture: the hardness of fresh and rehydrated dried Kaentawan was measured using a texture analyzer (TA.XT-plus Texture Analyzer; Stable Micro System, UK) equipped with a A/BE 46 mm cylindrical probe, compression mode using the speed of pre-test, test, and post-test at 1, 1, 10 mm/s, respectively with 50% strain according to the procedure of Kiatthanapaiboon *et al.*

(2007) (63). Rehydration of dried Kaentawan was the same as described in 4.3.2.3. All measurements were performed at 2 min after rehydration of dried Kaentawan, in ten replicates for each sample.

4.3.3 Sensory screening test

The sensory screening test was performed in order to test the suitability of rehydrated Kaentawan in instant rice porridge. The instant rice porridge containing dried Kaentawan was prepared in the same manner as described in 4.2.2. Sensory characteristics were evaluated by 25 panelists who are staff and graduate students at the Institute of Nutrition, Mahidol University using the same procedure as described earlier. The sensory evaluation was carried out using a 9-point hedonic test for appearance, flavor, taste, and overall acceptability. Specific characteristics of the products, including color and texture of Kaentawan were evaluated by 5-point “just-about-right” scales. The questionnaire used in this experiment is shown in Appendix F.

4.4 Formulation of Kaentawan added instant rice porridge

An instant rice porridge was added with dried Kaentawan to formulate a dietary fiber-enriched product. A commercial instant rice porridge, chicken-flavored was used as a base product for the formulation.

4.4.1 Determination of an optimum amount of dried Kaentawan added to instant rice porridge

Fresh Kaentawan was analyzed for its inulin content. Then the inulin content of dried Kaentawan was calculated based on the content in fresh sample. It was used to estimate the amount of Kaentawan to be added to instant rice porridge. Different levels of dried Kaentawan were added to instant rice porridge according to the recommendation for daily dietary fiber intake. The target level of addition included 10%, 15% and 20% of Thai RDI per serving. The optimum level of Kaentawan was selected by sensory evaluation and physical properties determination in order to

achieve the level of addition that was feasible to add to instant rice porridge and was as close to the maximum target as possible. The acceptability of the selected product was confirmed in an in-house consumer test.

4.4.2 Sensory screening test

The sensory screening test was performed in order to identify the optimum level of dried Kaentawan in the formulated products from 4.4.1. The instant rice porridge containing dried Kaentawan was prepared in the same manner as described in 4.2.2. Sensory characteristics were evaluated by 25 panelists who are staff and graduate students at the Institute of Nutrition, Mahidol University using the same procedure as described earlier. The sensory evaluation was carried out using a 9-point hedonic test for appearance, flavor, taste, and overall acceptability. Specific characteristics of the products, including color and texture of Kaentawan were evaluated by 5-point “just-about-right” scales. The questionnaire used in this experiment appears as Appendix F.

4.4.3 Physical and chemical properties determination

4.4.3.1 Viscosity: viscosity was measured using a Brookfield digital viscometer model RVT DV-II (Brookfield Engineering Laboratories, Inc., MA, USA). All measurements were performed using the same procedure as explained in 4.2.3.2. The value is expressed in centipoise (cps) unit.

4.4.3.2 Moisture content: moisture content of sample was determined by drying the sample in a hot air oven at 105°C until a constant weight was obtained (AOAC 990.19).

4.4.3.3 Water activity: water activity was measured using a water activity analyzer (Novasina MB-MIK 3000, Switzerland) at room temperature (approximately 25°C) with the same measurement method as in 4.2.3.1. Three replicate determinations were carried out for each sample.

4.5 In-house consumer test

The instant rice porridge products containing the highest possible amount of either commercial inulin or Kaentawan, which were accepted by the panelists in the sensory screening test (having an overall acceptability score > 5) were selected and prepared for an in-house consumer test to confirm the consumer acceptability. The sensory evaluation for an in-house consumer test was performed using a similar procedure and experimental design as those of the sensory screening test, except for the number of panelists. Fifty panelists were used for the in-house consumer test and only a 9-point hedonic test was used in the evaluation. The questionnaire for testing instant rice porridge containing commercial inulin and Kaentawan is shown in Appendix G.

4.6 Nutritional values of the formulated instant rice porridge

The selected instant rice porridge formulas with the highest acceptability score from the sensory evaluation were analyzed for proximate composition and inulin content. The determination was performed by the Food Chemistry Laboratory, the Institute of nutrition, Mahidol University.

4.6.1 Proximate composition analysis

Moisture content was determined by a hot-air oven method at 105°C (AOAC 990.19).

Protein was determined by a Kjeldahl method (AOAC 991.20 and 981.10, 2005).

Total fat was determined by acid hydrolysis and extraction on Soxtec System HTTM 1043 Extraction unit (AOAC 922.32 and 945.16, 2005).

Ash was determined by incinerating the sample at 550°C (AOAC 945.46 and 930.30, 2005).

Carbohydrate was calculated by deducting the sum of the percentage of protein, fat, ash and moisture from one hundred percent.

Energy content was the result from the sum of the amount (g) of protein, carbohydrate and fat multiplied by a factor of 4, 4 and 9, respectively

4.6.2 Dietary fiber analysis

Total dietary fiber content was determined by an enzymatic–gravimetric method (AOAC 991.42, 2005).

4.6.3 Sugar analysis

Total sugar content of the sample was determined by extraction with water and determination by gas chromatography (64).

4.6.4 Inulin analysis

Inulin content was analyzed by an enzymatic method (AOAC 997.08) with measurement by high-temperature gas chromatography (9). Five g of freeze dried samples, containing about 1 g of inulin, were extracted for total sugars, fructans, and fructo-oligosaccharides by hot water. Then inulin and fructo-oligosaccharides in the hot water extract were hydrolyzed by inulinase. Both hot water extracted and enzyme hydrolyzed fractions were derivatized by oxymation and silylation reaction. Individual sugars were then determined by high-temperature gas chromatography. Sugars in the hot water extract were equipped with a capillary aluminum-clad column and set temperature at 447°C for the flame ionization detector. Sugars in the solution of inulinase hydrolyzed extract were also determined using gas chromatography, equipped with a capillary fused silica column. The temperature of the flame ionization detector was set at 350°C.

4.7 Microbiological quality

The selected instant rice porridge formulas were evaluated for total plate count, yeast and molds, and *E. coli*. The determinations were performed by the Microbiological Laboratory, the Institute of Nutrition, Mahidol University using standard BAM methods.

4.8 Storage test

The selected instant rice porridge products were filled in an aluminum foil laminated package and stored at room temperature (27-30°C) for 2 months during which instrumental viscosity and water activity were checked every 2 weeks.

4.9 Statistical analysis

The results were reported as mean \pm standard deviation (where appropriate). The individual differences in the physical and sensory evaluation data were analyzed using analysis of variance (ANOVA) to establish the significance among samples at $p = 0.05$. Significantly different means were compared using Duncan's Multiple Range test at $p = 0.05$. All the statistical analyses were conducted using the SPSS statistical software (version 16.0), a commercial statistical package.

CHAPTER V

RESULTS

5.1 Formulation of commercial inulin enriched instant rice porridge

An instant rice porridge was added with commercial inulin powder to formulate a dietary fiber-enriched product. **Table 5.1** shows the results of sensory screening test when different levels of commercial inulin were added to instant rice porridge according to the recommendation for daily dietary fiber intake. The target level of addition included 10%, 15% and 20% of Thai RDI per serving. The general appearance score showed that instant rice porridge with different levels of inulin were not significantly different ($p>0.05$) compared with the control formula. However, there were significant differences ($p\leq 0.05$) between the formulated products and the control formula in term of taste and odor, except for 15% commercial inulin enriched instant rice porridge. The overall acceptability score of 10% and 15% commercial inulin added instant rice porridge was not significantly different ($p>0.05$) when compared with the control formula. The color and sweetness mean scores ranged from 2.88 to 3.08 and 2.96 to 3.28, respectively. This indicated that color and sweetness of all formula were close to the just-about-right score (3.0). On the other hand, when comparing the mean score of texture of the formulated instant rice porridge with score of 3.0, the result showed that the texture of instant rice porridge all formula was too thin.

Physical properties of commercial inulin added instant rice porridge were also determined. They included water activity and viscosity. From **Table 5.2** the results show that water activity of all formula of inulin added instant rice porridge were slightly although significantly higher ($p\leq 0.05$) than that of the control formula. Nevertheless, all water activity values were in the range of 0.309 to 0.325 which were still lower than the water activity level that can support the growth of microorganisms.

Table 5.1 Sensory screening test of commercial inulin enriched instant rice porridge at different levels of addition

Formula ¹	Before tasting			After tasting				
	General Appearance ²	Color ³	Overall acceptability ²	Taste ²	Odor ²	Sweetness ³	Texture of product ³	
0%	7.20±1.38 ^a	2.92±0.64	7.76±0.93 ^a	7.84±0.90 ^a	7.80±1.00 ^a	3.20±0.41 [*]	2.32±0.75 [*]	
10%	7.04±1.43 ^a	3.08±0.50	7.36±0.86 ^{ab}	7.16±0.80 ^{bc}	6.68±1.43 ^c	3.04±0.46	2.48±0.82 [*]	
15%	7.00±1.16 ^a	3.04±0.68	7.44±1.15 ^a	7.44±1.19 ^{ab}	7.40±1.08 ^{ab}	3.28±0.54 [*]	2.48±0.71 [*]	
20%	7.04±0.98 ^a	2.88±0.53	6.76±1.42 ^b	6.76±1.27 ^c	6.96±1.27 ^{bc}	2.96±0.94	2.12±0.93 [*]	

¹ Each formula showed percentage of commercial inulin added to instant rice porridge base on the Thai RDI for dietary fiber intake

² 9-point hedonic scale (1=dislike extremely, 5=neither like nor dislike, 9=like extremely)

³ 5-point just-about-right scale (5 = much too much, 3 = just-about-right, 1 = much too little)

^{a-c} Different letters mean statistically significant difference ($p \leq 0.05$) among values in a column

^{*} Significantly different ($p \leq 0.05$) from the score 3(just-about-right) in a column

The viscosity of all formulas was significantly different ($p \leq 0.05$) from the control formula. Commercial inulin added instant rice porridge showed lower viscosity than the control formula. These result supported the results of the sensory screening test where the panelists found the formulated products to be thinner than the control one.

Table 5.2 Water activity and viscosity of commercial inulin enriched instant rice porridge

Formula	Water activity (A_w)	Viscosity (cps) ¹
0% (Control)	0.29±0.00 ^a	441.3±12.32 ^a
10% of inulin	0.32±0.0 ^b	272.0±53.78 ^b
15% of inulin	0.31±0.01 ^b	183.7±17.50 ^b
20% of inulin	0.32±0.01 ^b	166.7±18.90 ^b

¹ Measured at a percent Torque range of 10-100

^{a-b} Different letters mean statistically significant difference ($p \leq 0.05$) among values in a column

Most importantly, the results of sensory screening test revealed that, in general, the commercial inulin enriched instant rice porridge was accepted by the panelists with the overall acceptability score being between like slightly and like moderately, especially the 15% commercial inulin enriched formula. Therefore, the commercial inulin enriched instant rice porridge at 15% addition level was selected for further study.

5.2 Preparation of dehydrated Kaentawan

Dehydrated Kaentawan was prepared from the fresh tubers by drying in a hot air oven at 50°C for 8, 9, and 10 h. The dehydrated products as well as their rehydrated samples (in certain cases) were determined for the physical and chemical properties as well as sensory evaluation to select an optimum drying condition.

5.2.1 Determination of physical and chemical properties

The dried Kaentawan samples were measured for their physical and chemical properties including moisture content, water activity, color, and texture (hardness).

Table 5.3 Moisture content and water activity of dried Kaentawan at 50°C

Drying time (h)	Moisture content (%)	Water activity (Aw)
8	9.0±0.00 ^a	0.52±0.00 ^a
9	7.9±0.00 ^b	0.47±0.00 ^b
10	6.8±0.00 ^c	0.42±0.00 ^c

^{a-c} Different letters mean statistically significant difference ($p \leq 0.05$) among values in a column

From **Table 5.3**, the results show the effect of drying time on the moisture content and water activity of Kaentawan. Moisture content was significantly ($p \leq 0.05$) decreased with increased drying time. According to the Thai standard for instant rice porridge, the product is required to have a moisture content lower than 7% (11) of its total weight. Therefore, the time for drying Kaentawan was selected to be 10 h. All the dried Kaentawan samples exhibited water activity in the range of 0.42-0.52. These values were considered lower than the water activity level that can support the growth of microorganisms which is 0.80 for mold, 0.88 for yeast, and 0.91 for bacteria (65).

The color of dried Kaentawan was measured after rehydration in hot water for 2 min. According to **Table 5.4**, drying time had no significant effects on the color values, L* (lightness), a* (redness), and b* (yellowness), of the samples. Moreover, the L* values of rehydrated dried Kaentawan were close to the value for fresh Kaentawan which was 59.31±2.55 ($p > 0.05$).

Table 5.4 Color values of dried Kaentawan after rehydration

Drying time (h)	Color		
	L*	a*	b*
8	61.20±1.24 ^a	2.78±0.38 ^a	14.11±1.09 ^a
9	61.08±2.52 ^a	2.25±0.57 ^a	16.08±2.16 ^a
10	61.13±1.71 ^a	2.00±0.35 ^a	16.75±2.22 ^a

^a Different letters mean statistically significant difference ($p \leq 0.05$) among values in a column

5.2.2 Sensory screening test

Sensory screening test was performed for dried Kaentawan added to instant rice porridge using 25 untrained panelists in order to examine the suitability of the texture of Kaentawan after preparation of the porridge.

Table 5.5 Sensory screening test of dried Jerusalem artichoke (at 50°C, 10 h) added instant rice porridge

Before tasting			After tasting		
General appearance ¹	Odor ¹	Color ²	Overall acceptability ¹	Taste ¹	Texture ²
7.45±1.15	7.40±0.50	3.15±0.37	6.65±1.27	7.20±1.06	3.95±1.10

¹ 9-point hedonic scale (1=dislike extremely, 5=neither like nor dislike, 9=like extremely)

² 5-point just-about-right scale (5 = much too much, 3 = just-about-right, 1 = much too little)

Table 5.5 shows that the overall acceptability of hydrated instant rice porridge with dried Kaentawan (10 h drying) was 6.65 (like moderately). However, the score of texture of Kaentawan was 3.95. This indicated that the texture of hydrated Kaentawan was still too hard. When comparing the score of texture with score of 3 (just-about-right score), the result showed that texture of hydrated Kaentawan was significantly different ($p \leq 0.05$) from the score 3. Hence, dried Kaentawan preparation

was modified by using smaller pieces of the sample and changing the drying condition.

5.2.3 Modification of the preparation of dried Kaentawan

To obtain smaller pieces of dried Kaentawan, the fresh tuber was chopped using a food processor. The Kaentawan pieces were then dried in a hot air oven at 70° C for 3, 4, and 5 h (62). The photograph of the dried pieces appears as **Figure 5.1**. The moisture content, water activity, texture, and color of the dried Kaentawan are presented in **Table 5.6**. The results showed that the texture and color values of Kaentawan after rehydration were not significantly different ($p>0.05$) among the 3 treatments. L^* values revealed that the hydrated Kaentawan gave quite light color. The moisture content and water activity was decreased when drying time was increased. The moisture content and water activity of Kaentawan dried at 4 and 5 h were not significantly different ($p>0.05$). The optimum time for drying Kaentawan was selected to be 4 h to prevent overdrying and severe color change.



Figure 5.1 Dried Kaentawan pieces (at 70° C for 4h)

Table 5.6 Physical and chemical properties of dried Kaentawan at 70°C

Drying time (h)	Moisture (%)	Water activity	Texture ¹	Color ¹		
				L*	a*	b*
3	5.56±0.02 ^a	0.41±0.01 ^a	10037.61±1386.62 ^a	60.25±3.08 ^a	1.37±0.04 ^a	13.93±0.47 ^a
4	4.08±0.07 ^b	0.41±0.00 ^b	10244.79±1170.82 ^a	59.36±1.93 ^a	1.52±0.18 ^a	13.85±0.54 ^a
5	4.19±0.02 ^b	0.39±0.01 ^b	8677.93±1011.43 ^a	61.74±0.82 ^a	1.55±0.08 ^a	14.60±0.38 ^a

¹ Determined after rehydration^{a-b} Different letters mean statistically significant difference ($p \leq 0.05$) among values in a column

Table 5.7 shows the sensory screening test which performed to confirm the suitability of using dried Kaentawan from drying at 70°C, 4 h in instant rice porridge at the ratio 1:2 (w/w).

Table 5.7 Sensory screening test of dried Kaentawan (at 70°C, 4 h) added instant rice porridge

Before tasting			After tasting		
General appearance ¹	Odor ¹	Color ²	Overall acceptability ¹	Taste ¹	Texture of Kaentawan ²
7.35±1.15	7.20±0.50	3.00±0.37	7.60±1.27	7.65±1.06	3.20±1.10

¹ 9-point hedonic scale (1=dislike extremely, 5=neither like nor dislike, 9=like extremely)

² 5-point just-about-right scale (5 = much too much, 3 = just-about-right, 1 = much too little)

From **Table 5.7**, the overall acceptability of reformulated instant rice porridge with dried Kaentawan at 70°C, 4 h increase to 7.60 (like very much). The score of texture of Kaentawan was 3.20 which was not significantly different from the score 3 (just-about-right score). This indicated that the texture of hydrated Kaentawan was “just-about-right”. Therefore, the drying condition at 70°C for 4 h was selected for the preparation of dried Kaentawan for adding to instant rice porridge.

5.3 Formulation of Kaentawan enriched instant rice porridge

5.3.1 Inulin content of Kaentawan

Fresh Kaentawan tubers were analyzed to determine the inulin content. Then the inulin content of dried Kaentawan was calculated based on the content in fresh sample in order to estimate the amount of dried Kaentawan to be added to instant rice porridge.

Table 5.8 Inulin and moisture content of Kaentawan

Kaentawan sample	Moisture content (%)	Inulin content
Fresh	73.4±0.30	19.4±1.04
Dried (at 70°C, 4 h)	4.08±0.07	70.0 ¹

¹Inulin content of dried Kaentawan calculated based on fresh sample

From **Table 5.8**, the inulin and moisture content of fresh Kaentawan tubers was 19.4±1.04 and 73.4±0.30% respectively. Inulin content of dried Kaentawan was calculated to be 70.0%. The result revealed that inulin content increased about 4 folds after drying.

5.3.2 Sensory screening test of Kaentawan enriched instant rice porridge

Different levels of dried Kaentawan were added to instant rice porridge according to the recommendation for daily dietary fiber intake. The target level of addition included 10%, 15% and 20% of Thai RDI per serving. **Table 5.9** shows the results of the sensory screening test. The general appearance scores showed that instant rice porridge with different levels of inulin did not appear to be significantly different ($p>0.05$) compared with the control formula. Adding 15% and 20% of Kaentawan caused a significant difference ($p\leq 0.05$) from the control formula in term of taste. The scores of overall acceptability and odor were not significantly different ($p>0.05$) compared with the control formula, except for the score of 15% Kaentawan enriched instant rice porridge. When comparing the score of color and texture of Kaentawan with the score of 3 (just-about-right score), the result showed that there were no significant differences ($p>0.05$). The amount of Kaentawan was judged to be just-about-right except for the score of 10% Kaentawan enriched instant rice porridge which was significantly different ($p\leq 0.05$) from the score 3. This indicated that amount of Kaentawan at 10% by weight in the product was too little.

Table 5.9 Sensory screening test of Kaentawan enriched instant rice porridge at difference levels of addition

Formula ¹	Before tasting			After tasting			
	General Appearance ²	Color of Kaentawan ³	Amount of Kaentawan ³	Overall acceptability ²	Taste ²	Odor ²	Texture of Kaentawan ³
0%	7.20±1.38 ^a	-	-	7.76±0.93 ^a	7.84±0.90 ^a	7.80±1.00 ^a	-
10%	6.72±1.37 ^a	3.00±0.50	2.16±0.62 [*]	7.24±0.88 ^{ab}	7.20±1.23 ^{ab}	7.28±1.10 ^{ab}	3.08±0.49
15%	6.60±1.56 ^a	3.24±0.66	2.84±0.62	6.80±1.50 ^b	6.68±1.68 ^b	6.92±1.55 ^b	3.24±0.60
20%	6.64±1.41 ^a	3.16±0.47	3.12±0.33	7.24±1.42 ^{ab}	6.92±1.44 ^b	7.36±1.12 ^{ab}	3.12±0.33

¹ Each formula showed percentage of Kaentawan added to instant rice porridge based on the Thai RDI for dietary fiber intake

² 9-point hedonic scale (1=dislike extremely, 5=neither like nor dislike, 9=like extremely)

³ 5-point just-about-right scale (5 = much too much, 3 = just-about-right, 1 = much too little)

^{a-b} Different letters mean statistically significant difference ($p \leq 0.05$) among values in a column

^{*} Significantly different ($p \leq 0.05$) from the score 3 (just-about-right) in a column

5.3.3 Determination of physical properties

Physical properties of Kaentawan added instant rice porridge were determined including water activity and viscosity. The results are shown in **Table 5.10**. Water activity of all formulas of Kaentawan added instant rice porridge were significantly different ($p \leq 0.05$) from the control formula. However, water activities were ranged from 0.31 to 0.33. These values were still lower than the water activity level that can support the growth of microorganisms

The viscosity of all formulas was significantly different ($p \leq 0.05$) from the control formula. Kaentawan enriched instant rice porridge showed higher viscosity than that of the control formula. Nevertheless, this did not negatively affect the preference toward the formulated products.

Table 5.10 Water activity and viscosity of Kaentawan enriched instant rice porridge

Formula	Water activity (A_w)	Viscosity (cps) ¹
0% (Control)	0.29±0.00 ^a	441.3±12.32 ^a
10% of Kaentawan	0.31±0.01 ^b	650.0±102.59 ^b
15% of Kaentawan	0.32±0.00 ^{bc}	805.0±143.44 ^c
20% of Kaentawan	0.33±0.01 ^c	1,650.0±60.83 ^d

¹ Measured at a percent Torque range of 10-100

^{a-d} Different letters mean statistically significant difference ($p \leq 0.05$) among values in a column

The overall results indicated that Kaentawan enriched instant rice porridge could be accepted by the panelists with the overall acceptability score being around like moderately, especially the 20% Kaentawan enriched instant rice porridge. Therefore, instant rice porridge with added Kaentawan at 20% level by weight was selected for further study.

5.4 In-house consumer test

An in-house consumer test was carried out to confirm the consumer acceptability of the formulated commercial inulin and Kaentawan enriched instant rice porridge. The photographs of the products before rehydration are shown in **Figure 5.2** and **5.3**, respectively.



Figure 5.2 15% commercial inulin enriched instant rice porridge



Figure 5.3 20% Kaentawan enriched instant rice porridge

Table 5.11 presents the results of an in-house consumer test of formulated instant rice porridge. The overall acceptability score of 15% commercial inulin added instant rice porridge was 7.36 meaning like moderately while the score of 20% Kaentawan added instant rice porridge was 6.10 meaning like slightly. The results of the in-house consumer test indicated that both formulated instant rice porridge products added with either 15% commercial inulin or 20% Kaentawan were accepted by the panelists. They could be promoted as an alternative to the existing products.

Table 5.11 In-house consumer test of the formulated instant rice porridge¹

Formula	Before tasting		After tasting		
	General appearance	Color	Overall acceptability	Taste	Texture
15% of inulin	6.80±1.26	6.96±1.48	7.36±0.88	7.42±1.07	7.02±1.17
20% of Kaentawan	6.14±1.78	5.98±1.74	6.10±1.63	6.32±1.84	6.02±1.96

¹ 9-point hedonic scale (1=dislike extremely, 5=neither like nor dislike, 9=like extremely)

5.5 Nutritional values of the formulated instant rice porridge

The formulated instant rice porridge containing either commercial inulin or Kaentawan was examined for their nutritive values and the results are tabulated in **Table 5.12**. Moreover, the nutrition information of these products and the control product are displayed in **Figure 5.4, 5.5** and **5.6**, respectively.

Table 5.12 Nutritive values of formulated instant rice porridge

Nutrient	Amount per 100 g ¹	
	15% of inulin added	20% of Kaentawan added
Energy (kcal)	341	330
Moisture (g)	6.0	6.5
Protein (g)	8.2	9.3
Total fat (g)	2.3	2.2
Carbohydrate (g)	77.2	75.6
Soluble dietary fiber (g)	4.7	4.6
Insoluble dietary fiber (g)	0	0
Ash (g)	6.4	6.5

Table 5.12 Nutritive values of formulated instant rice porridge (cont.)

Nutrient	Amount per 100 g ¹	
	15% of inulin added	20% of Kaentawan added
Total sugar (g)	4.4	3.9
Cholesterol (mg)	2.3	2.1
Sodium (mg)	2,100	2,106
Inulin and fructo-oligosaccharides (g)	10.1	14.4
Vitamin B ₁ (mg)	2.0	2.0
Vitamin B ₂ (mg)	0.0	0.0
Calcium (mg)	20.7	46.7
Iron (mg)	0.8	0.8

¹ Results are means of duplicate analysis of one sample

Proximate composition and inulin content of formulated instant rice porridge are shown in **Table 5.12**. The commercial inulin enriched instant rice porridge contained slightly more energy and carbohydrate than the Kaentawan enriched instant rice porridge. On the other hand, the protein and inulin contents of Kaentawan enriched instant rice porridge were higher than those of commercial inulin enriched instant rice porridge.

Figures 5.4-5.6 show the nutrition information of instant rice porridge products. One serving (35 g) of commercial inulin and Kaentawan enriched instant rice porridge contained 5 and 7 g of dietary fiber, respectively which provides 21% and 27% of the Thai RDI value for dietary fiber. On the other hand, the control formula contained less than 1 g of dietary fiber per serving. According to the Ministry of Public Health Notification No. 182, a product that could be labeled as an excellent source of dietary fiber must contain dietary fiber per one serving at equal or more than 20% of the Thai RDI of 25 g (66). Hence, the instant rice porridge formulated in this study can be claimed as an excellent source of dietary fiber.

Nutrition Information			
Serving size: 1 cup (35 g)			
Serving (s) per cup: 1			
Amount per serving			
Total energy 130 kcal (Energy from fat 10 kcal)			
			Percent Thai RDI*
Total fat	1 g		2 %
Saturated fat	0 g		0 %
Cholesterol	0 mg		0 %
Protein	3 g		
Total carbohydrate	26 g		9 %
Dietary Fiber	<1 g		3 %
Sugars	1 g		
Sodium	840 mg		35 %
			Percent Thai RDI*
Vitamin A	0 %	Vitamin B ₁	40 %
Vitamin B ₂	0 %	Calcium	0 %
Iron	4 %		
* Percent Thai Recommended Daily Intake for Thai population over 6 years of age, are based on 2,000 kcal diet.			
Energy requirement vary by individuals. If your activities require energy of 2000 kcal per day, your daily should provide the following nutrients:			
Total Fat	Less than	65	g
Saturated Fat	Less than	20	g
Cholesterol	Less than	300	mg
Total Carbohydrate		300	g
Dietary Fiber		25	g
Sodium	Less than	2,400	mg
Calories per gram: Fat 9; Protein 4; Carbohydrate 4			

Figure 5.4 Nutrition information of instant rice porridge (control formula) according to the Notification of the Ministry of Public Health No. 182, Thailand

Nutrition Information			
Serving size: 1 cup (35 g)			
Serving (s) per cup: 1			
Amount per serving			
Total energy 110 kcal (Energy from fat 10 kcal)			
		Percent Thai RDI*	
Total fat	1 g		1 %
Saturated fat	0 g		0 %
Cholesterol	0 mg		0 %
Protein	3 g		
Total carbohydrate**	22 g		7 %
Dietary Fiber	5 g		21 %
Sugars	2 g		
Sodium	740 mg		30 %
		Percent Thai RDI*	
Vitamin A	0 %	Vitamin B ₁	45 %
Vitamin B ₂	0 %	Calcium	<2 %
Iron	2 %		
* Percent Thai Recommended Daily Intake for Thai population over 6 years of age, are based on 2,000 kcal diet.			
Energy requirement vary by individuals. If your activities require energy of 2000 kcal per day, your daily should provide the following nutrients:			
Total Fat	Less than	65	g
Saturated Fat	Less than	20	g
Cholesterol	Less than	300	mg
Total Carbohydrate		300	g
Dietary Fiber		25	g
Sodium	Less than	2,400	mg
Calories per gram: Fat 9; Protein 4; Carbohydrate 4, Inulin 2			

Inulin = 3.5 g

**Total carbohydrate excludes inulin and dietary fiber

Figure 5.5 Nutrition information of 15% commercial inulin enriched instant rice porridge according to the Notification of the Ministry of Public Health No. 182, Thailand

Nutrition Information			
Serving size: 1 cup (35 g)			
Serving (s) per cup: 1			
Amount per serving			
Total energy 110 kcal (Energy from fat 10 kcal)			
			Percent Thai RDI*
Total fat	1 g		1 %
Saturated fat	0 g		0 %
Cholesterol	0 mg		0 %
Protein	3 g		
Total carbohydrate	20 g		7 %
Dietary Fiber	7 g		27 %
Sugars	1 g		
Sodium	740 mg		30 %
			Percent Thai RDI*
Vitamin A	0 %	Vitamin B ₁	45 %
Vitamin B ₂	0 %	Calcium	2 %
Iron	2 %		
* Percent Thai Recommended Daily Intake for Thai population over 6 years of age, are based on 2,000 kcal diet.			
Energy requirement vary by individuals. If your activities require energy of 2000 kcal per day, your daily should provide the following nutrients:			
Total Fat	Less than	65	g
Saturated Fat	Less than	20	g
Cholesterol	Less than	300	mg
Total Carbohydrate		300	g
Dietary Fiber		25	g
Sodium	Less than	2,400	mg
Calories per gram: Fat 9; Protein 4; Carbohydrate 4, Inulin 2			

Inulin = 5.0 g

**Total carbohydrate excludes inulin and dietary fiber

Figure 5.6 Nutrition information of 20% Kaentawan enriched instant rice porridge according to the Notification of the Ministry of Public Health No. 182, Thailand

5.6 Microbiological quality

From **Table 5.13** the microbiological quality of the formulated instant rice porridge conformed to the criteria of the Thai industrial standard for instant rice porridge (11). These results suggested that both products were acceptable in term of food safety.

Table 5.13 Microbiological quality of formulated instant rice porridge

Analysis per g	15% inulin	20% Kaentawan	Thai industrial standard
Total plate count	9.2×10^2 cfu	7.2×10^2 cfu	$< 1 \times 10^5$ cfu
MPN <i>Escherichia coli</i>	< 3	< 3	< 3
Yeast and Mold	< 10 cfu	< 10 cfu	< 100 cfu

5.7 Storage test

Table 5.14 Physical properties of formulated instant rice porridge during 2-month storage at room temperature (27-30°C)

Storage time	Water activity (A_w)		Viscosity (cps) ¹	
	15% inulin	20% Kaentawan	15% inulin	20% Kaentawan
Day 0	0.31±0.01 ^a	0.31±0.01 ^a	183.7±17.50 ^a	805.0±143.44 ^a
2 nd week	0.34±0.00 ^b	0.37±0.01 ^b	254.0±21.17 ^b	980.0±70.00 ^b
4 th week	0.34±0.01 ^b	0.36±0.01 ^b	314.7±20.43 ^c	953.3±40.42 ^{ab}
6 th week	0.39±0.00 ^c	0.41±0.00 ^c	218.0±22.54 ^{ab}	1,088.7±109.84 ^{bc}
8 th week	0.41±0.00 ^d	0.44±0.00 ^d	366.0±22.00 ^d	1,196.7±20.82 ^c

¹ Measured at a percent Torque range of 10-100

^{a-d} Different letters mean statistically significant difference ($p \leq 0.05$)

The commercial inulin and Kaentawan enriched instant rice porridge products were stored at room temperature (27-30°C) for 2 months. Their physical properties, i.e. water activity and viscosity, were determined every 2 weeks. **Table 5.14** reported the effects of storage time on water activity and viscosity of the formulated products. Water activity and viscosity of all formulas increased gradually during storage. All values were significantly different ($p \leq 0.05$) from the initial values (Day 0).

CHAPTER VI

DISCUSSION

6.1 Formulation of commercial inulin enriched instant rice porridge

In this study, a commercial inulin, Fibruline® S20, was added to instant rice porridge. It was added to instant rice porridge according to the recommendation for daily dietary fiber intake. The target level of addition included 10%, 15% and 20% of Thai RDI per serving (25g) (66). Fibruline® S20 contains at least 90% of inulin by weight (Appendix A). Therefore, the amount of the ingredient used was calculated to meet the target level. The results showed that the general appearance score of commercial inulin enriched formulas were not significantly different ($p>0.05$) from that of the control formula. In terms of taste and odor, 15% commercial inulin added instant rice porridge was not significantly different ($p>0.05$) compared with the control formula. Although the sweetness score of 15% commercial inulin added formula (3.28) was significantly different ($p>0.05$) from the score 3 (just-about-right), it did not affect the overall acceptability of the product. Furthermore, the sweetness score of 15% commercial inulin added formula was similar to the control one. This could be from the natural property of commercial inulin which is moderately sweet (67). The color score ranged from 2.88 to 3.08. This indicated that color of all formula were just-about-right. Addition of inulin did cause any changes in the color of the product since it is a white powder which dissolves in water to form a colorless solution. The characteristic of the product most affected by the presence of inulin was the texture (body). The panelists could clearly detect the difference in the texture of product compared to the control formula. When comparing the score of texture of instant rice porridge with the score of 3 (just-about-right), the result showed that the texture of inulin enriched instant rice porridge were too thin. This may be because inulin is more readily soluble in water than starch in broken rice which is the main component of the porridge. Consequently, it may deter gelation of rice starch by competing for available water resulting in a lower viscosity in the final product after preparation by

adding hot water. Nevertheless, it did not significantly affect on the overall acceptability score. The product was still accepted as liked moderately. The results of sensory evaluation for texture could be supported by the measurement of product viscosity. Commercial inulin enriched instant rice porridge showed lower viscosity than the control formula. This is because of the property of commercial inulin which is low in viscosity (67). Moreover, it may act as impediment to swelling of starch during heating (68).

Another quality characteristic of the inulin enriched product was also examined to ensure product stability and safety. Water activity is generally used for evaluating the stability of food products. The results showed that water activity of commercial inulin enriched instant rice porridge was significantly different ($p \leq 0.05$) from control formula. This may be due to the hygroscopic property of inulin. Incidentally, water activity of the formulated product was still lower than the value that can support the growth of microorganisms which is 0.80 for mold, 0.88 for yeast, and 0.91 for bacteria (65).

In summary, the results indicated that commercial inulin enriched instant rice porridge was well accepted by the panelists and the formula with 15% added commercial inulin was selected for further study.

6.2 Preparation of dehydrated Kaentawan

Dried Kaentawan pieces were prepared by drying fresh Kaentawan tubers. The optimum condition for drying diced Kaentawan was determined by the suitability of the dried ingredient.

The water activity of the dried Kaentawan from drying at 50°C for 8, 9, and 10 h was lower than the minimum level for microbial growth (65). Only the moisture content of dried Kaentawan at 10 h was 6.8% which conformed with the criteria of the Thai standard for instant rice porridge (lower than 7% of its total weight) (11). The color of dried Kaentawan after rehydration in hot water for 2 min was creamy white. The drying time did not significantly affect the L* (lightness), a* (redness), and b* (yellowness) values. Moreover, L* values of dried Kaentawan were similar ($p > 0.05$) to fresh Kaentawan. During the early stage of the study the optimum

time for drying Kaentawan was selected to be 10 h which yielded the lowest moisture content.

When the dried Kaentawan pieces were tested for suitability in the porridge, the overall acceptability score of hydrated instant rice porridge with dried Kaentawan at 10 h was 6.65 (like moderately). However, the score of texture of Kaentawan was 3.95 meaning that it was too hard comparing to the score of 3 (just-about-right score). The comments of the panelists also suggested that the diced Kaentawan pieces were too hard. This may be because the time of rehydration (2 min) was not enough for hydration of dried diced Kaentawan. However rehydration at 2 min was according to the preparation procedure of instant rice porridge. Therefore, the drying condition was adjusted to obtain dried Kaentawan with suitable texture and low moisture content. A higher temperature, shorter time drying process was then investigated. The fresh tubers were chopped to smaller pieces using a food processor (Multi Moulinette AT71) in order to increase the surface area for drying and rehydration. The Kaentawan pieces were dried in a hot air oven at 70°C for 3, 4, and 5 h. The water activity of all the dried Kaentawan from the new drying condition was still lower than the minimum level for microbial growth (65). Their moisture content also passed the criteria of the Thai standard for instant rice porridge (lower than 7% of its total weight) (11). Furthermore, drying beyond 4 h did give a lower moisture content in the final product since the moisture content of Kaentawan dried at 4 and 5 h were not significantly different ($p>0.05$).

The texture of Kaentawan after rehydration were not significantly different ($p>0.05$) among the 3 treatments. For color, the L* value of rehydrated dried Kaentawan was slightly higher than fresh Kaentawan. This may be because the enzyme polyphenol oxidase (PPO), which causes browning reaction, was inactivated during drying. According to Emine and Sule (2003) (69), they reported that the PPO activity declined at temperatures above 40 °C and the enzyme was completely inactivated at 75 °C for 60 min. When tested in instant rice porridge, the overall acceptability of reformulated instant rice porridge with dried Kaentawan at 70°C, 4 h increased from 6.65 (like moderately) to 7.60 (like very much). The score of texture of Kaentawan was 3.20. This indicated that the texture of hydrated Kaentawan was

close to “just-about-right”. Hence, it was possible to add Kaentawan, dried at 70°C for 4 h, to instant rice porridge.

6.3 Formulation of Kaentawan enriched instant rice porridge

In this study, dried Kaentawan pieces were added to instant rice porridge according to the recommendation for daily dietary fiber intake. The target level of addition included 10%, 15% and 20% of Thai RDI per serving (25g) (66). To specify the suitable amount of dried Kaentawan to be added, the inulin content of Kaentawan was measured. The mean inulin content of fresh Kaentawan was 19.4% by weight which is in the same range as previously reported (16-20%) by Loo *et al.* (1995) (32) and Judprasong *et al.* (2011) (9). The inulin content in the dried sample was then calculated by adjusting the moisture content. The result demonstrated that inulin content increased about 4 folds after drying.

Kaentawan enriched instant rice porridge was then formulated. All products were equally acceptable and comparable to the control formula. Although adding dried Kaentawan significantly affect ($p \leq 0.05$) the score of taste, it did not significantly ($p > 0.05$) affect the overall acceptability. The overall acceptability score was like moderately.

Regarding other properties of the formulated product, the water activity of Kaentawan added formula was higher than the commercial inulin added formulas. This may be affected by the moisture of dried Kaentawan. Nevertheless, the value was still lower than the value that can support the growth of microorganisms which is 0.80 for mold, 0.88 for yeast, and 0.91 for bacteria (65). For viscosity, Kaentawan added instant rice porridge showed higher viscosity than that of the control formula. Moreover, viscosity was significantly increased ($p \leq 0.05$) when increasing the amount of Kaentawan. This may be due to the fact that dried Kaentawan pieces absorb water and swell during rehydraton.

Finally, the overall results indicated that Kaentawan enriched instant rice porridge was accepted by the panelists and the 20% added formula was selected for further study.

6.4 In-house consumer test

The 15% commercial inulin and 20% Kaentawan added formulas were selected to conduct an in-house consumer test. The test was performed to confirm the consumer acceptability of the products using more panelists. Only preference towards different sensory quality characteristics was evaluated using 9-point hedonic scales. For the color, taste, and texture score of formulated products, addition of commercial inulin was more preferred than Kaentawan. The reason may be because of certain properties of commercial inulin that is white powder and high soluble. The overall acceptability score of 15% commercial inulin enriched instant rice porridge was 7.36 which means like moderately. Besides, 20% Kaentawan enriched instant rice porridge was accepted with a score of 6.10 which means like slightly.

Inulin has been successfully applied in several food products due to its dietary fiber benefits as well as functional properties such as fat replacer, sweetener, and texture modifier without adversely affecting flavor. These products included yoghurt, cheese, cookies and ice cream (7, 48-50). The current study shows that inulin in both forms i.e. a natural plant source or a commercially produced food ingredient could be applied in instant rice porridge with satisfactory consumer acceptability.

6.5 Nutritional values of the inulin enriched instant rice porridge

The commercial inulin enriched instant rice porridge contained slightly higher energy and carbohydrate than the Kaentawan enriched instant rice porridge. This was caused by the lower amount of commercial inulin application in the product than Kaentawan. Moreover, both formulated instant rice porridge contained lower energy than the control formula because inulin provides a lower caloric value than starch. The protein and inulin content of Kaentawan enriched instant rice porridge were higher than commercial inulin enriched instant rice porridge. This could be explained by the fact that Kaentawan contains about 7.8% protein (70). Sodium content of the formulated products was lower than control formula when compared on a per serving basis since the present of inulin as an ingredient tended to dilute the

product. This could be considered an advantage to help consumer reducing sodium intake that is likely to be more beneficial for consumer health (71).

One serving (35 g) of commercial inulin and Kaentawan enriched instant rice porridge contained 5 and 7 g of dietary fiber. The dietary fiber content in the formulated products increased 5-7 times when compared with the control formula. Consumption 35 g of 15% commercial inulin and 20% Kaentawan enriched instant rice porridge would provide 21% and 27% of the Thai RDI value for dietary fiber. According to the Ministry of Public Health Notification No. 182, a product that could be labeled as an excellent source of dietary fiber must contain dietary fiber per one serving at equal or more than 20% of the RDI (66). As a result, the instant rice porridge formulated in this study could be claimed as an excellent source of dietary fiber.

6.6 Microbiological quality

The results of microbiological analysis of formulated instant rice porridge showed that the total plate count, MPN *Escherichia coli*, yeast and mold were within the criteria limit set in the Thai standard (11). Hence, the products could be considered safe for the consumers.

6.7 Storage test

The commercial inulin enriched instant rice porridge and Kaentawan enriched instant rice porridge packed in sealed aluminum foil laminated packages and stored at room temperature (27-30°C) for 2 months. During storage water activity gradually increased in both products. Water activity is generally used for evaluating the stability and biological of products during storage. Nonetheless, the water activity of formulated products ranged from 0.31 to 0.44 which was lower than the minimum level for microbial growth. Hence, the formulated products could be preserved for 2 months without microbial problems.

The viscosity of formulated products also significantly increased ($p \leq 0.05$) during storage time. Similar results were found in the work of Jang and Lee (2012)

(72), which demonstrated that the viscosity of porridge significantly increased during storage for 20 weeks.

CHAPTER VII

CONCLUSION

The study was successful in formulating instant rice porridge products enriched with commercial inulin and Kaentawan as a source of soluble dietary fiber. The target level of commercial inulin and Kaentawan addition was aimed at providing 10%, 15% and 20% of Thai RDI per serving. Firstly, the optimum condition for drying Kaentawan was determined by considering the moisture content, water activity, color, and texture of rehydrated pieces in the porridge. Then the inulin enriched instant rice porridge was developed. The sensory screening test (n=25) was performed in order to identify the optimum level of commercial inulin and Kaentawan which could be added to instant rice porridge. All formulas of instant rice porridge were also determined for water activity and viscosity. The formulated products with the best sensory screening score were selected to determine the nutrition value and microbiological quality, prepared for an in-house consumer test (n=50) to confirm the consumer acceptability, and used in the storage test.

Drying diced Kaentawan at 50°C for 10 h gave a moisture content that conformed to the Thai standard for instant rice porridge. However, the sensory panelists judged diced Kaentawan pieces in the prepared porridge as too hard. The preparation procedure was improved by chopping the fresh Kaentawan to a smaller size and drying at a higher temperature and shorter time condition. Subsequently, the optimum condition for drying Kaentawan was at 70°C for 4 h. The final moisture content was 4.1% and water activity was 0.41 with a light color appearance. Besides, the texture after rehydration was suitable for including in instant rice porridge.

The final formulas for inulin enriched instant rice porridge obtained were instant rice porridge with 15% addition of commercial inulin and 20% addition with dried Kaentawan. The sensory evaluation results demonstrated that both products were accepted by the consumers. All formulas of instant rice porridge were also evaluated for water activity and viscosity. Nutritionally, the formulated products

provided significantly more dietary fiber than the original instant rice porridge. One serving (35 g) of commercial inulin and Kaentawan enriched instant rice porridge contained 5 and 7 g of dietary fiber which provide 21% and 27% of the Thai RDI of dietary fiber, respectively. As a result, the instant rice porridge formulated in this study could be claimed as an excellent source of dietary fiber. The storage test showed that formulated products could be preserved at least for 2 months.

In conclusion, the commercial inulin and Kaentawan enriched instant rice porridge products could be introduced as an alternative food fiber source to increase the dietary fiber intake for the consumers, particularly soluble dietary fiber. Moreover, they would also provide the consumers with other benefits of inulin including prebiotic and calcium absorption enhancing properties.

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APPENDICES

APPENDIX A

Product Sheet **Fibruline® S20**

Fibruline®, chicory inulin, is a soluble dietary fibre extracted from chicory roots by a natural process. It's a naturally-sourced food ingredient. Fibruline® S20 is a fine granulated white powder, offering a high solubility with a neutral impact on the viscosity of most food applications. Belonging to the fructan group, inulin is non-digestible oligosaccharide built up of fructose units with 52-1 bonds, mostly ending by a glucose unit.

Specifications (Analytical methods available on request)

Dry matter (D.M.) 96 +/- 1%

Composition based on D.M

Ash max 0.3%
Total carbohydrates min 99.7%
Inulin min 90%
Free fructose, glucose & sucrose max 10%

Microbiology

Bacillus cereus max 100/g
Enterobacteriaceae absent/1g
E. Coli absent/1g
Moulds max 20/g
Salmonella absent/100g
S. Aureus absent/1g
Aerobic plate count max 1000/g
Aero thermo count max 2000/g
Yeasts max 20/g

Typical Data

General Characteristics

Average DP (degree of polymerisation)	<10	Heavy metals (Pb, Cd, Hg, As)	max 0.5 ppm
Colour	white	pH (30% in water)	~ 6.0
Density - Tapped	~ 0.6 kg/l	Solubility	≥ 200 g/l
Dispersibility	max 1% lumps	Stability	Heat stable, at pH<3.5, hydrolysis risk increases significantly
Granulometry	< 500 µm	Taste	neutral / slightly sweet

Labelling
(Chicory) inulin, Chicory (dietary) fibre, Chicory (Vegetable) fibre, (Chicory) Fructo-Oligosaccharide, (Chicory) Oligofructose.

Nutrition Labelling (values expressed per 100g commercial product)

Caloric Value (energy)	208 kcal (1), 840kJ	Fat	0 g (2)
Carbohydrates	8 g (96 g) (3)	of which saturated	0 g (2)
of which sugars	8 g	Protein	0 g (2)
Dietary Fibre	88 g	Sodium	0.1 g

(1) Based on a caloric value of 2kcal/g for pure inulin/oligofructose & subject to local regulations, (2) Non detectable, (3) Including dietary fibre

Method of analysis
Inulin and oligofructose (fructan) level in food products can be analysed by the following method: AOAC 997.08.

Certification
KOSHER & HALAL (on demand) certified ingredient.
Does not contain GMO's or GMO-derived components. Not produced using GMO-based technology (not concerned by EC 1829/2003 and EC 1830/2003).

Allergens
No labelling required according to EC legal requirements for Allergen Labelling 1169/2011/EC, repealing Directive 2000/13/EC.

SOLUTIONS

fibruline®

- Fibre enrichment
- Calorie reduction
- Gut health
- Calcium absorption

APPLICATIONS

- Dairy
- Bakery
- Confectionery
- Savoury
- Powder blends
- Beverages

PRODUCTS

- Fibruline® Instant, native inulin
- Fibruline® S20, soluble inulin
- Fibruline® DS2, desugared inulin
- Fibrulose® F97, oligofructose
- Fibruline® XL, long chain inulin

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R01 P.1/2

Cosucra Group Warranting. This information is believed to be true, accurate and reliable to the best of our knowledge. It is the user's responsibility to determine the conditions for his own and specific purpose or use, especially regarding the existing regulations and/or the practice of any industrial property rights.

ES20_01E7 10/2012
1

Safety

Food grade, suitable for human consumption. Free from any harmful or toxic substances. Food Safety System Certification 22000 : 2010 in compliance with ISO 22000: 2005 and PAS 220: 2008 certified by SGS Systems and Services Certification, (Certificate Reference No. : 000001 Food Safety Reference 02700)



Shelf-life

4 years in dry conditions (Max 30°C, Max 60% R.H.), in original sealed bag.

Packaging

Multi-layer paper bags (with blue PE liner inside) 20 kg net on pallet.
Industrial Pallet 960 kg net (120x120xmax180 cm)*, Export-pallet 960 kg net (115x115xmax185 cm)*,
Euro-pallet 720kg net (120x80xmax170 cm)*. On demand: Plastic pallet and Big Bag.
*(LengthxWidthxHeight cm)

Produced by

Cosucra Groupe Warcoing S.A., Belgium (Manufacturing site : Warcoing Industrie, Belgium).

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R-01 P. 2/2

APPENDIX B

The photograph of dried Kaentawan



Figure 8.1 No rinsing with water after size reduction in a food processor



Figure 8.2 Rinsing with water after size reduction in a food processor

APPENDIX C

Determination of moisture content **Hot-air oven method (AOAC 990.19, 2005)**

Principle

A homogeneous sample is dried in a hot air oven at $100\pm 5^{\circ}\text{C}$ until constant weight is obtained. The loss of weight is taken as a measure of the moisture content in sample. In liquid or wet sample, acid washed sand is used to mix with sample prior to drying for increase surface area in order to rapid and complete evaporation of water from the sample.

Procedure

1. Bring aluminum dish and cover cap into hot air oven at $100\pm 5^{\circ}\text{C}$ for 30 min.
2. Remove aluminum dish and cover cap and cool in desiccators.
3. Weigh aluminum dish with cover cap on electronic balance (=a g)
4. Add approximately 3 g of sample into the dish and then record weight (dish with cover cap and sample = b g).
5. Dry the sample dish to hot air oven at $100\pm 5^{\circ}\text{C}$ for 2 h.
7. Remove the sample dish and cool in desiccators (weight = c g).
8. Return the sample dish to the hot air oven for 30 min and reweigh the sample dish every 30 min until a constant weight is obtained.
9. The different weight between each interval time (30 min) should not be more than 0.005 g.

Calculation

$$\% \text{ Moisture} = \frac{(b-c) \times 100}{(b-a)}$$

Where

- a = weight of dish and cover cap
- b = weight of dish, cover cap and sample
- c = weight of dish, cover cap and sample after drying

APPENDIX D

Inulin enriched instant rice porridge formulas (One serving = 35g)

Table 8.1 Inulin enriched instant rice porridge formulas

Formula¹	Instant rice porridge (g)	Commercial inulin² (g)	Dried Kaentawan³ (g)
Control	35	-	-
10% Commercial inulin	32.22	2.78	-
15% Commercial inulin	30.83	4.17	-
20% Commercial inulin	29.44	5.56	-
10% Kaentawan	31.42	-	3.58
15% Kaentawan	29.63	-	5.37
20% Kaentawan	27.84	-	7.16

¹ Each formula showed percentage of inulin added to instant rice porridge based on Thai RDI for dietary fiber intake

² Calculated based on the 90g of inulin content in commercial inulin (Fibruline®S20)

³ Calculated based on the 69.8g of inulin in 100 g dried Kaentawan

APPENDIX E

แบบทดสอบทางประสาทสัมผัส

ผลิตภัณฑ์ โจ๊กกึ่งสำเร็จรูปเสริมผงอินนูลิน

คำอธิบาย กรุณาชิมตัวอย่าง แล้วเขียนเครื่องหมาย ✓ ตามความชอบของตัวอย่างที่ใกล้เคียงกับความรู้สึกของท่านมากที่สุด

เพศ ___ ชาย ___ หญิง ___ อายุ ___

รหัสตัวอย่าง _____

ก่อนชิม

ลักษณะปรากฏโดยรวม	กลิ่น	สี
___ ชอบมากที่สุด	___ ชอบมากที่สุด	___ สีเข้มมาก
___ ชอบมาก	___ ชอบมาก	___ สีเข้มเล็กน้อย
___ ชอบปานกลาง	___ ชอบปานกลาง	___ สีกำลังดี
___ ชอบเล็กน้อย	___ ชอบเล็กน้อย	___ สีอ่อนเล็กน้อย
___ เฉยๆ	___ เฉยๆ	___ สีอ่อนมาก
___ ไม่ชอบเล็กน้อย	___ ไม่ชอบเล็กน้อย	
___ ไม่ชอบปานกลาง	___ ไม่ชอบปานกลาง	
___ ไม่ชอบมาก	___ ไม่ชอบมาก	
___ ไม่ชอบมากที่สุด	___ ไม่ชอบมากที่สุด	

หลังชิม

ความชอบโดยรวม	รสชาติ	เนื้อสัมผัส	รสหวาน
___ ชอบมากที่สุด	___ ชอบมากที่สุด	___ หนืดมาก	___ หวานมาก
___ ชอบมาก	___ ชอบมาก	___ หนืดเล็กน้อย	___ หวานเล็กน้อย
___ ชอบปานกลาง	___ ชอบปานกลาง	___ กำลังดี	___ กำลังดี
___ ชอบเล็กน้อย	___ ชอบเล็กน้อย	___ เหลวเล็กน้อย	___ จืดเล็กน้อย
___ เฉยๆ	___ เฉยๆ	___ เหลวมาก	___ จืดมาก
___ ไม่ชอบเล็กน้อย	___ ไม่ชอบเล็กน้อย		
___ ไม่ชอบปานกลาง	___ ไม่ชอบปานกลาง		
___ ไม่ชอบมาก	___ ไม่ชอบมาก		
___ ไม่ชอบมากที่สุด	___ ไม่ชอบมากที่สุด		

ข้อเสนอแนะ _____

ขอบคุณที่ให้ความร่วมมือค่ะ

APPENDIX F

แบบทดสอบทางประสาทสัมผัส

ผลิตภัณฑ์ โจ๊กกึ่งสำเร็จรูปเสริมแก่นตะวัน

คำอธิบาย กรุณาชิมตัวอย่าง แล้วเขียนเครื่องหมาย ✓ ตามความชอบของตัวอย่างที่ใกล้เคียงกับความรู้สึกของท่านมากที่สุด

เพศ ___ ชาย ___ หญิง ___ อายุ _____

รหัสตัวอย่าง _____

ก่อนชิม

ลักษณะปรากฏโดยรวม	สีของแก่นตะวัน	ปริมาณแก่นตะวัน
___ ชอบมากที่สุด	___ เข้มมาก	___ เยอะมาก
___ ชอบมาก	___ เข้มเล็กน้อย	___ เยอะเล็กน้อย
___ ชอบปานกลาง	___ กำลังดี	___ กำลังดี
___ ชอบน้อยที่สุด	___ อ่อนเล็กน้อย	___ น้อยเล็กน้อย
___ เฉยๆ	___ อ่อนมาก	___ น้อยมาก
___ ไม่ชอบเล็กน้อย		
___ ไม่ชอบปานกลาง		
___ ไม่ชอบมาก		
___ ไม่ชอบมากที่สุด		

หลังชิม

ความชอบโดยรวม	รสชาติ	กลิ่น	เนื้อสัมผัสของแก่นตะวัน
___ ชอบมากที่สุด	___ ชอบมากที่สุด	___ ชอบมากที่สุด	___ แข็งมาก
___ ชอบมาก	___ ชอบมาก	___ ชอบมาก	___ แข็งเล็กน้อย
___ ชอบปานกลาง	___ ชอบปานกลาง	___ ชอบปานกลาง	___ กำลังดี
___ ชอบน้อยที่สุด	___ ชอบน้อยที่สุด	___ ชอบน้อยที่สุด	___ นิ่มเล็กน้อย
___ เฉยๆ	___ เฉยๆ	___ เฉยๆ	___ นิ่มมาก
___ ไม่ชอบเล็กน้อย	___ ไม่ชอบเล็กน้อย	___ ไม่ชอบเล็กน้อย	
___ ไม่ชอบปานกลาง	___ ไม่ชอบปานกลาง	___ ไม่ชอบปานกลาง	
___ ไม่ชอบมาก	___ ไม่ชอบมาก	___ ไม่ชอบมาก	
___ ไม่ชอบมากที่สุด	___ ไม่ชอบมากที่สุด	___ ไม่ชอบมากที่สุด	

ข้อเสนอแนะ _____

ขอบคุณที่ให้ความร่วมมือค่ะ

APPENDIX G

แบบทดสอบทางประสาทสัมผัส

ผลิตภัณฑ์ โจ๊กกึ่งสำเร็จรูปเสริมอินนูลิน

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เพศ ___ ชาย ___ หญิง ___ อายุ ___

รหัสตัวอย่าง _____

ก่อนชิม

ลักษณะปรากฏโดยรวม	สีของ โจ๊ก
___ ชอบมากที่สุด	___ ชอบมากที่สุด
___ ชอบมาก	___ ชอบมาก
___ ชอบปานกลาง	___ ชอบปานกลาง
___ ชอบเล็กน้อย	___ ชอบเล็กน้อย
___ เฉยๆ	___ เฉยๆ
___ ไม่ชอบเล็กน้อย	___ ไม่ชอบเล็กน้อย
___ ไม่ชอบปานกลาง	___ ไม่ชอบปานกลาง
___ ไม่ชอบมาก	___ ไม่ชอบมาก
___ ไม่ชอบมากที่สุด	___ ไม่ชอบมากที่สุด

หลังชิม

ความชอบโดยรวม	รสชาติ	เนื้อสัมผัสของ โจ๊ก
___ ชอบมากที่สุด	___ ชอบมากที่สุด	___ ชอบมากที่สุด
___ ชอบมาก	___ ชอบมาก	___ ชอบมาก
___ ชอบปานกลาง	___ ชอบปานกลาง	___ ชอบปานกลาง
___ ชอบเล็กน้อย	___ ชอบเล็กน้อย	___ ชอบเล็กน้อย
___ เฉยๆ	___ เฉยๆ	___ เฉยๆ
___ ไม่ชอบเล็กน้อย	___ ไม่ชอบเล็กน้อย	___ ไม่ชอบเล็กน้อย
___ ไม่ชอบปานกลาง	___ ไม่ชอบปานกลาง	___ ไม่ชอบปานกลาง
___ ไม่ชอบมาก	___ ไม่ชอบมาก	___ ไม่ชอบมาก
___ ไม่ชอบมากที่สุด	___ ไม่ชอบมากที่สุด	___ ไม่ชอบมากที่สุด

ข้อเสนอแนะ _____

ขอบคุณที่ให้ความร่วมมือค่ะ

APPENDIX H

Texture profile analysis of fresh Kaentawan

Table 8.2 Hardness of fresh Kaentawan

Replicates	Force (g)
1	35400.290
2	35146.388
3	38801.339
4	39105.454
5	35113.749
6	28750.578
7	25552.564
8	33911.915
9	27937.457
10	28858.427
Average	32857.816

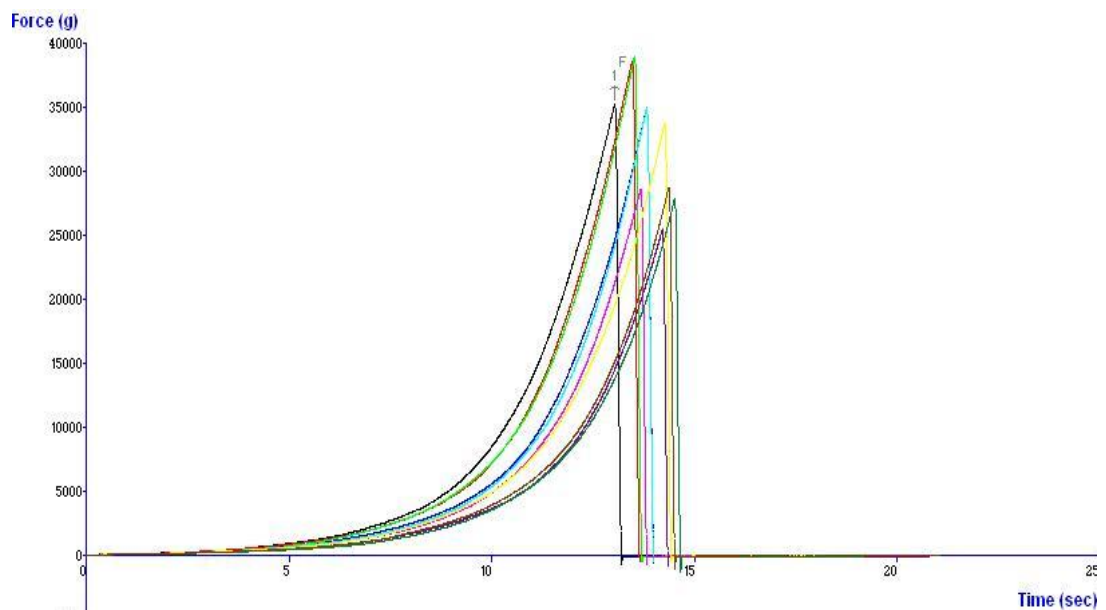


Figure 8.3 Texture profile analysis graph of fresh Kaentawan

APPENDIX I

Texture profile analysis of dried Kaentawan (at 70°C, 3 h)

Table 8.3 Hardness of dried Kaentawan

Replicates	Force (g)
1	9990.068
2	10417.533
3	11209.586
4	7924.027
5	10519.377
6	8863.554
7	10680.495
8	12715.972
9	9227.706
10	8827.750
Average	10037.607

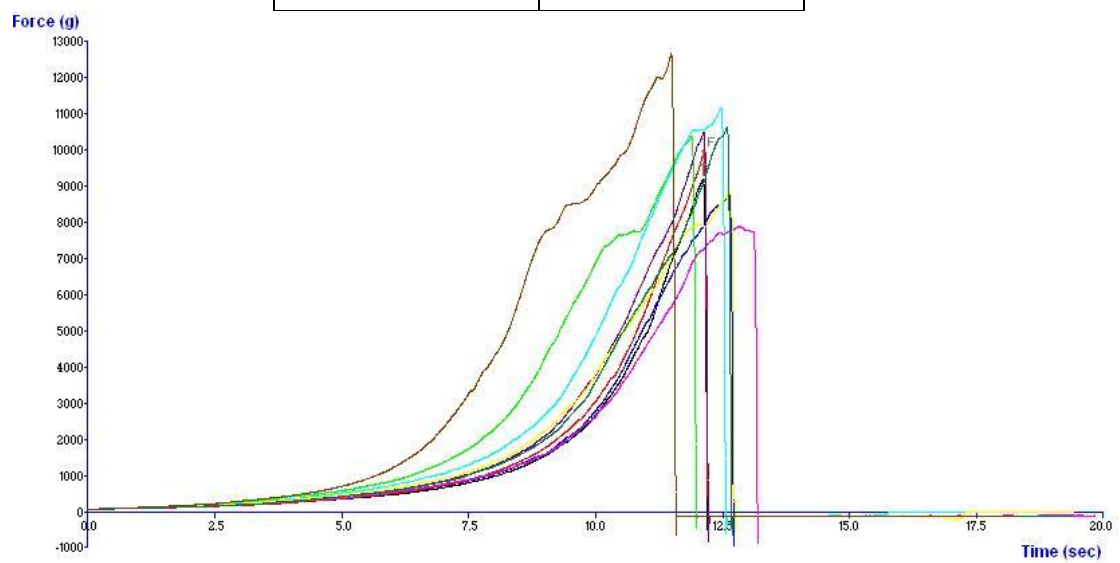


Figure 8.4 Texture profile analysis graph of dried Kaentawan

APPENDIX J

Texture profile analysis of dried Kaentawan (at 70°C, 4 h)

Table 8.4 Hardness of dried Kaentawan

Replicates	Force (g)
1	9489.795
2	9811.158
3	8777.537
4	9276.827
5	10299.314
6	11906.344
7	9469.601
8	9844.560
9	12111.780
10	11460.978
Average	10244.789

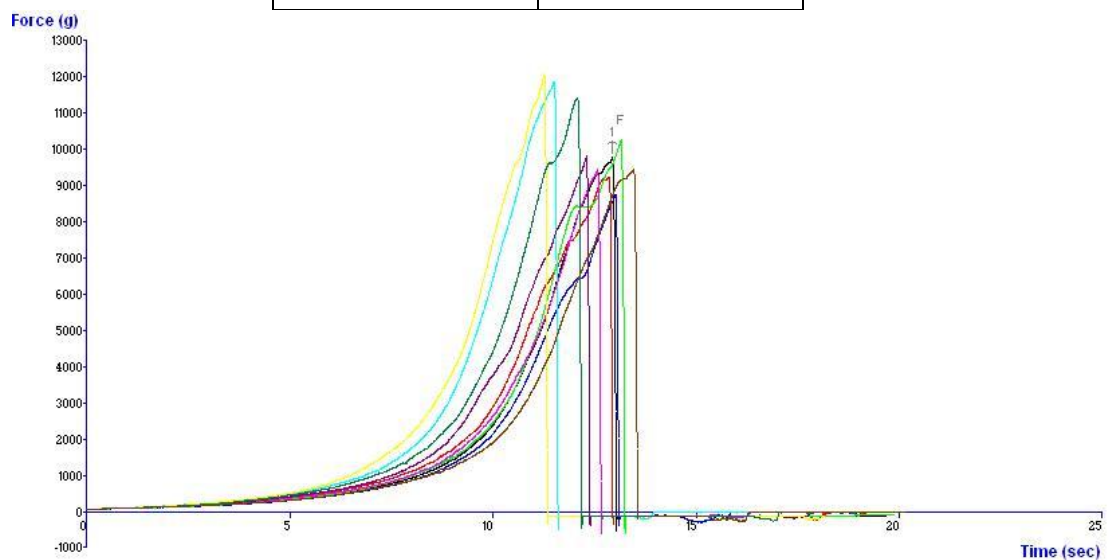


Figure 8.5 Texture profile analysis graph of dried Kaentawan

APPENDIX K

Texture profile analysis of dried Kaentawan (at 70°C, 5 h)

Table 8.5 Hardness of dried Kaentawan

Replicates	Force (g)
1	7470.911
2	7620.894
3	7407.053
4	8754.177
5	8904.488
6	8106.649
7	9812.031
8	9059.602
9	10362.626
10	9281.303
Average	8677.973

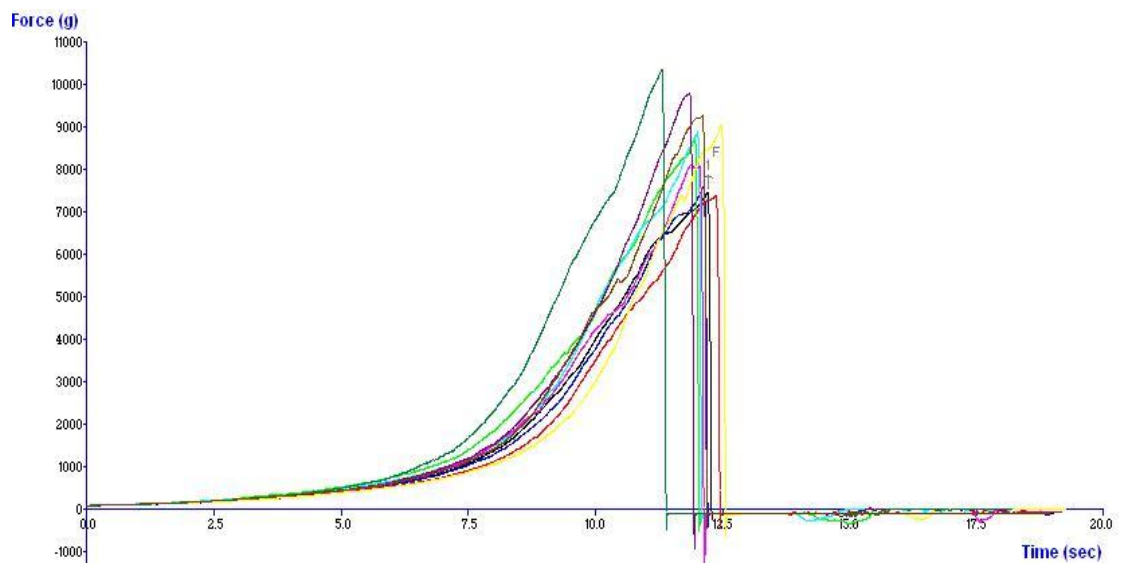


Figure 8.6 Texture profile analysis graph of dried Kaentawan

BIOGRAPHY

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PUBLICATION / PRESENTATION	Poster presentation at the 13 th ASEAN Food Conference 2013 September 9-11, 2013. Singapore Expo, Singapore