Study on the Use of Sweet Potato Flour in Cake

By
Ms. Somrudee Sripanomtaporn

A special project submitted to the Faculty of Biotechnology,
Assumption University in part fulfillment of the requirements
for the degree of Master of Science in Biotechnology

Special Project

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Title	: Study on the Use of Sweet Potato Flour in Cake
By	: Ms. Somrudee Sripanomtanakorn
Advisor	: A. Nootrudee Siriboon
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Advisory Committee :

Nootrudee Siri Advisor

(A. Nootrudee Siriboon)

Abstract

Three varieties of local sweet potato; Mun Kra Tay, Mun Kai, and Mun Tor Phuek are selected for production of sweet potato flour. Proximate chemical analysis of the three sweet potato flour show that there are 6.72, 6.93, 8.32 % of moisture content; 2.61, 4.07, 2.80% of protein content; 1.74, 1.41, 1.25 of fat content; 3.20, 3.00, 2.97% of fiber content; 1.78, 2.43, 2.74% of ash content; and 83.95, 82.16, 81.92% of carbohydrate content, respectively. From RVU analyzer, show that Mun Kra Tay, Mun Kai, and Mun Tor Phuek have pasting temp. at 83.20, 83.95, 83.25 °C; peak of 217.67, 220.67, 210.00 RVU; break down of 19.33, 72.53, 52.42 RVU ; and set back of 38.50, 56.08, 68.08 RVU, respectively.

The substitution of sweet potato flour with wheat flour at 25% is found to be the optimum ratio to give the best quality of cake in all of the three varieties of sweet potato cake determined by using a method of scoring of cakes. At 25% of Mun Kai and Mun Kra Tay flour can be used in substituted the wheat flour cake with acceptable result by 16 taste panelists.

Acknowledgment

I would like to express my profound gratitude to my advisor, A. Nootrudee Siriboon, for her kind encouragement, suggestion, motivation, invaluable guidance and time that makes this project possible.

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I would like to thank Charpa Tech Center Co., Ltd. For the use of RVU analyzer

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Introduction

Sweet potato (Ipomoea batatas , Convolvulaceae) this large edible root is native to tropical areas of America. Nowadays sweet potato is also a major agricultural produce and commodity in many countries of the world, particularly in Asian. Statistics from the Food and Agricultural Organization indicate an average production of 128.4 millions metric tons from 1986 to 1988, ranking sixth among food crops. (FAO, 1989).

In Thailand many varieties of sweet potato are grown. Presently, sweet potato products are being widely consumed from the home processing level and commonly available in market place, the industrial processing seems to grow quite slowly. However, due to its high yielding potential, wide adaptability because of its inherent drought resistance characteristics and multifunctional usage sweet potato is considered as an economic crop in the tropics. The perspective for its increased and better usage will depend on how people will accept in the present day economic systems. As and excellent caloric and nutrient source, sweet potato is utilized as a staple food in a variety of ways all over the world. It has been reported that the major constraints for the increased usage of sweet potato is in part due to its high sugar, starch content which may not be totally digested and lead to flatulence, fat and cholesterol free, very low in sodium, good source of fiber, and high in vitamins A and C. However, sweet potato have a short storage life, generally less than four weeks in the tropics. The thin skin of the sweet potato is easily damaged during harvest and post harvest handling leaves the crop highly perishable. It is therefore usually consumed soon after harvesting.

Objectives

1. Study a method in producing sweet potato flour from three local varieties.

2. Study physical and chemical properties of the obtained sweet potato flour.

3. Study the application of sweet potato flour in cake.

4. Study the quality of sweet potato cake in comparison with the control cake.

5. Study the organoleptic properties of the sweet potato cake.

Literature review

SWEET POTATO

Family: Convolvulaceae
Genus: Ipomoea
Species: batatas

There are mumerous varieties of sweet potato in Thailand. In this study we selected three varieties that are normally presented at the local market. There are

- Mun Kra Tay
- Mun Kai
- Mun Tor Phuek

1.1 The pattern of production and utilization of Sweet potato

It is reported that although sweet potato is grown in many countries, its production is concentrated relatively few locations. 15 countries with the largest sweet potato production account for nearly 97% of this total. (Scott, 1991)

In Asia and pacific, except for Japan, Korea, and Taiwan, 70 to 100% of the sweet potato roots and greens are reported to be used mainly for human consumption in many producing countries. A small portion of sweet potatoes are used for animal feed and a negligible amount is used for industrial purposed. Dried sweet potato chips are used as hog feed, which are of importance in Taiwan. In Japan and Korea, about 35 to 36 % of all sweet potatoes produced are used for industrial purposed, mainly for starch extraction and fermentation. Sweet potato is used mainly as a staple food in Ocean where about 9 to 10 % are used for feed, mainly for hogs. (Bouwhamp, 1985)

Sweet potato was introduced in China about 400 years ago. Recently China has the largest production of sweet potato in the world. It is estimated that 15% of total sweet potato production is used as fresh roots for human consumption, 15% as raw material for processing of food products, 28% as animal feed and 12% as planting material. Processing of sweet potato into starch and noodle is important at village and household level. Sweet potato can be processed into product such as acid, calcium citrate, monosodium glutamate, organic solvents, and glucose syrup.

Sweet potato production and utilization in Thailand, the total production of sweet potato is 49,125 tons and the yield is 6.23 ton/ha (1990). Commercial plantation are very few in the previous time, but since 1987 the government of Thailand has a national policy to promote commercial production scale with the Department of agriculture and the Department of Agricultural extension. (Maneepun and Soontornnarunrungsi, 1991)

Table 1 Production of major world food crops and root crops

Crop	Global production (ton)	United States production (ton)
Wheat	538056	55407
Rice	506291	7007
Maize	470318	191197
Barley	168964	8784
Potato	276740	16659
Sweet potato	133234	542
Cassava	147500	-
Yam	23459	-
Aroids	5814	3
Root crops total	590176	17204

Source: FAO 1989 Production Year Book (FAO 1990)

Table 2 Area harvested, average yield, and production of sweet potato in Asia and Pacific

Country / territory kg/ person/ year	Area harvest 1000ha	Yield kg/ha	Production kg/ha	Consumption
Japan	63	22222	1400	11.4
Korea	29	25655	, 744	17.5
Bangladesh	51	10924	558	5.2
India	176	8241	1453	1.8
Indonesia	226	9062	2048	11.8
Malaysia	3	11935	37	2.2
Philippines	162	4802	778	13.2
Srilanka	12	6250	75	4.6
Thailand	41	8901	368	6.7
Vietnam	400	5250	2100	32.6
Papua new guinea	105	4526	473	132.9
World total	9258	14081	130335	-
Asia total	7593	15927	120927	-
china	6371	17369	110660	-

Source: FAO Production Year Book, 1998
Statistic Indicator For Asia and Pacific, 1989.

1.2 Breakfast cereal

A breakfast food similar to "cereal" can be made from any sweet potato. The sweet potato is grated (not as finely ground as for starch), suspended in water, and filtered through a cloth. The liquid is saved for starch, the residue is suspended 1-3 times more in water, and filtering is repeated. The portion of the sweet potato that does not pass through the filter is then dried and lightly toasted on a hot plate (over the fire). The toasting is very delicate. The product must be stirred and turned almost continuously, and should not become sticky and jellified. The toasted product can be stored in sealed containers and eaten with milk without further cooking, or can be used much like starch or flour, imparting its characteristic flavor (Frank , 1997).

1.3 Sweet potato chips

Wiersema (1991) The roots are sliced by hand after harvesting and left to dry in the field for periods up to 10 days. The dried chips have a moisture content of 12%-14% and can be stored at ambient temperature for long period with little losses. The ratio of fresh roots to dried chips is about 2.5:1. The dried chips are usually stored in bags in open air.

In East Africa and India, traditional process of chips are slicing and drying. Tubers are peeled and sliced. The pieces are placed into the sun to dry and can then be stored. When the product is needed for consumption the dried slices are washed and boiled or ground into flour for making local dishes. In Philippines. Flakes are processed by drying and pounding. The tubers are peeled and flaked, placed in the sun to dry and then stored. When needed for consumption the dried flakes are pounded into a flour either made into gruel by mixing with water and water and sugar, or form into small balls of a dough consistency which are wrapped in sugarcane leaves and boiled (Unifem, 1989).

The chips are used for pig, poultry feed and also for human consumption. A newly developed method for making sweet potato chips is described as follow: wash and peel sweet potato tubers; soak in 2% common salt for 0.5 to 11 hours; slice 0.5 to 1 mm thick; drain and fry in cooking oil at 138 to148 $^{\circ}$ C until brown and crisp: drain and pack in moisture proof (Siki, 1979).

1.4 Sweet potato flour.

The flour of sweet potato is much more difficult to make than that of potato because the reducing sugars readily released from the starch combine with free amino acids to produce disagreeable colors, odor, and flavors. To avoid this the peeled sweet potato can be shredded, and the shreds immersed in water 2 hours. This process works better if the water is changed 2-3 times. The shreds are drained and then dried, first in the shade (with air movement or wind) and later in the sun (in some cased, drying oven will be necessary)/ the brittle shreds are easily crushed to flour, or this can be done rapidly in a household blender. The flour can store for 6 months or more in sealed container. It can be used as a substitute for wheat flour in the following amounts: 100% in white sauces, 25-50%in cookies, cakes and flat breads, and 15-20%in breads. From the water, starch can be recover (Frank , 1997).

1.5 Starch production

The peeled sweet potato is ground in a mill or blender as finely as possible, and mixed with 5-10 times its weight in water. The starch settles out, and the water is carefully poured away (can be used as pig feed). The starch is then mixed with water 1-3 times more and the process is repeated. After the last settling the water is carefully drained and the starch is dried on a metal surface in the sun. It can be used as is any starch, such as corn or potato starch, and can be stored (Frank, 1997).

1.6 Making of Noodles

Timmins (1991) reported that sweet potato can be produced into transparent noodle for human consumption. Although it is reported on year. There are three fundamental stages of starch preparation: extraction, purification and final preparation.

The method of transparent noodle preparation is following: preparation of starch dough, formation, gelatinization and retrogradation of moist noodles and drying of the noodles. The first step is mixing of gelatinized starch. The dough is extruded into boiling water through saucepan-type "former" and becomes wet noodle. Wet noodles are cut and hung on bamboo cross pieces to dry (sun drying). Aluminum potassium Sulphate, KAI $(SO_4)_2$: H_2O_{at} levels up to 0.8% (w/w) in the starch dough is used to increase the strength of noodle (Nghe, 1989).

1.7 Fermentation of Sweet potato for feed

Dawson et al. (1951) found that wastewater from starch milling was a good medium for the production of yeast, Torulposis utilis. With addition of a nitrogen source, sugar content of the medium was reduced from 0.75 to 1.0% to about 0.05% after 8 hr. They estimated that approximately one ton of dried yeast containing 50% protein could be produced per 100 tons of fresh sweet potatoes processed for starch.

Gray (1996) reported that sweet potato could serve as a suitable substrate for a range of fungi imperfecti species. Under optimum experimental conditions 100 kg of dried mycelium and unutilized sweet potato tissue containing 31.6 kg of protein. Thus protein concentration can be increased to over four times that of original concentrations.

Culture, harvesting, and storage

Sweet potato is a hot weather crop. It is difficult to imagine an earthly environment that is too hot for sweet potato. In general, hot temperatures only speed up the activity and growth of sweet potato. On the other hand sweet potatoes will survive at any temperature above freezing, and are very productive at temperatures that are comfortable for humans as well. Sweet potato is often said to be a tropical vegetable. However, 1 or 2 crops per year are grown in the Temperate Zone during the summer where special provisions are made for conserving the storage roots during the winter. Sweet potatoes require a moist but well drained soil for best growth. Temperate Zone sweet potatoes are especially sensitive to flooding but many tropical varieties can tolerate short periods (a few days) of flooding. Sweet potatoes need adequate water at the time of planting and for several weeks thereafter. They can tolerate light drought in the second and third month of growth, and often fairly severe drought in the fourth or fifth month. Depending upon variety, sweet potatoes may be ready for harvest after 10 weeks or may require up to 9 months in the field. The majority of the varieties can be harvested after 4-5 months in the field. Cool conditions such as found in tropical highlands can extend the needed growth period of normal varieties to 8-9 months. Sweet potatoes from an individual planting may be harvested as needed over a three to four month harvest season (Frank, 1997)

The storage roots can be dug by hand with spades or forks, or by plow especially a "middlebuster". As soon as possible after digging, remove the sweet potatoes from the sun, in boxes, or baskets. Sweet potatoes may have to be cleaned, depending on the soil where produced. After washing the roots should be drained and dried, but not in the sun. Sound roots can be stored at cool temperatures (minimum 55°F or 13°C) for 2-8 weeks. Rot of roots in storage is reduced by curing at high (80-90%) humidity at high (90-95°F) temperature for 4-5 days. Cured roots can be stored at the recommended temperature for up to 1 year.

Table 3 Tablet Sweet potato

Characteristics	Phases	Sub-characteristic
Internal color	White	No vitamin A activity
	yellow	Little vitamin A activity
	Orange	High vitamin A activity
Sweetness	High	Common
	Intermediate	Common
	Low or none	Rare
Texture	Very dry	Least preferred
	Intermediate	Often preferred
	Moist	Common in orange root
Plant habit	Running	Normal
	Bunch	Uncommon

Nutritional of sweet potato

It is reported that the chemical composition of the different sweet potato varieties were not significantly different. The protein content was low from 3.2 to 4.75%. The fat content was low for all sweet potato varieties and was less than 1%. All sweet potato varieties had a high carbohydrate content ranging from 85.61% to 89.15 %. (Maneepun et al., 1991)

Sweet potato contains approximately 20% starch and 5% simple sugar, and is generally considered as a high-energy food. It also provides a considerable amount of vitamin C (20-30 mg/100g), and deep yellow varieties of sweet potato can provide sufficient provitamin A carotenoids for health, if eaten in large quantity. However, overall the variation in carotene content is great (0-800 IU/100g). Vitamin B1 (thiamin) is also present in

adequate amount is terms of calories, 0.8-1.0-mg/1000 cal, about twice the level required by humans. Potassium (200-300 mg/100g) is known to be the predominant mineral present, and iron content (0.8 mg/100g) is sufficient for sweet potato eaters who consume 2 kg or more per day. However, sweet potato is a starch root and contains very little fat (0.1-0.2%). The content of protein (mainly in the form of a kind of globulin) is generally low, providing about 4-6% of the total calories (1-2% on a wet basis), although sweet potato's essential amino acid pattern is reasonable (chemical score: 80) and the limiting amino acid is leucine. According to some food analysis tables, sweet potato is giving a chemical score of 65, with sulfur-containing amino acids listed as the limiting ones if compared with the FAO/WHO reference pattern (1973). It is reasonable to assume therefore, if sweet potato contributes more than 90% of the total calorie intake in any diet, protein deficiency is likely to occur. Therefore, sweet potato eaters have to supplement their diets with some protein-rich food (Huang, 1982).

The sweet potato provides more calories than the potato (113vs 75/100g). It is also and exceptionally rich source of vitamin A (100g provide 7,100 IU, about two and a half times the daily minimum requirement for adults) and with its appreciable quantities of ascorbic acid, thiamin, riboflavin, niacin, phosphorus, iron and calcium (Winarno, 1982).

Table 4 Composition of sweet potato and some foods per 100g

	Rice	Soybean	Mungbean	Sweet potato	Potato
Moisture(g)	13	8	11	70	67
Fiber (g)	0.5	18	1.1	0.3	0.1
Cal	354	325	320	113	75
Protein (g)	6.5	36.8	22.9	2.3	2.3
Fe (mg)	0.6	7.4	4.9	1.0	0.7
Ca (mg)	15	216	86	46	7
Vitamin A (IU)	0	20	70	7.10	0
Vitamin B1 (mg)	0.11	0.44	0.52	0.08	0.07
Vitamin B2 (mg)	0.04	0.31	0.29	0.05	0.04
Niacin (mg)	1.4	3.2	3.1	0.9	1.0
Vitamin C (mg)	0	0	-	20	7

Source: AVRDC (1976)

Major nutritional components of the sweet potato

Carbohydrate and energy

The major energy supply to the human body is carbohydrates. Most of the current sweet potato varieties grown in the United Stated contain 25-30% carbohydrate in the roots and approximately 98% of those carbohydrate are easily digestible. Vines are much lower in carbohydrate content. A 113 g serving of sweet potatoes per day can supply 5% of the energy requirements for a 23-50 year old male.

Vitamin

Vitamin A: sweet potatoes are an excellent source of provitamin A (carotene) which is converted into vitamin A (retinol) by the body. Many factors affect the level of carotene in sweet potatoes.

Vitamin B complex: a 113 g serving of sweet potatoes can supply 2-6% of the recommended dietary allowance (RDA) of niacin, 3-5% of the riboflavin requirement and 1-7% of the thiamine requirement. The main source of these vitamins is usually meat or meat products. There seems to be little variation in concentrations of vitamins from the B complex in sweet potatoes; the range of those tested is extremely narrow.

Vitamin C (ascorbic acid): sweet potatoes currently being grown differ in ascorbic content with cooking method. They can supply between 25% and 50% of the RDA allowance of vitamin C depending on whether the roots or canned or baked.

Minerals

The major inorganic elements necessary for body process are sodium potassium, calcium and iron. The RDA for calcium, iron, sodium, and potassium are 800, 10, 1000, and 200 mg/day respectively.

A 113 g serving of sweet potato will supply 1.6% of the calcium RDA and 10.2% of the iron RDA. It will also supply 2.3% of the sodium and 10.8% of the potassium RDA (Lopez et al, 1980).

Protein

The RDA for protein is 56g for a 23-50 year old male. A 113 g serving of sweet potato roots can provide 3-4% of the RDA (Collins &Walter, 1982).

Since there are numerous varieties of sweet potato, especially in Thailand. Each variety is not significantly different. Maneepun et al. (1991)

reported their result on sweet potato starch and flour in Thailand: Selected thirty-four sweet potato varieties were grown in 1990 to study their chemical composition. The result were in the range of 57-71% moisture content, 3.19-12.06 dry weight, 4.96-12.93% fiber, 1.37-4.15% ash and 28.6-43.1% dry matter.

CAKE

Cake is defined as bakery product that is characterized by soft, tender leavened sweet baked product, produced from soft wheat flour, sugar, egg, milk, fat, baking power, salt and flavor.

Types of cakes

There are three types of cake, according to ingredients and mixing steps.

1. Batter type. The batter is viscous, little leavened by creaming butter first so that air is incorporated in the cream before other ingredients are added.

2. Foam type. Egg is the main leavening agent in this type of cake, such as in sponge cake with whole egg and only white egg in angle cake or meringue cake.

3. Mixed between batter type and foam type. Chiffon cake is an example for this type of cake. Where one part is leavened by white egg, and another portion is creaming butter.

Production of Cake

The usual steps in cake making include mixing, pouring into a pan, and baking. Mixing is aiming to create a homogenous mixture that entraps air as much as possible with less gluten is formed. Because gluten will cause the batter to become too viscous during mixing and subsequently too dense texture. Thus mixing is important in cake making that each ingredient, time; mixing speed, temperature during mixing should be controlled.

There are 3 commercial methods for butter cake as

1. Creaming method, butter and sugar are beaten together to cream with medium speed propeller. Egg is added before milk and flour are alternately added. Time of mixing should complete in 15-20 minutes.

2. Blending method. Shortening and flour are mixed until creaming. Another portion is prepared by beating egg and sugar to gain semi-solid

foam. Each mixing should finish within 10 minutes. Mix these two parts and slowly milk is added. The cake has fine structure.

3. Single -stage method. Mix all ingredients together at low speed for 1-2 minutes. Then, mixing speed is increased to medium for 3-5 minutes and finally decreased to slow speed for at least 2 minutes. Mixing time is 8-10 minutes.

Baking

The crucial step in baking is temperature. And time in baking step must be suitable for each cake. It is suggested that after mixing, mixture is quickly poured into the pan and transferred to an oven immediately.

Time in baking depends on size of the cake and size of the oven as well as the amount of cake being baked. Normally, 16 oz, cake will be bakes in 15-20 minutes, pound cake is 50-65 minutes, and sponge cake in 40-50 minutes.

Cake ingredients

The main ingredients for cake can be separated into two types, ingredients that create structure of cake: flour, egg, milk; and ingredients that contribute to leavening action of a product: fat, leavening agents and sugar. Other ingredients help in providing color and flavor of the products.

1. Flour

Soft wheat flour is used in cake. The flour is coming from 45-65% extraction with low protein and ash contents, depending on type of cake. Flour with low protein and low ash contents is used in angle cake or chiffon cake that have soft and light texture. Flour that has protein 8% and ash 0.32 % is preferred to use in sponge cake. Butter cake is prepared from flour that has high protein (9.1%) and high ash (0.42%). This cake has heavy and sticky texture

Therefore cake flour should have low protein or should provide soft gluten. For during mixing, it will not become too sticky and give tough texture. But, it should provide stable and porous structure and soft body.

Table 5 characteristics of cake flour

Flour	Moisture content 14%		Types of cake
	Protein %	Ash %	
1	4.70	0.23	Angle cake
2	7.35	0.29	Chiffon, some angle cake
3	8.30	0.32	Sponge, chocolate, pound
4	9.10	0.42	Pound, 7chocolate, and some low quality cake

2. Egg

Egg provides structure, color, flavor, and nutritional value to the cake. Especially sponge and chiffon cake that require leavening action of egg to entrap and create porous light structure of the product. Egg composes of 11% shell, 58% egg white, 31% egg yolk.

The readily coagulable proteins of egg contributes to structure of the baked cake, though the rather high lipid concentration in egg yolk must be considered a tenderizing factor. Egg also emulsifies added fat. The role of egg in emulsification of shortening is attributable to the lipoproteins of the yolk; both high density and low-density lipoproteins have been implicated as emulsifiers. The effects of egg on color, flavor, and nutritive value are obvious (shortened cake).

3. Milk

Milk contributes to structure of cake due to its protein content. Milk also provides nutrition as well as flavor to cake. Now there are many type of milk products available. In sweeten condensed milk, moisture is removed about 2/3and sucrose is added about 40%. For evaporated milk, moisture is removed 2/3, sugar may be added or not. Dried milk powder may be full fat or non-fat milk, each milk based-product is chosen to balance the product formulas.

4. Shortening

Shortening provides benefits to cake including leavening action, moisturizing without wetness, lengthen shelf, and value.

In cake, shortening inserts itself between protein and starch creating a smooth-flowing texture and subsequently producing a soft textured product. Emulsified shortening also helps emulsify liquid portion with other

ingredients and produces a moisten and soften texture of a cake due to uniform distribution of small air cell in the cake.

Air cell character and leavening of the mixture affect specific gravity of the product. If liquid shortening is used, the product will have specific gravity around 0.75-0.755. In case of solid shortening, the specific gravity is between 0.8-0.85. Specific gravity is related to volume of the product and subsequently texture of such product. We can determine specific gravity and texture characteristics of the cake, low specific gravity cake refers to the cake that is light and soft, high volume and easy to collapse

Butter is preferred to use in cake because it provides high flavor to the product. While shortening and margarine with emulsifier help entrapping air and create a soft-textured products with high volume. Now many cake formulas employ both butter and shortening or margarine to gain better structure with butter flavor.

5. Leavening agent

There are three kind of leavening agents involving in cake leavening. First, air that incorporated during mixing, secondly carbon dioxide created from chemical reaction of baking powder, and lastly expansion of vapor during baking.

The important chemical containing in the leavening agents are sodium bicarbonate, 30%, and various acidic salts. Action of baking powder, because sodium bicarbonate is salt from strong alkaline (NaOH) that reacts with weak acid (H_2CO_3), the salt is alkaline. Sodium bicarbonate reacts with acidic salt and produces gas carbon dioxide when they are wet. The reaction is fast or slow depending on type of salt in the baking powder.

There are two types of baking powder action.

5.1 Quick or single action baking powder. Acid in the baking powder is dissolved in water and produces gas carbon dioxide when the batter is still cold. They are including cream of tartar or potassium acid tartrate.

5.2 Slow or double action baking powder. In this group, there are two acid in the formula. The first acid, monocalcium phophate acts fast during mixing the batter. Then, the second acid reacts during baking. Heat accelerates degradation of sodium aluminum sulfate to sulfuric acid, which will react with sodium bicarbonate to create carbonic acid. Carbonic acid degrades to carbon dioxide and water.

Single action baking powder is not popular now because the reaction occurs too soon during mixing the batter. Thus, prolong mixing will result in low volume cake. Therefore double action baking powder is more preferred. The single action is used in cake that does not want too high volume.

6. Sugar

Sugar provides softness, freshness, and sweetness to the cake. There are three types of sugar used in cake-granulated sugar, syrup, and icing sugar.

Sugar obviously affects flavor. It also contributes to moisture retention of the baked cake because of its hygroscopicity. In addition, sugar has a tenderizing effect through its dilution of flour proteins and delaying of starch gelatinization. The sugar that ordinarily is used in cakes is sucrose, which is non-reducing; therefore, the contribution to browning is minimal (Shortened cake).

7. Flavorings

Flavorants that added in cake, cookie, and etc. include salt and spices. There are two kinds of flavorants adding in cake; extract essential oil, and fruit aroma. Vanilla is the most preferred. Due to its expensive, difficult to produce, and concentrated. Flavorants is added only when necessary and usually in small amount.

8. Colorants

There are 2 kinds of food colorant adding in cake; natural colorants and synthetic colorants. They are added to provide color to the product.

9. Fruits and nuts

Many kinds of cake are added with fruits and nuts, especially fruit cake. When fruits or nuts are added in the cake, other ingredients must be balances. Because fruits that usually added is sweetened, sugar should be reduced in the formula. If dried fruits are used, they must be soaked in water so they will float in the cake, not sinking down to the bottom of a pan.

Cake qualities

Cake quality is assessed by measurement of volume (or determination of a volume index), compressibility, and breaking strength and by sensory evaluation. In addition to having a high specific volume, a high-quality cake is symmetrical. A loaf cake has a rounded top, but a layer cake needs to be

flat for stacking. The crumb of a high-quality cake has a fine grain, with small cells and thin cell walls. It is moist but not soggy and tender but not crumbly. It has a velvety mouth feel many variations in ingredients and in baking conditions have been found to affect cake quality (Marjorie & Campbell, 1990).

Effects of ingredients

1. Flour

Many nonwheat flours have been studied in relation to their effects on cake quality. Some studies have involved partial replacement of wheat flour for improvement of nutritive value or increased utilization of a particular source of the development of hypoallergenic cakes.

Glover et al. (1986) replaced up to 50% of the wheat flour in high-ratio cakes with sorghum flour. Volume and texture were affected responsible. At 5, 10, and 15% replacement levels the cakes were acceptable, though different from the control.

Although flour is an important structural ingredient of cakes, the flour proteins are dispersed as discrete particles in cake batter, rather than forming a continuos structure as in yeast dough. Thus starch plays a larger role in cake structure than do flour proteins. Its gelatinization increases batter viscosity that prevents collapsing during baking.

2. Liqid

Both the amount and the kind of liquid affect cake properties. Too little liquid can result in a peaked center and/ or cracked crust because of excessive batter viscosity.

It also can cause dipping because of insufficient swelling of starch in the top center of the cake. Too much liquid can result in a heavy cake with low volume because of the viscosity lowering effect and consequent decrease in retention of incorporated air.

The type of liquid used in cake can have effects that depend on the formula. For example, the effect of using buttermilk depends not only on total leavening equivalency but also on the resulting pH. With balance between buttermilk and sodium bicarbonate along with equivalent total leavening, the effects of the substitution of buttermilk may be slight.

3. Leavening agent

Obviously too little leavening results in poor volume and a heavy cake. Excessive leavening up to a point increases volume but results in a crumb that is coarse and irregular as well as crumbly.

4. Egg

Too little egg can result in a coarse or irregular crumb. Too much egg has a toughening effect.

5. Sugar

A low sugar concentration results in toughness and possibly a tunneled crumb. An excessive sugar concentration results in dense, heavy crumb because of interference with structure development and consequent inability to retain leavening gases; the cake is crumbly.

A moderate increase in sugar without other changes is possible with some formulas. More often, however, higher levels of sugar are accompanied by increased levels of total liquid, egg, and fat. The reason for increasing the level of shortening is related to batter aeration. Without increased fat, batter viscosity is likely to be relatively low as a result of the other changes, and retention of air is correspondingly reduced.

6. Shortening and Surfactants

Both the amount and kind of shortening affect cake quality. Increasing the concentration of shortening results in increased tenderness, fineness of grain, and apparent moistness. A low level results in toughness. Shortenings have undergone considerable change in recent years, and with the emulsifiers that are available today, the source of the fat is not as important as it once was; some unusual fats and oils can be used as shortening in cakes (Marjorie & Campbell, 1990).

Effect of baking conditions

Charley (1950, 1952) studied the effects of baking pan material, size, and shape. Baking was more rapid in dark or dull finished pans than in shiny pans. Cakes baked in faster baking pans had greater volume and better crumb quality, though they tended to be peaked. Cakes baked in shallow pans tended to be larger, more tender, less brown, and flatter topped than those baked in deeper pans. Those baked in round and square pans of the same depth were similar.

Oven temperature is an important factor affecting speed of heat penetration. If the temperature is too low, coagulation of proteins and gelatinization of starch are slow, and gas is lost from the batter. As gas is lost from the cells, the remaining cells enlarge, their walls thicken, volume is reduced, and the cake may settle in the middle. If the oven temperature is too high, a crust forms on the cake before it has risen fully.

Material and Method

Materials

1. Raw material Three varieties of local sweet potato
   - Mun Kra Tay
   - Mun Kai
   - Mun Tor Phuek

2 Chemical reagents
   2.1 0.5% Sodium metabisulphite
   2.2 Sodium hydroxide
   2.3 Boric acid
   2.4 Std H_2SO_4 0.00524M
   2.5 Light petroleum ether
   2.6 HCl
   2.7 Potato amylose
   2.8 Diethyl ether
   2.9 Ethyl alcohol

3. Equipment
   3.1 Knife and chopping board
   3.2 Sieve, size of 60, 100 mesh
   3.3 Glassware
   3.4 Hot air oven, Memmert Model 600
   3.5 Aluminium tray
   3.6 Moisture can
   3.7 Kjedalh Digestion Apparatus, Gerhardt Model KI 12/26
   3.8 Kjedalh Distillation Apparatus, Gerhardt Model KI 11/26
   3.9 Analytical balance
   3.10 RVU analyzer
   3.11 Soxhlet appalatus
   3.12 Spectrophotometer, Spectronic Genesys 5
   3.13 Centrifuge, Chermle Model Z 230A
   3.14 Vernier caliper

Method

1. Produce the sweet potato flour from three varieties of sweet potato

- Mun Kra Tay
- Mun Kai
- Mun Tor Phuek

Hand peel the sweet potato roots. Dipping the peeled root in 0.5% sodium metabisulphite solution for five minutes. Then slice the root into 2 mm and dip the sliced root in 0.5% sodium metabisulphite for another two minutes. Arrange the sliced sweet potato roots on a tray and dry in a hot air oven at 60-70°C until dry. Then mill and sieve to produce flour.

2.Analyze the chemical properties of sweet potato flour.

Sweet potato flour gained from method (1) were analyzed to determine the amounts of fat, protein, ash, fiber content by method of AOAC. (1984) and Amylose content is determined by Kerr (1950).

3.Analyze the physical properties of sweet potato flour

Sweet potato flour gained from method were analyze to determine the percent of solubility and swelling power by Schoch (1984), viscosity by AOAC. (1984), and determine the color by Muncell book

4.Cake

4.1 Cake's formula

Ingredient	Weight	
Shortening	45	g
Sugar	75	g
Salt	1	g
Milk powder	5	g
Egg	45	g
Water	45	ml
Flour	75	g
Baking powder	3	g

4.2 Method

4.2.1 Substitute wheat flour with sweet potato flour by

- 25%
- 50%
- 75%

4.2.2. Prepare cake

Weight all ingredients

↓

Stiff sugar, salt and milk

↓

Beat shortening with sugar to cream.

↓

Add the stiffed ingredients and mix at medium speed for 5 minutes until creaming

↓

Add egg in the cream, one by one

↓

Mix flour and baking powder, alternately with water. By dividing flour 4 parts and water 3 parts. Start and end with flour.

↓

Mix at low speed or with hand

↓

Pour the batter into a greased pan, about 3/4 of the pan height

↓

Bake at 350 °F for 25-30 minutes or until done.

5.Study and compare the quality of cake

5.1 Determine the quality of cakes by using scoring system for cake (Marjorie, Penfield and Campbell, 1990)
5.2 Determined the height of cakes and symmetry
5.3 Sensory Evaluation by 9-point hedonic scale preference test
5.4 Statistic analysis

Result and Discussion

1. Production

1.Percent yield of Sweet potato flour

From table 6 the result show that there is not much different in percent yield of three varieties sweet potato flour. The percent yield is between 24.53-26.15%.

Table 6 Percent yield of sweet potato flour

Varieties	Percent yield
Mun Kra Tay	25.80
Mun Kai	26.15
Mun Tor Phuek	24.53

2. Chemical Analysis

2.1 Proximate Analysis

Table 7 Proximate analysis of sweet potato flour

Varieties	Composition in percentage					
	Moisture	Protein	Fat	Fiber	Ash	CHO
Mun Kra Tay	6.72	2.61	1.74	3.20	1.78	83.95
Mun Kai	6.93	4.07	1.41	3.00	2.43	82.16
Mun Tor Phuek	8.32	2.80	1.25	2.97	2.74	81.92

Table 7 shows that there are similarity in chemical composition among three varieties of these sweet potato flour. The moisture content is between 6.71_8.32%, protein content is between 2.61-4.07%, fat content is between 1.74-1.41%, fiber is between 2.97-3.20%, and ash content is between 1.78-2.74%, and predominant component is carbohydrate that may consist of starch and some sugar. There is not different in chemical composition in three varieties of sweet potato flour. However due to its moisture content which lower than 14%, all flour are considered safe from mold spoilage.

Table 8 Amylose content of sweet potato flour

Varieties	Percent of Amylose
Mun Kra Tay	4.07
Mun Kai	4.00
Mun Tor Phuek	6.00

Table 8 show that the sweet potato flour gained from Mun Tor Phuek has the highest percent of amylose content from the range of 4-6%.

3. Physical Analysis

3.1 Percent solubility and Swelling power

Table 9 Percent solubility and swelling power

Varieties	% solubility at 85°C 30 min	%swelling power at 85° C 30 min
Mun Kra Tay	6.12	7.71
Mun Kai	16.03	7.86
Mun Tor Phuek	10.90	7.27

Table 9 shows that the sweet potato flour gained from Mun Kai has the highest of percent of solubility that may be due to high degree of small fraction, sugar and damage starch. While Mun Kra Tay and Mun Tor Phuek flour have the percent of solubility more than of Mun Kai flour. For swelling power, all of these flour are not different with the range of 7.27-7.86%.

3.2 Color

Table 10 The Munsell Book of Color

Varieties	Color
Mun Kra Tay	2.5Y8.5/2
Mun Kai	5Y8.5/2
Mun Tor Phuek	10RP8/2

From table 10 and figure 1, Three varieties of sweet potato flour are absolutely different in their color, depending on their varieties. Mun Kra Tay flour has dark pink skin color and white flesh. Mun Kai has brown skin color

and yellow flesh. Mun Tor Phuek has pink skin color and light purple flesh. Thus sweet potato flour gained from method (1) have white color, yellow color, and light purple color, respectively.

Figure 1. Product of sweet potato flour

3.3 Viscosity of sweet potato flour past

Table 11 Viscosity of sweet potato flour paste

Varieties	Pasting Temp (°C)	Peak Viscosity (RVU)	Breakdown (RVU)	Set back (RVU)
Mun Kra Tay	83.20	217.67	19.33	38.50
Mun Kai	83.95	220.67	72.53	56.08
Mun Tor Phuek	83.25	210.00	52.42	68.08

The study on the behavior of sweet potato flour using RVU analyzer on the viscosity change during heating and cooling is summarized in table 11 and figure 8. It is found that these three flour started to gelatinize around 83-84 ° C and complete gelatinization during holding at 95°C. During gelatinization Mun Tor Phuek and Mun Kai show a rapid increase in viscosity due to high degree of swollen granules while Mun Kra Tay show a moderately increased in viscosity which means that it's starch granules are stronger than those in Mun Tor Phuek and Mun Kai flour. Nevertheless they produce the peak viscosity at almost the same height around 210-220 RVU. While holding at 95°C together with continuing stirring the paste, Mun Tor Phuek and Mun Kai demonstrate a decrease end viscosity to almost 50 RVU, indicated that their paste are not quite strong. On the another hand Mun Kra Tay is much stronger with a decrease of about 20 RVU during holding. After cooling to50°C all three flour demonstrated retrogradation with the final viscosity 237 RVU for Mun Kra Tay, 226 RVU for Mun Tor Phuek, and 204 RVU for Mun Kai.

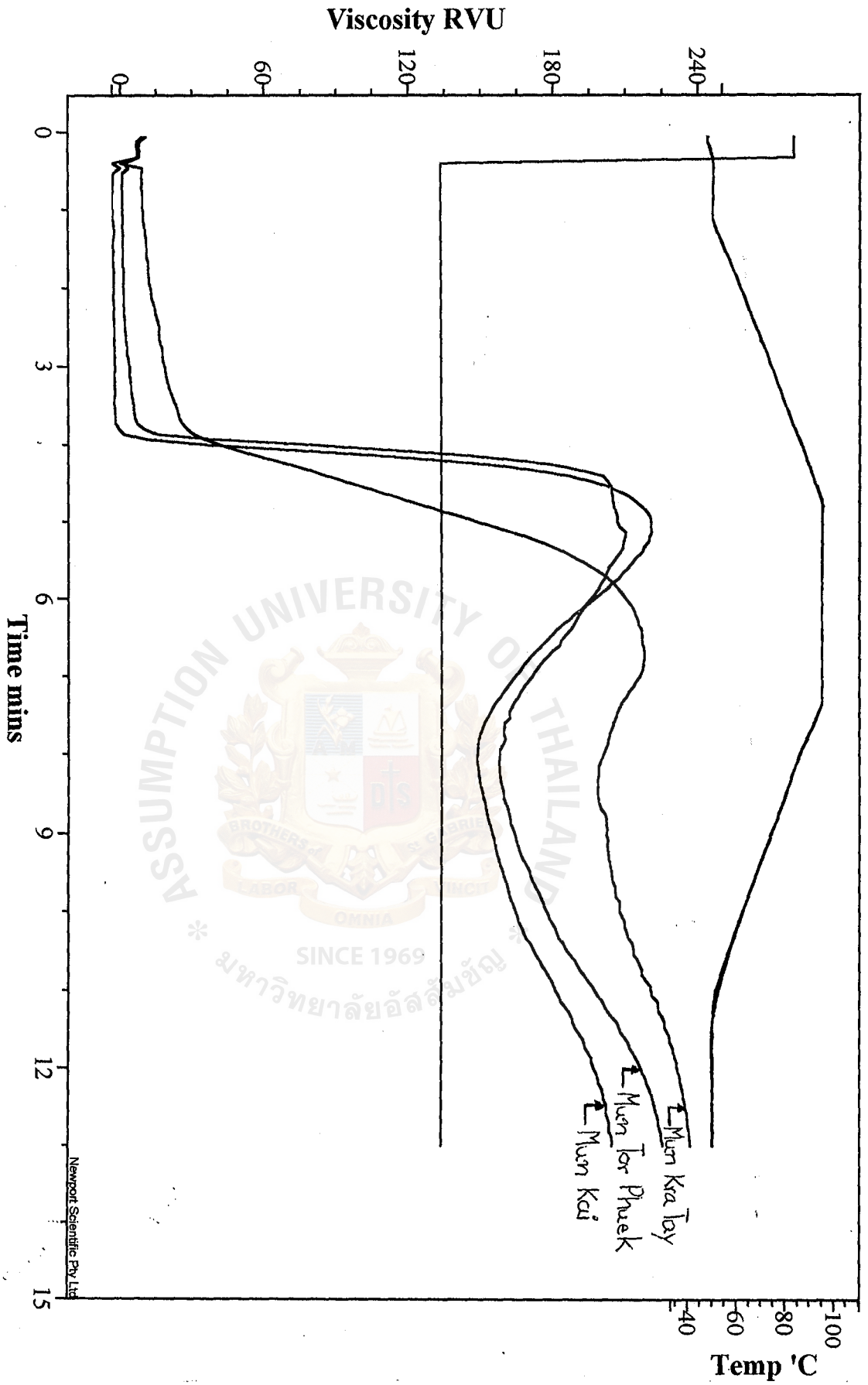

Figure 2. Graphical analysis result from RVU analyzer

4. Analyze the properties and Quality of cakes

4.1 Scoring system for cakes

Table 12 Scoring of cakes

characters	control	Mun Kra Tay			Mun Kai			Mun Tor Phuek		
		25 %	50 %	75 %	25 %	50 %	75 %	25 %	50 %	75 %
Size of cells	10	10	10	10	10	10	3	10	3	1
Distribution of cells	6	6	6	4	4	6	4	6	4	2
Crumb character	10	10	10	8	10	10	8	10	8	2
Tenderness	8	8	8	3	8	8	3	8	3	3
Moist	10	10	10	2	10	10	2	10	2	2
Flavor	10	10	5	5	10	5	5	10	5	5
Total	54	54	49	32	52	49	25	54	25	15

Table 12 shows a comparison of the quality of each substituted sweet potato cakes with control. At 25% substituted, substituted cakes from Mun Kra Tay, and Mun Tor Phuek flour have the total score equal to total score of control (54) and 25% substituted cake from Mun Kai flour has 52 scores that is slightly lower than the control due to irregular distribution of the cell.

At 50% substituted, Mun Kra Tay and Mun Kai get 49 scores while Mun Tor Phuek get only 25 scores. It is noticed that the cake prepared form Mun Kra Tay and Mun Kai are too sweet while another attributes are rated similar to the control. On the contrary the attributes from Mun Tor Phuek

cake are large cell, irregular distribution of the cell, slightly had crumb, crumbly, wet, and too sweet which were bad for cake.

At 75% substituted, all three cakes are rated with lower scores which shown that the more substitution the less quality of the cake will be. They become wet, and crumbly and packed.

Therefore in sensory evaluation 25% substitution is chosen to prepare cake.

4.2 Proximate height of cake

Table 13 Height of the cake in centimeter

Type of cakes	Height of the cake in cm		
	25% substituted	50 % substituted	75% substituted
Moon Kra Tay	4.50	4.43	4.18
Mun Kai	4.60	4.29	3.84
Mun Tor Phuek	3.98	3.78	3.64
Control	**4.75**		

Table 13 and figures 3, 4, 5, 6, 7, and 8 show that the heights of substituted cakes are decreased when the ratio of substituted are increased. At 25% substituted of each flour have the highest height when compared within three ratio of substituted. And at 25% substituted cake of Mun Kai flour has the highest height when compared with another substituted cake in the same ration of substituted. As starch influences cake structure rather than flour protein (Glover et.al.,1986). Mun Tor Phuek flour would contain starch which is much weaker than Mun Kra Tay and Mun Kai flour so that it produces significantly low volume cake.

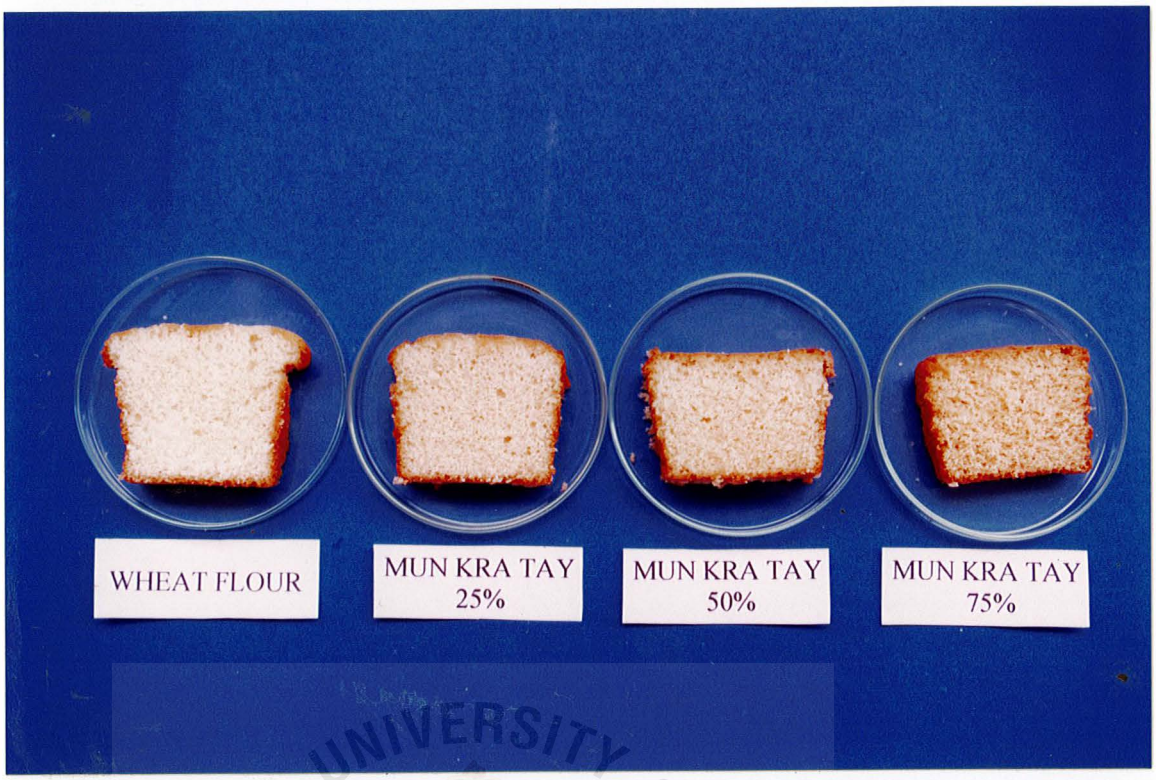

Figure 3. Cake produced by wheat flour and Mun Kra Tay flour

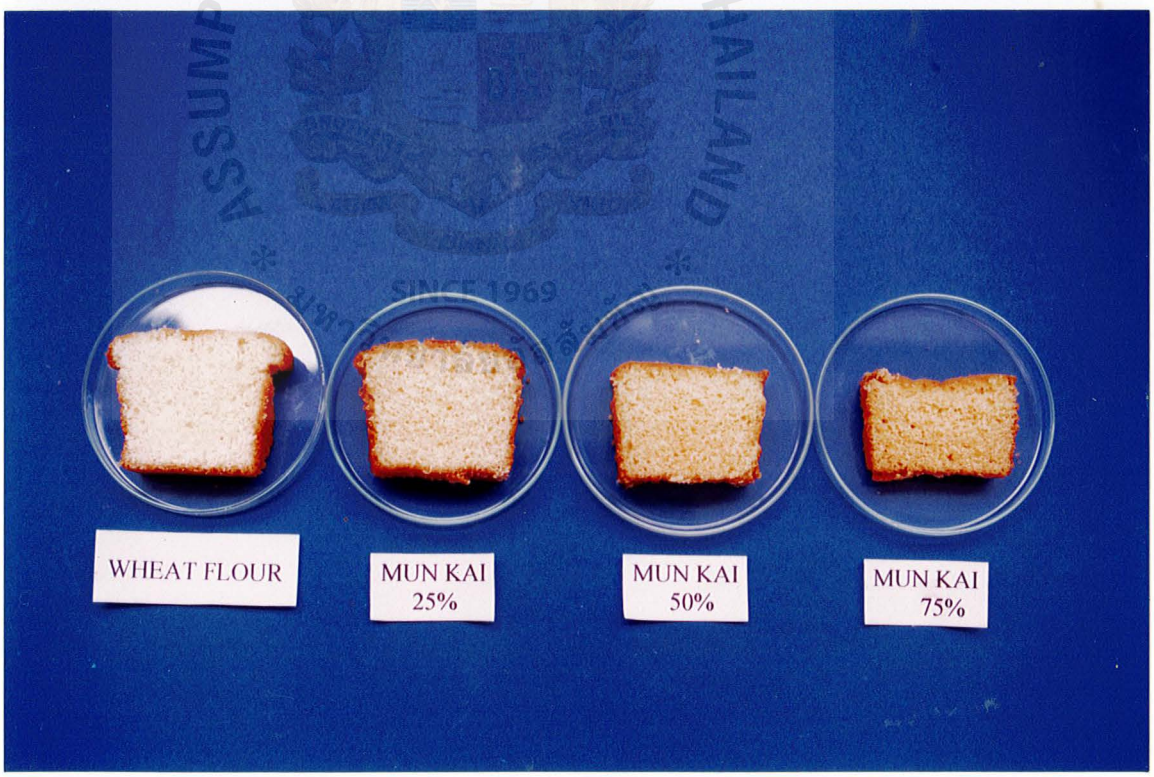

Figure 4. Cake produced by wheat flour and Mun Kai flour

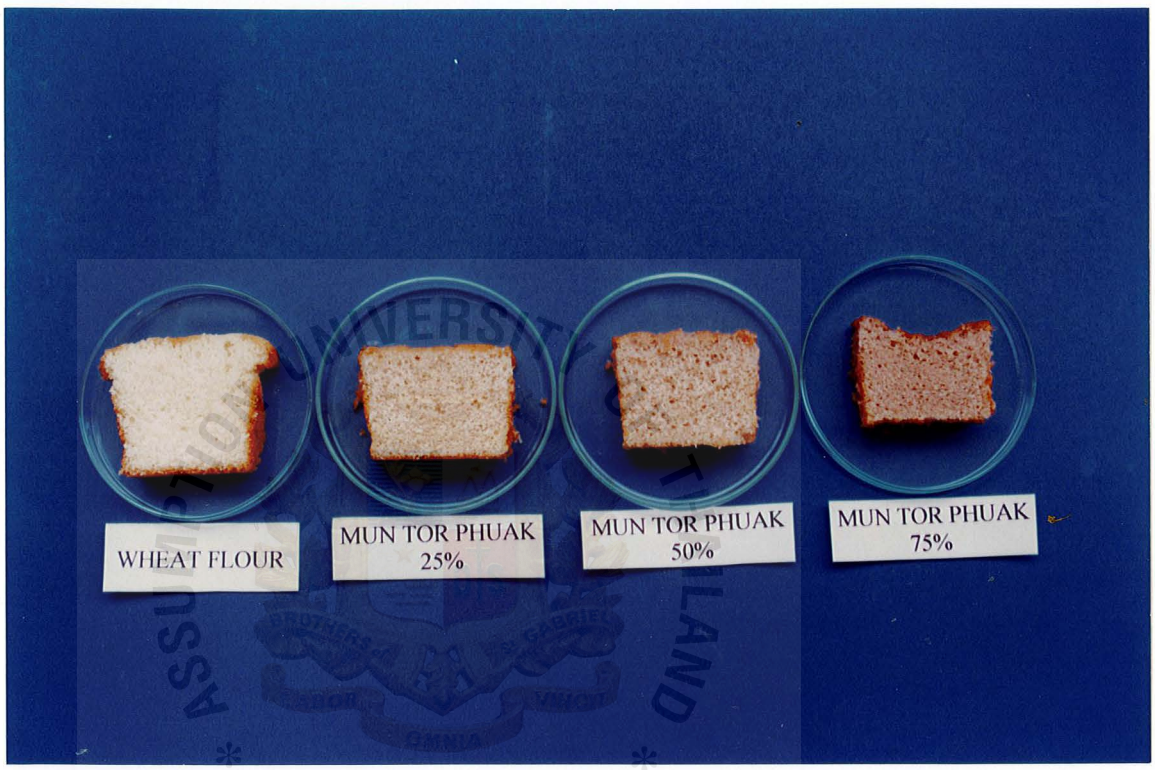

Figure 5. Cake produced by wheat flour and Mun Tor Phuek flour

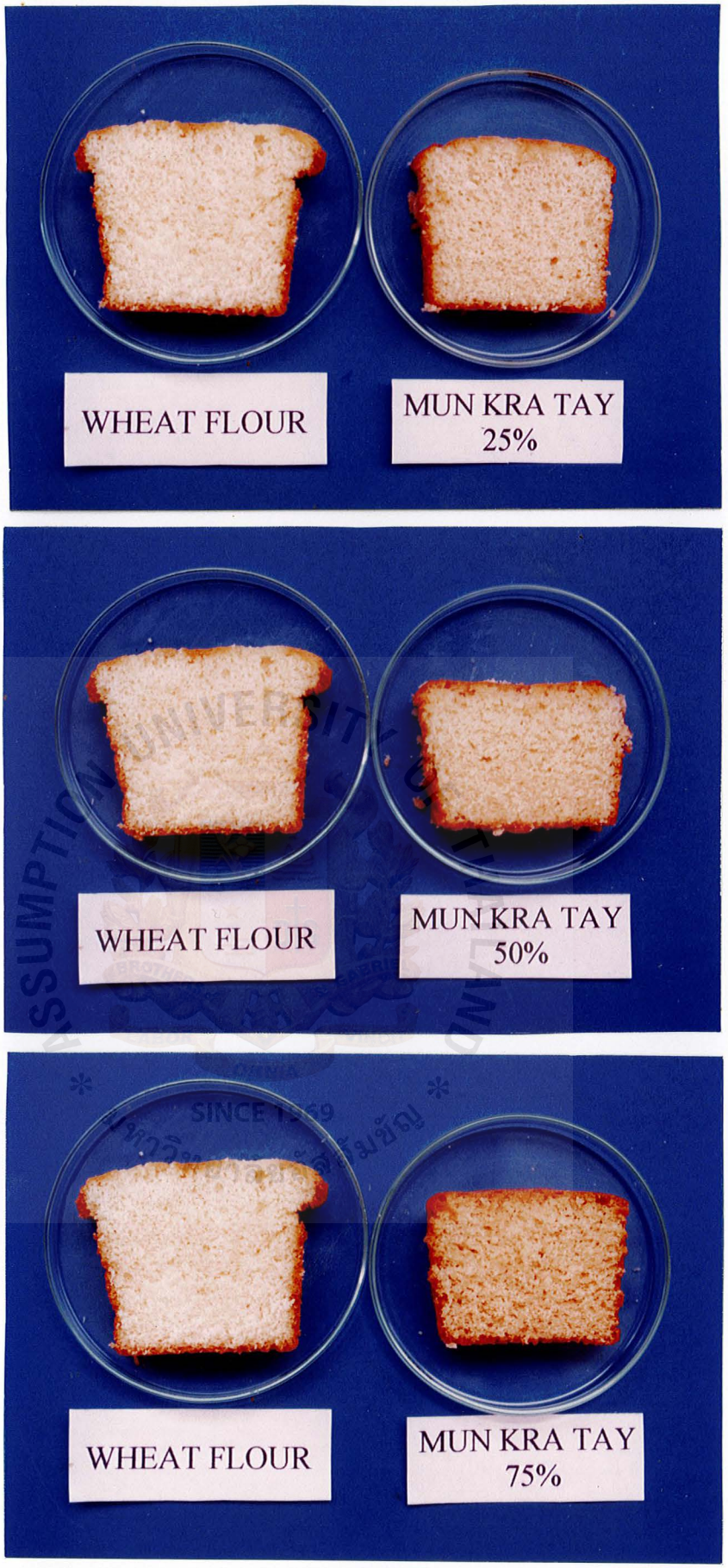

Figure 6. Comparison of cake that are produced by wheat flour and Mun Kra Tay flour at the various ratios of substitution

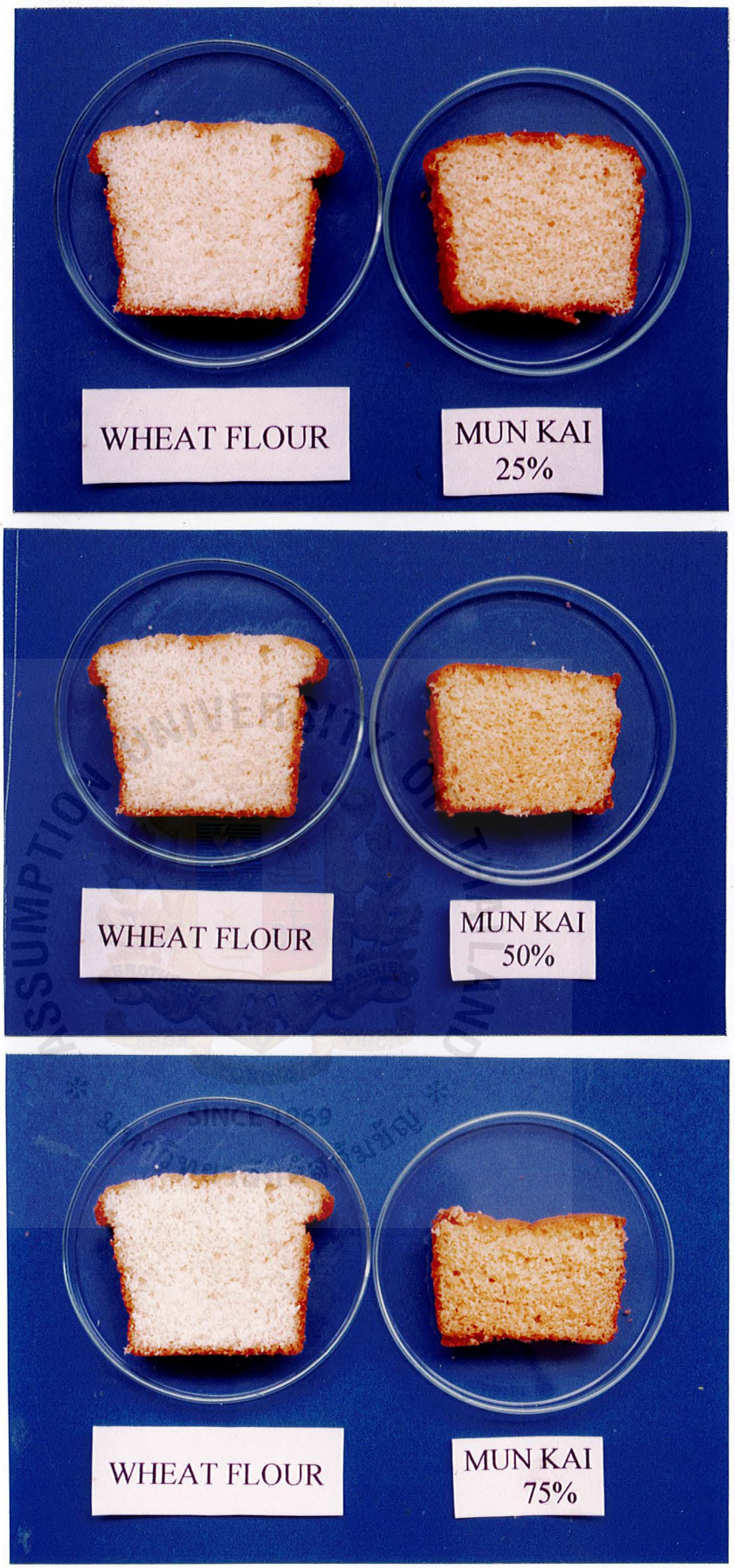

Figure 7. Comparison cake that are produced by wheat flour and Mun Kai flour at various ratios of substitution

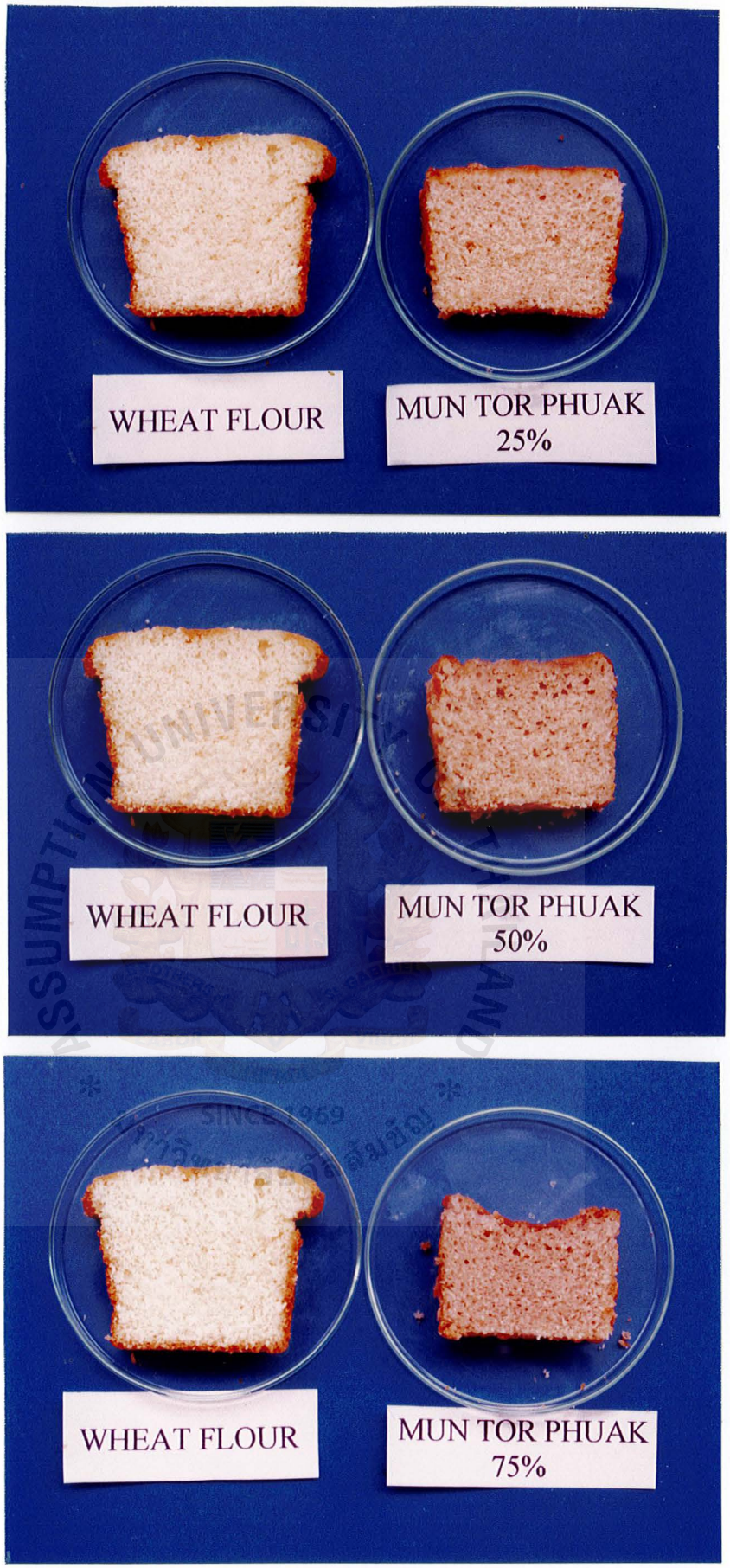

Figure 8. Comparison of cake that are produced by wheat flour and Mun Tor Phuek flour at various ratios of substitution

4.3 Sensory Evaluation

Table14 Average scores of 25% substitution sweet potato cake vs. control cake

Attributes	Control	25% Mun Kra Tay	25% Mun Kai	25% Mun Tor Phuek
Appearance	6.81^{a}	6.19^{a}	7.25^{a}	6.31^{a}
Color	7.13^{a}	6.31^{a}	7.94^{a}	5.81^{b}
Texture	6.50^{a}	6.94^{a}	7.00^{a}	6.19^{a}
Flavor	6.94^{a}	6.25^{a}	7.25^{a}	5.75^{b}
Overall acceptance	6.88^{a}	6.50^{a}	7.56^{a}	5.69^{b}

Sensory evaluation of the cake prepared by substituted 25% of cake flour with Mun Kra Tay, Mun Kai, and Mun Tor Phuek flour vs. a control cake is tested on 16 taste panelists. The result of mean scores from 5 attributes are shown in table 14. From statistical analysis, analysis of variance, and Dunnett's test, it was shown that

1.There are no significant different in appearance and texture among these cakes. When comparing with the control the substituted cakes are rated from 6 to 7 in the appearance and the texture, which means that the panelist preferred these cakes.

2.There were significant different in color, flavor, and overall acceptance of the products vs. control. Cake prepared from substituted by Mun Kra Tay, Mun Kai flour ware rated as good as control in these three attributes while cake prepared from substituted Mun Tor Phuek is rated lower than control. Nevertheless there are rated between slightly to almost like very much.

As conclusion, 25% of Mun Kra Tay and Mun Kai flour can be use in substituted the wheat flour in butter cake with acceptable result from the tasted panelist. But 25% of Mun Tor Phuek flour, when substituted in butter cake is not quite as good as the control and the other two cake.

Note Samples with different subscribe letters are significantly difference.

Conclusion

1. For chemical study, proximate analysis of the three sweet potato flour show that Mun Kra Tay flour, Mun Kai, Mun Tor Phuek have 6.72, 6.93, 8.32% of moisture content; 2.61, 4.07, 2.80% of protein content; 1.74, 1.41, 1.25% of fat content; 3.20, 3.00, 2.97 of fiber content; 1.78, 2.43, 2.74 of ash; 83.95, 82.16, 81.92% of carbohydrate content. And their amylose content are 4.07, 4.00, 6.00%, respectively.

2.For physical analysis, the sweet potato flour from Mun Kai has highest percent solubility and percent swelling power than the another sweet potato flour. And there are absolutely different in color, Mun Kra Tay flour is white, Mun Kai flour is yellow, Mun Tor Phuek flour is light purple.

3. For study of viscosity changing, all three of sweet potato flour started to gelatinize around 83-84°C. During holding at95°C, Mun Kai and Mun Tor Phuek demonstrate the decrease of paste viscosity while Mun Kra Tay demonstrates the strongest paste with little change in viscosity. After cooling to 50°C, all three flour demonstrated retrogradation with the final viscosity of 237 RVU, 226 RVU, and 204 RVU, respectively.

4. For scoring system of cakes, at 25% substitution of Mun Kai and Mun Kra Tay cakes are rated as good as control in all of the attributes. While Mun Tor Phuek cake has the slightly lower score due to irregular distribution of its cell.

At 50% substituted, Mun Kra Tay and Mun Kai are rated similar to the control in the all of attributes except in the flavor attributes which were too sweet . While Mun Tor Phuek cake is rated lower than control in all of the attributes that demonstrate the bad quality of cake.

At 75% substituted, all of the three varieties of cakes from sweet potato flour are rated lower than control in every attribute indicate the bad quality of cake.

5. For height of cake, Mun Kai cake is the highest height among these sweet potato cakes. However, the heights of the substituted cakes are decreased when the ratio of substitution are increased.

6. Result from scoring system of cakes, the substitution of sweet potato flour at 25% with wheat flour are found to be the optimum ratio to

give the best quality of butter cake in all of the three varieties of sweet potato flour cakes.

7.At 25% of Mun Kra Tay and Mun Kai flour can be used to substitute the wheat flour in butter cake with acceptable result form the taste panelist. But 25% of Mun Tor Phuek flour produced not quite as good quality as the control and the other two.

Suggestions

1. For Mun Tor Phuek, it would be better to test by using this flour in the amount less than 25% in the butter cake in the further experiment.

2. Utilization processes and techniques of sweet potato should be tested to develop or make the new products such as noodles, chips, and another bakery product to increase the value of sweet potato roots.

3. Due to short storage life of sweet potato root, utilization processed and techniques can maintain the use of sweet potato throughout the years such as flour.

References

AOAC. (1980). Official Methods of Analysis of the Association of Officia Analytical Chemist. 14th ed. Virginia USA: Association of Official Analytical Chemists.

BouwKamp, J.C. (1985). Sweet potato product. A natural resource for the tropic. CRC Press, Boca Raton, Florida.

Charley, H. (1952). Effect of the size and shape of the baking pan on the quality of shortened cakes. Journal of Home Econ. 44: 115-118

Coollin W.W., and Walter W.M. (1982). Potential for increasing Nutritional Value of Sweet potatoes, Proceeding of the First International Symposium AVRDC, Taiwan.

Dawson, P. R., Greathouse, L. H., and W. O. Gordon. (1951). Sweet potatoes. More than starch. in crops in Peace and war. Yearbook of Agriculture 1950-1951, U.S. Department of agriculture, washington.C.C., p195

FAO. (1989). FAO Production Year Book 1988. Food and Agriculture Organization of the United Nations, Rome

Frankin Martin. (1997). Root and Tuber Crops. [on-line]. Available: http://www.xc.org/echo/azillus/azch3roo.htm

Huang P.C. (1982). Sweet potato. Proceeding of the First International Symposium. AVRDC, Taiwan.

Gloven, J. M., Walker, C. E., and Mattern, P. J. 1986. Functionality of sorghum flour components in a high ratio cake. Journal of Food Science. 51:1280-1283,1292.

Gray, W. D and Mld., About-EL-Seuud. (1966). Fuggal protein for food and feed. II. Whole potato as a substrate,Econ. Blot., 20,119,1966

Kerr. R.M.(1950). Chemistry and Industry of Starch. 2nd ed. Academic Press, New York. 691 p.

Marjorie, Penfield and Ada Marie Campbell. (1990). Experimental Food Science 3rd ed. Academic Press, Inc. New York

Maneepun,S., and S. Soontornnarurungsi. (1991). Sweet potato Production and Utilization in Thailand. Paper presented at workshop on rood and tuber processing, marketing and utilization in Asia. Visca, Leyte, The Philipines 22 April 1 May 1991

Manėepun, S.,and M. Yunchalad. (1991). Sweet potato starch and flour research in Thailand. Paper presented at workshop on rood and tuber processing, marketing and utilization in Asia . Visca, Leyte, The Philippines 22 April-1 May 1991.

Nghe, B. V., and N. D. Lan. (1989). Confection of Noodles from Maize and Cassava. Agricultural and foodstuff industry journal, N2, Hanoi, in Vietnam.

Siki, B.F. (1979). Processing and Storage of Root Crops in Papua New Guinea, in small scale processing and storage of Tropical Root Crops. Plucknett, D.L., Ed. , Westview Press, Boulderm Colo.

Unifem. (1989). Root Crop Processing. Food Cycle Technology Source Book, Verdegrafica&Pubblita, Rome.

Winarno F.G. (1982). Sweet potato Processing and By-Product Utilization in the Tropics, Proceeding of the first International Symposium AVRDC, Taiwan

Appendix A :

Chemical Analysis

Quality evaluation of sweet potato flour

1. Moisture content. (AOAC,1980)

1.1Method

Place moisture cans in a hot air oven for 20-30 minutes. And cool down in a dessicator before weighing and recording the weight.

↓

Weigh the sample approximately 5grams, in the moisture can and record the weight.

↓

Place in the waterbath to evaporate some moisture out and place in the hot air oven at 100°c for 3 hrs. and cool down in the dessicator.

↓

Weigh and record the result.

↓

Calculate % Moisture Content.

2.Crude fiber Analysis

2.1 Chemical Reagent

- Light petroleum ether
- NaOH
- HCl
- Diethyl ether
- H_2SO_4
- Ethyl alcohol

2.2 Method

Weight 3 g of sample to 4 digits number.

↓

Extract fat with petroleum ether 3 times by stirring the sample.

↓

Air-dry in the sample.

↓

Add 200 ml, 0.255N. H_2SO_4 solution and few glass beads. Boil for 1 min. Cover the flask with watch glass.

↓

Gently boil for 30 min (maintain volume by add distilled water.) Filter through Bucher funnel containing #4 filter paper that has already been poured with boiling water with applied suction. (Filtration should be complete within 10 minutes)

↓

Wash with distilled water until the filtrate free of acid Transfer the residue into the same flask by mean of a washing bottle containing 0.313 N. NaOH 200 ml.

↓

Repeat refluxing with alkali solution the same as with acid. Filter by mean of suction. Wash the residue with water until the filtrate is free from alkali. Transfer the residue back to the same flask.

↓

Repeat reflux with 1% HCl 200 ml. And filter. Wash the residue with water.

↓

Wash it twice with 95% ethyl alcohol.

↓

Wash it 3 times with diethyl ether.

↓

Transfer the residue to the known weight dried ashless filter paper

↓

Dry at 100°C to a constant weight (A)

↓

Incinerate at 500-550°C for 3 hrs.

↓

Weigh the ash (B)

↓

Calculate percentage of crude fiber.

2.3 Calculation

Weight of the crude fiber = A-B

%Crude fiber = (A-B)100 / weight of sample

3. Ash Content Analysis

3.1 Method

Place a crucible in a muffle furnace at 500 C for 1 hr. and cool down in dessicator and record the weight

↓

Weigh the sample 3 grams into the crucible.

↓

Burn the sample by suing Bunsen burner until there is no smoke.

↓

Put it in the muffle furnace at 500-600 °C and incinerate until no carbon left

↓

Cool down in the dessicator and record the weight.

↓

Calculate % total ash.

3.2 calculation

% Total ash = (weight of ash)100 / weight of sample

4. Fat and Oil Content Analysis

4.1 chemical Reagent

- Petroleum ether, boiling point 40-60°C

4.2 Method

Weigh sample approximate 10 grams on a pieced of filter paper.

↓

Fold the content and put it in a thimble. Place the timble in the soxhlet apparatus that is connected one end with the known weighed receiving flask.

↓

Extract the sample with petroleum ether for 6 hrs.

↓

Remove thimble away from the soxhlet. And evaporate the excess petroleum ether.

↓

Disconnect the r-b flask and put it in the hot air oven at 100 °C for 2-3 hrs.

↓

Weigh the dry flask containing the extracted fat and record its weight

↓

calculate % fat content

4.3 calculation

% Fat content = (weight of extract fat)100 / weight of sample

5. Protein Content Analysis

5.1 Chemical Reagents

- Catalyst mixture of $CuSO_4.5H_2O$ and Na_2SO_4
- Conc. Sulfuric acid
- Sodium hydroxide
- 4% Boric acid
- Bromocrysol green and methyl red indicator
- std. H_2SO_4 0.0046 M solution

5.2 Method

Weigh sample approx. 5 grams and transfer to a Kjeldahal digestion flask

↓

Add 8 grams of catalyst mixture and 80 ml. Conc. H_2SO_4

↓

Digest the mixture by slowly bringing to boil until no bubble appears (about 2 hrs.)

↓

Remove from the digestion apparatus and cool down to room temp.

↓

Slowly add 400 ml. Of H_2O and some glass beads.

↓

Slowly add 75 ml of 50% NaOH solution and instantly connect the flask to the distillation apparatus, which has immersed one end beneath 4% boric acid solution containing few drops of indicator mixture.

↓

Slowly boil the content to release ammonia gas into the acid solution.

↓

Titrate the distillate solution with std. H2SO4 0.0046 M. and determine % of total nitrogen in the food sample

5.3 calculation

% Total N = (weight of N) 100 / dry weight of sample

% Protein = % total N (convection factor of flour)

*Convection factor of flour = 5.7

6. Amylose content

6.1 Chemical reagents

- Iodine solution. Dissolve 0.2 grams iodine and 2 grams potassium iodide in the distilled water and make the volume to 100 ml. Keep the solution away from light
- 1 N. Sodium hydroxide solution

- 1 N. Acetic acid solution
- 95% Ethyl alcohol

6.2 Method

1) Potato amylose standard solution preparation

Weigh 0.04 g pure potato amylose.

↓

Add in an100 ml. volumetric flask.

↓

Add 1 ml. Of Ethyl alcohol

↓

Shake slowly and add 9 ml. Of NaOH

↓

Keep it at room temperature for 15-24 hrs.

↓

Make up the volume with distilled water

2) Determination of amylose standard curve.

Pipette the potato amylose solution 0,1,2,3,4,5 ml. In 100 ml.volumetric flasks.

↓

Add 70 ml. of distilled water

↓

Add 0, 0.2, 0.4, 0.6, 0.8, and 1.0 ml of acetic acid, respectively

↓

Add 2 ml. of iodine solution

↓

Add distilled water to make volume

↓

Shake and keep it for 20 minutes.

↓

Measure the absorbance of the solution by using a spectrophotometer at wavelength 620 NM.

↓

Plot graph the absorbance vs. concentration.

3) Sample solution preparation.

Weigh the sample 0.1000 g. and follow the same steps as for potato amylose.

↓

Read the absorbance of the sample

↓

Determine amylose content in the sample from the standard curve.

7. Percent solubility and swelling power.

7.1 Method

Weigh the sample 0.2500g. in test tube.

↓

Add 6 ml distilled water

↓

Immense the tube in 85 °C water bath for 30 minutes.

↓

Shake it by using vortex.

↓

Centrifuge at 2200 rpm. for 15 minutes.

↓

Pour the liquid in know weight of crucible

↙ ↘

Weigh the precipitate

Dry in a hot air oven at 100° C for 4 hrs.

↓

Weigh

8.2 Calculation

$$\text{Degree of solubility} = \frac{\text{(weight of solubility part) } 100}{\text{Weight of dry sample}}$$

$$\text{Swelling power} = \frac{\text{(weight of wet weight) } 100}{\text{Weight of dry sample (100 - \%solubility)}}$$

Appendix B :

Statistical Analysis

Appendix Table 1 Questionnaire for 9 points hedonic scale.

Name:_____ Date:_____

Sample : Sweet potato cake

Please test the samples and give the score according to your preference by comparing with the control

Like extremely	9	Dislike	4
Like very much	8	Dislike moderately	3
Like moderately	7	Dislike very much	2
Like	6	Dislike extremely	1
Neither like or dislike	5		

Attributes	Control	Sample code		
		933	375	651
Appearance Color Texture Flavor Overall acceptance				

Comment_____

Appendix Table 2 Anova of attributes from sensory evaluation

Attribute: Appearance

Sov	df	SS	MS	fcal	ftab	
Trt	3	11.39	3.80	2.18	2.82	n. s.
Blk	15	66.95	4.46	2.56	1.9	*
Err	45	78.36	1.74			
Total	63					

Attribute: Color

Sov	df	SS	MS	fcal	ftab	
Trt	3	41.84	13.95	8.94	2.82	*
Blk	15	34.15	2.28	1.46	1.9	n. s
Err	45	70.41	1.56			
Total	63					

Attribute: Texture

Sov	df	SS	MS	fcal	ftab	
Trt	3	7.03	2.34	1.26	2.82	n. s.
Blk	15	71.90	4.79	2.58	1.9	*
Err	45	83.48	1.86			
Total	63					

Attribute: Flavor

Sov	df	SS	MS	fcal	ftab	
Trt	3	21.96	7.32	3.49	2.82	*
Blk	15	55.65	3.71	1.77	1.9	n. s.
Err	45	94.29	2.10			
Total	63					

Attributte: Overall acceptance

Sov	df	SS	MS	fcal	ftab	
Trt	3	29.28	9.76	4.32	2.82	*
Blk	15	45.40	3.03	1.34	1.9	n. s.
Err	45	101.72	2.26			
Total	63					

Dunett's test

$$d' = d_{\alpha\,(t\text{-}1,\ dfErr)}\sqrt{2MSE/r}$$

$$d_{0.05\,(3,45)} = 2.12$$

$$d' = 0.98$$

Attribute: Appearance

Control	=	6.81		
Mun Kra Tay	=	6.19	0.62 < d'	n. s.
Mun Kai	=	7.25	0.44 < d'	n. s.
Mun Tor Phuek	=	6.31	0.5 < d'	n. s.

Attribute: Color

Control	=	7.13		
Mun Kra Tay	=	6.31	0.82 < d'	n. s.
Mun Kra Kai	=	7.94	0.81 < d'	n. s.
Mun Tor Phuek	=	5.81	1.32 > d'	*

Attribute: texture

Control	=	6.50		
Mun Kra Tay	=	6.94	0.44 < d'	n. s.
Mun Kai	=	7.00	0.50 < d'	n. s.
Mun Tor Phuek	=	6.19	0.31 < d'	n. s.

Attribute: Flavor

Control	=	6.94		
Mun Kra Tay	=	6.25	0.69 < d'	n. s.
Mun Kai	=	7.25	0.31 < d'	n. s.
Mun Tor Phuek	=	5.75	1.19 > d '	✳

Attribute: Overall acceptance

Control	=	6.88		
Mun Kra Tay	=	6.50	0.38 < d'	n. s.
Mun Kai	=	7.56	0.68 < d'	n. s.
Mun Tor Phuek	=	5.69	1.19 > d'	✳

Note n. s. = non significance

✳ = significance