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Adding value to underutilized food resources: substituting wheat flour with sago starch in cookie formulations

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Sago starch has been consumed as a food in wetland areas for centuries. Relatively little has, however, been done to upgrade village level technology for the extraction of sago starch and to maximise its value added potential as a major food starch ingredient. The substitution of wheat flour with sago starch in a standard cookie formulation was studied. Findings revealed that wheat flour can be substituted by sago starch up to a level of 40 percent in producing cookies that find good consumer acceptance in Southern Thailand. Consumer acceptance of cookies, however, declined dramatically when the level of sago starch in the cookie formulation increased beyond 40 percent, owing to poor appearance and a crumbly texture. These findings highlight the potential of sago starch to replace wheat flour in other types of local confectionery and food products and the untapped value added potential of underutilized crops such as sago palm. Greater attention and emphasis must be paid in maximising the use of such underutilized food security crops.

Keys words: starch, Southern Thailand, crumbly texture

Introduction

Sago palm *Metroxylon sagu* Rottb. has been described as one of humankind's oldest food plants (Ave, 1977). Starch present in the trunk of the palm has for centuries, been consumed as a staple food in South-East Asian countries where the crop is grown. Sago starch is commonly prepared by pouring hot water over slightly sour wet starch and stirring with a stick or a spoon into a paste (Karim *et al.,* 2008) for consumption. A range of other traditional sago-based food products such as cookies, puddings and pancakes are produced and consumed by poor households in sago-producing countries.

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Apart from these traditional food uses, sago starch is widely used together with rice, corn and potatoes in the manufacture of noodles in Malaysia (Karim *et al.,* 2008). Sago starch is commonly used as a functional ingredient – thickener, stabilizer and gelling agent – in the food industry (Mohamed *et al*. 2008).

Structurally, sago starch consists of 24 to 31 percent of the linear polymer amylose (Fasihuddin et al. 1999), and 73 % of the branched polymer, amylopectin (Ito and and Hisajima, 1979). It is, however, of a low protein content 0.19 – 0.25 percent crude protein (Fasihuddin et al., 1999) and lacks gluten, which negatively impacts on its functional properties in bakery applications.

Despite its traditional uses, and industrial potential, relatively little has been done in Thailand to modernize the extraction of sago starch or to upgrade village level technologies used in adding value to sago starch, in order to maximise the use of this crop. Considerable potential, however, exists to build on and improve traditionally produced value added products based on sago starch, and to market those products to a wider consumer base, thereby generating income and employment opportunities for individuals living in sago starch producing areas. We report here, the partial substitution of wheat flour by sago flour in the production of cookies that find wide consumer acceptance in Southern Thailand.

Materials and methods

Materials

Sago flour used in the study was produced in Nakhon Si Thammarat, Thailand, following the methodology described in Konuma *et al*., 2012. Bakery ingredients including butter, powdered sugar, baking powder, egg and vanilla were purchased from the local market. All reagents and chemicals used in studies were of analytical grade.

Proximate analysis of the composition of wheat and sago flours

Standard AOAC (American Association of Cereal Chemists, 2000) methods were used for the determination of the moisture, fat, ash, and nitrogen content of sago starch. The protein content of sago starch was determined on the basis of estimates of total nitrogen, using a conversion factor of 6.25.

Selection of cookie formulations for testing

Three cookie formulations (Table 1 to 3) that incorporate wheat flour as a key starch ingredient, were tested. Cookies were prepared in accordance with these formulations and their overall acceptability was evaluated as described below in the section on sensory evaluation. The cookie formulation with the highest overall acceptability scores, aribitrarily identified as HA, was adopted as the basic formulation for the conduct of further studies.

Proportioning of wheat flour and sago flour for incorporating into cookie formulations

Sago flour was mixed with wheat flour in different ratios and proportions of (wheat:sago): 100:0 (control), 80:20, 60:40, 40:60, 20:80 and 0:100 on a weight to weight basis, and was incorporated into cookie the formulation HA as a substitue for wheat flour. Sensory evaluations were conducted on cookies produced.

Cookie Production

Preparation of cookie dough

Cookie dough was prepared using a Hobart type mixer (Continental Kitchen Aid, USA). Margarine was weighed and transferred into the bowl of the mixture, and mixed to a thin and shiny consistency. Powdered sugar was then added, followed by thorough mixing. The flours were weighed, combined and sieved, following which the sieved flour was added to the cookie dough and mixed. This followed by the addition of eggs, vanilla and milk butter flavour. The cookie dough thus obtained was flattened with a rolling pin and was subsequently cut into appropriate shapes. The cookies were transferred to an oven pre-heated to 160 C and baked for 15 – 20 minutes.

Sensory evaluation of cookies

The quality, sensory attributes - appearance, color, flavor, texture - and overall acceptability of the cookies was evaluated according to Ranganna, 1994, using a 5 point hedonic scale. Evaluations were performed by a semi-trained panel consisting of 30 judges. The scores for individual attributes were recorded and an analysis was carried out to determine the significance of variation of average scores, and the contribution of individual parameters.

Just-About-Right Scale Test for Cookies

Thirty respondents were requested to rate the acceptability of cookies prepared using a mixture of 60 % wheat flour and 40 % sago starch into formulation HA. Acceptance was rated on the basis of appearance, color, smell, flavor, hardness and cohesiveness using the 5 point hedonic scale (Table 4) and the just about right scale, a 1–7 point scale, ranging from the extreme like (1) to dislike extremely (7) as described by Larmond (1977).

Evaluation of consumer acceptance of cookies

Consumer preferences were determined using the Central Location Test (CLT), wherein a total of 150 respondents of three age groups: 1-5 years old, 6-15 years old, and 17-25 years old, (50 individuals per age group) were randomly requested to indicate their preferences for specific attributes of the cookies produced using 60 percent wheat flour and 40 percent sago starch in the HA formulation. The level of satisfaction of the surveyed tasters was recorded and analyzed.

Texture Analyses

Cookie dough was blended using a Hobart type mixer (Continental, Kitchen Aid, USA) operating at a medium speed for 3 minutes. The dough was allowed to rest for 30 min prior to testing. The dough was sheeted using a cocky cylinder over a rectangular frame of 6 mm height in order to obtain uniform thickness. The cookies were subsequently baked according to the previously described conditions.

Textural characteristics of the baked cookies were evaluated using a Texture Analyzer equipped with a three-point bending probe HDP/BSK with the following settings:

Pre-Test Speed:	5.0 mm/s
Test Speed:	5.0 mm/s
Post Test Speed:	10.0 mm/s
Distance:	10 mm.

Each texture parameter was calculated based on the average of 10 replications.

Results and discussions

Proximate composition of wheat flour and sago flour

The proximate composition of wheat flour and sago flour used in cookie formulations is summarised in Table 5. Wheat flour was found to be of a lower (12.8 percent) moisture content than sago flour (13.1 percent). Fasihuddin *et al*., 1999 studied the physiochemical characteristics of sago starch and determined that the moisture content varied between 10.6 and 20 percent, which is typical for commercial starches. The moisture and ash contents of the sago starch samples (13.1 percent and 0.19 percent respectively) used in the current study were in line with the Codex Regional Standard for Edible Sago Flour (*CODEX STAN 301R-20*). The protein content of the sago flour was found to be somewhat lower than that reported by Fasihuddin *et al*. (1999).

Sensory attributes of the three cookie formulations tested

Results of the sensory evaluation of cookies prepared using formulation Nos 1, 2 and 3 (Tables 1-3) are presented in Table 6. Cookie formulation No. 3, had the highest overall acceptability in terms of appearance, odor, flavour and texture (Table 6) and was therefore used as the base formulation (HA) for all subsequent consumer testing.

Evaluation of sago cookies prepared using sago and wheat flour combinations

Sensory scores for cookies produced using different proportions of wheat flour and sago flour in product formulation HA, revealed a preference for cookies produced using wheat flour and sago flour proportioned in ratios of 60:40 and the 80:20 (Table 7). Cookie formulations containing a high proportion of sago flour showed a very low level of cohesiveness, thereby crumbling very easily. This low level of cohesiveness and was largely due to the low gluten content, of sago starch.

Dramatic changes were observed in consumer acceptance of the cookies, based on their appearance when sago starch was included in the product formulations at levels exceeding 40 percent (Figure 1). Poor consumer acceptance of the latter formulations was largely due to the comparably flat appearance of cookies containing large quantities of sago starch. Consumer acceptance of color, taste and texture also declined, for cookies having a sago starch content exceeding 40 percent, but somewhat less dramatically (Figure 1).

Cookie formulations containing the 60:40 proportioning of wheat to sago flour were of a softer texture when compared to those containing 100 percent wheat flour. The inclusion of sago flour in the mixture decreased the crispiness and hardness of the cookie (Table 8).

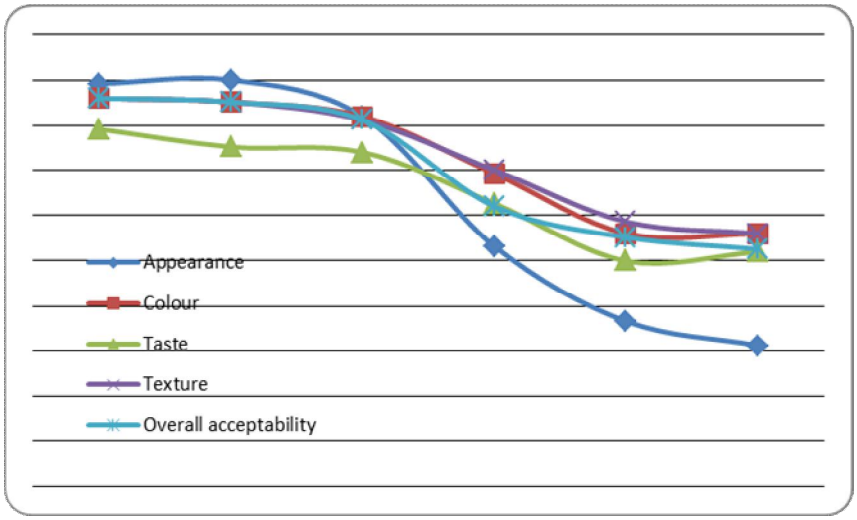

Fig. 1. Average sensory scores obtained for cookie formulation containing different proportions of sago flour and wheat flour
Ratios of wheat to sago starch: Ratio 1 (100:0); Ratio 2 (80:20); Ratio 3 (60:40); Ratio 4 (40:60); Ratio 5 (20:80) and Ratio 6 (0:100)

Just About Right scale test for cookies

Cookies formulated using a 60:40 ratio of wheat flour to sago flour were found acceptable by a panel of judges, on the basis of their appearance, color, smell, flavor, hardness and cohesiveness using the 5 point Hedonic Scale, and the Just About Right Scale, with an overall acceptance value of 90 percent (Table 9).

Assessment of consumer satisfaction with sago-based cookies

A Central Location Test (CLT) was conducted in order to assess consumer acceptance of sago-based cookies. Seventy two percent 72 percent of children aged 1-5 were satisfied with the cookies formulated with a 60:40 proportioning of wheat flour to sago flour (Table 10).

Consumers in the 6-15 age group were likely satisfied with the physical appearance and color of the cookie formulation containing a 60:40 proportioning of wheat flour to sago flour. A majority of these consumers were

"mostly likely" satisfied with the smell, flavor and eating characteristics of the cookies (Table 11), with overall "most likely" satisfaction of 70 percent.

The 16-25 age group showed a similar trend to the 6-15 age group, wherein more than half of these individuals were "likely" satisfied with the physical appearance (Table 12). Approximately 86 percent were "likely" (40 percent) and most likely (46 percent) satisfied with the color of the cookies. More than half were "most likely" satisfied with the flavor and eating characteristics. Overall, seventy-eight percent of these respondents were "most likely" satisfied with the cookie product.

Table 1. Cookie Formulation No.1 (Puengkam, 1999)

Ingredients	Quantity	Unit
Wheat flour	250	gram
Butter	220	gram
Icing sugar	110	gram
Milk	60	gram
Powdered Milk	50	gram
Baking powder	1	teaspoon
Vanilla	1/2	teaspoon

Table 2. Cookie Formulation No. 2 (Chitsanantavittaya, 2011)

Ingredients	Quantity	Unit
Wheat flour	3	Cup
Butter	1	gram
Cheese	1/2	gram
Sugar	1 1/4	gram
Yolk	2	gram
Baking powder	2	teaspoon
Vanilla	2	teaspoon

Table 3. Cookie Formulation No. 3 (Ngamprapawat, 2011)

Ingredients	Quantity	Unit
Wheat flour	500	gram
Baking powder	1	Tablespoon
Salt	1	Teaspoon
Butter	200	Gram
Margarine	100	Gram
Icing sugar	250	Teaspoon
Yolk	2	Pieces
Vanilla	1	Teaspoon
Milk butter flavor	1/2	Teaspoon

Table 4. Some terms and definitions for sensory texture attributes of cookies

Sensory Attributes	Definition	Evaluation	Scale (5-point)
Color	i) The actual hue of the color, light to dark brown ii) Homogeneity of the color	Observe the intensity of the color along with homogeneity	5-light brown (smooth) to 1-dark brown with patches
Hardness (Firmer bite)	Something that is not too hard but does not immediately disintegrate in the mouth	Compress or bite through sample with molars	5-needs firm bite 1-easily crumbles
Chewiness	Number of chews necessary to prepare sample for swallowing	Chew sample 3 or 8 times and evaluate	5- completely swallow 1-gummy and leathery
Texture	Amount of smoothness perceived in the chewed sample	Chew sample with molars 8 times and evaluate	5-with smooth texture 1-with rough mass
Over all flavor	Degree to which mouth contains small particles after samples have been swallowed		5-like the most 1-with-out feelings

Table 5. Proximate composition of wheat flour and sago flour

Parameters	Wheat flour	Sago	Codex Standard*
Moisture (%)	12.8	13.1	13
Fat (%)	0.90	0.01	
Ash (%)	0.65	0.19	0.5
Protein (%) n x 6.25	10.9	0.04	

*Codex Stan 301R-2011

Table 6. Sensory evaluation scores for three cookie formulations produced using 100 percent wheat flour

Sensory Parameter	Formula 1	Formula 2	Formula 3
Appearance	4.05 ± 0.43	2.72 ± 0.51	4.10 ± 0.84
Color	3.93 ± 0.57	3.15 ± 0.76	3.86 ± 0.72
Odor	3.91 ± 0.53	3.31 ± 0.68	4.02 ± 0.71
Flavor	4.03 ±0.66	3.14 ± 0.67	4.14 ± 0.75
Texture	4.13 ± 0.52	3.08 ± 0.59	4.22 ± 0.83
Overall Acceptability	4.07 ± 0.37	3.18 ± 0.51	4.21 ± 0.77

Table 7. Sensory scores of cookies formulated using different proportions of wheat and sago starch

Parameter	Average Value	Just About Right Scale						
		1	2	3	4	5	6	7
		Very Low			Moderate		Very High	
Appearance	4.30	-	-	-	70.00	30.00	-	-
Color	4.23	-	-	3.33	80.00	16.67	-	-
Odor	4.53	-	-	3.33	86.67	6.67	3.33	-
Flavor	4.20	-	-	10.00	76.67	13.33	-	-
Mouth sensibility	4.56	-	-	3.33	86.67	10.00	-	-
Cohesiveness	4.26	-	-	-	96.67	3.33	-	-
Overall Acceptance	4.43	-	-	-	90.00	10.00	-	-

Table 8. Texture values of cookie formulations with and without the addition of sago flour

Product	Hardness (Kg)	Crisp Linear Distance (mm)
Cookie (control)	1.920_+0.385	24.567+_0.768
Cookie with 40 % sago flour	1.693+_0.308	23.541+_0.256

Table 9. Sensory scores obtained for sago cookies containing a 60:40 ratio of wheat flour to sago flour

Wheat: Sago	Sensory Score			
	Appearance	Hardness	Flavor	Overall acceptability
0:100	1.56	2.80	2.50	2.63
20: 80	1.83	2.93	2.60	2.76
40: 60	2.66	3.50	3.13	3.10
60: 40	4.10	4.06	3.70	4.06
80: 20	4.50	4.26	3.76	4.26
100:0	4.50	4.30	3.96	4.30

Table 10. Consumer satisfaction of 1-5 year old children, with sago cookies formulated using a 60:40 proportioning of wheat flour to sago

Preference scale	Number of respondents	Percentage
Most satisfied	36	72
Satisfied	12	24
Neutral	1	2
Less satisfied	-	-
Not satisfied	1	2

Table 11. Consumer satisfaction of 6-15 year olds, with sago cookies formulated using a 60:40 proportioning of wheat flour to sago

Parameter	Consumer Satisfaction									
	Most likely		Likely		Neutral		Less likely		Not at all	
	No.	%	No.	%	No.	%	No.	%	No.	%
Physical Appearance	18	36	28	56	3	6	1	2	-	-
Color	21	42	26	52	2	4	1	2	-	-
Smell	31	62	15	30	4	8	-	-	-	-
Flavor	35	70	15	30	-	-	-	-	-	-
Eating characteristics	34	68	13	26	3	6	-	-	-	-
Overall satisfaction	35	70	13	26	2	4	-	-	-	-

Table 12. Consumer satisfaction of 16-25 year olds, with sago cookies formulated using a 60:40 proportioning of wheat flour to sago

Parameter	Consumer Satisfaction									
	Most likely		Likely		Neutral		Less likely		Not at all	
	No.	%	No.	%	No.	%	No.	%	No.	%
Physical Appearance	15	30	26	52	9	18	-	-	-	-
Color	23	46	20	40	6	12	1	2	-	-
Smell	28	56	17	34	5	10	-	-	-	-
Flavor	34	68	15	30	1	2	-	-	-	-
Eating Characteristics	30	60	18	36	2	4	-	-	-	-
Overall satisfaction	39	78	10	20	1	2	-	-	-	-

Conclusions

Our findings reported here, highlight that sago flour can be used to substitute up to 40 percent of wheat flour in cookie formulations, with good consumer acceptance of the product. Appropriate proportioning of the wheat and sago flour in such formulations was, however, found to be critical in assuring consumer acceptance of appearance and texture of the final product. These findings highlight the considerable potential of sago starch in substituting for wheat flour in cookies and in other bakery and food products and highlights the untapped potential of sago starch in contributing to the food security of local communities in wetland areas where sago palms are grown.

Realizing the true potential of sago starch in food security and livelihoods development will hinge greatly on upgrading the technology for starch extraction in order improve yields, reduce drudgery and provide opportunity for diversified food and non-food uses of sago starch.

This will also necessitate research and training in product development designed to improve consumer acceptance of foods prepared with the incorporation of sago flour. These findings also highlight the need for greater attention and emphasis to be accorded to the improvement of food security crops such as the sago palm.

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