Purple Sweet Potato Soft Bun as a Value-adding of Local Agricultural Production

Boonyaporn Chuamsompong[a*] & Chanchana Siripanwattana[b]

[a] Department of Culinary Technology and Service, School of Culinary Art, Suan Dusit University, Suphanburi Campus, Suphanburi, 72000, Thailand

[b] Department Home Bakery, Suan Dusit University, Bangkok, 10300, Thailand

Abstract

The research was undertaken to study the appropriate substituting level of purple sweet potato (PSP) flour for bread flour in making soft buns. Soft buns with 0-50% PSP flour substituting for bread flour were prepared. Prepared soft buns were visually observed and tests were performed to determined pH, moisture, color, firmness and springiness. A hedonic test was conducted with 30 untrained panelists in order to select the suitable level of PSP flour substitution. The original soft bun and the suitable PSP flour substituted soft bun were compared regarding shelf-life and nutritional values. When PSP flour substitutions were increased from 0 to 50%, visual observation of prepared soft buns showed size decreasing, crust color changed from light golden brown to dark purplish brown, crumb color changed from off white to dark purplish brown, texture was firmer, and springiness was lesser. The pH of the soft buns was 5.47 – 5.65, which were not significantly different. The moisture contents of the soft buns with 10 -50 % PSP flour substitution, 25.03-26.35 %, were significantly different and slightly higher than 24.49 % of the control sample (0% PSP flour substitution). The hedonic test showed that 30 % PSP flour substituted soft bun had the highest score (8.16) on overall liking. Therefore, it was selected as an appropriate soft bun for further study. The shelf-life of the control and 30% PSP flour substituted soft buns stored in polyvinylidenechloride (PVDC) bags with oxygen absorber, resulted in 3 days at room temperature (25 °C) and 7 days at refrigerator temperature (4 °C). Soft bun at 30 % PSP flour substitution had a noticeable increase in vitamin A (from 981.0 to 3105 µg), carotene (from 0.7 to 13.4 mg), vitamin E (from 5.5 to 11.9 mg) and potassium (from 520.4 to1093.4 mg) compared to original one. Commercial PSP soft bun production with 30% PSP flour substitution for bread flour could add value for the local agricultural produce.

Keywords: soft bun, purple sweet potato, shelf-life, nutritional value

**** Corresponding Author. Tel.: +668 9521 8023, E-mail Address: boonyaporn_chu@dusit.ac.th***

Introduction

At present Western foods, especially bakery products, are popular in Thailand. Bakery products can be consumed often, as a snack, refreshment or part of the meal. One of the popular bakery products is soft bun. Soft bun is a semi-sweet bread with soft texture and a sweet taste. It is convenient to eat and suitable to consume in a rush time. Thailand is an agricultural country. The integration of local agricultural produce with soft bun will benefit farmers by adding value their produce and for people to enjoy it."

The main ingredient of the soft bun is high protein wheat flour, known as bread flour. Bread flour contains proteins, glutenin and gliadin that form gluten when kneading the flour with water. Gluten is a protein network that creates a sticky, flexible dough structure. Gluten holds carbon dioxide gas produced by yeast during dough resting and baking (Jammak & Naivikul, 2017). If the amount of gluten is low, the dough structure is not strong enough to retain carbon dioxide gas during baking (Sandstedt, 1961). A good smooth bun should be round, soft, chewy, puffy and elastic (Lopez et al., 2004) Purple sweet potato (PSP) is a native crop commonly grown in Suphanburi Province. (Postharvest and Processing Research and Development Division, 2023). The main composition of PSP is starch, 70% (Limrungruangrat, 2004).

PSP is a source of anthocyanin, a natural antioxidant that can lower blood sugar (i.e., Jang et al., 2019). It is high in phenolics (Grace et al., 2014), contains minerals (Ca, P, Fe and K), Vitamin C, folic acid and dietary fiber (Wolfe, 1992). PSP has

about 3 % fiber (Postharvest and Processing Research and Development Division, 2023) offing benefits to health and adding to the importance of purple sweet potatoes as being a popular food source. It is processed into purple yam flour and developed into various food products such as purple sweet potato cookie products (Charoenphan, 2018).

The objective of this research was to develop a PSP soft bun by partially substituting PSP flour for bread flour, in order to add value to local agricultural produce in Suphanburi Province. The appropriate percent of PSP flour substitution was investigated. The shelf-life and nutritional values of the appropriate level of PSP substituted soft bun was compared with the control. The process technology will be transferred to Suan Dusit Home Bakery of the university, communities, local, public and private organizations in Suphanburi Province. Stakeholder's will be able to utilize purple sweet potato by using technology and knowledge that is suitable for the target group of customers who like to eat healthy bread.

Materials and methods

1. Preparation of purple sweet potato flour

Purple sweet potato (PSPs) from farms in Mueang District, Suphan buri Province, were washed, peeled, cut into 4.5 mm. thick pieces and dried in a hot air oven at 60°C for 7 hr. The dried PSPs were ground with a fine blender and sifted through a 140 - mesh screen. The obtained PSPs flour was stored in polyethylene bags and kept at 10 °C to be used as raw material throughout the research.

2. Preparation of soft buns with PSP flour substitution for bread flour

Soft buns in which bread flour (White Swan Brand) was substituted with PSP flour at 0, 10, 20, 30, 40 and 50 % were prepared. The formulations of the soft buns are shown in Table 1. Both types of flour were sifted and set aside. Cold water, sugar, salt and eggs were mixed to become liquid. The flours and yeast were put in a food processor followed by the liquid part and mixed until combined. The softened butter was added and mixing was continued until the dough could form a thin film when stretched. The dough rested at room temperature for about 20 min, then cut into 30 grams pieces, rolled into a round shape and rested until doubled in volume. The shaped dough was baked at 180°C for 15-20 min and then placed on a grill to cool down. The size of the crust, crumb color and crumb texture of each soft bun sample were visually observed.

Table 1 Formulations of soft buns at various levels of PSP flour substitution for bread flour

Ingredients	PSP flour substitution (%)					
	0%	10%	20%	30%	40%	50%
bread flour	100	90	80	70	60	50
PSP flour	0	10	20	30	40	50
sugar	20	20	20	20	20	20
salt	2	2	2	2	2	2
water	4.5	4.5	4.5	4.5	4.5	4.5
egg	20	20	20	20	20	20
butter	20	20	20	20	20	20
yeast	2	2	2	2	2	2

3. Soft bun properties determination

Properties of prepared soft buns at 0 – 50% PSP flour substitutions were determined as follows.

pH

Ten g. of ground soft bun sample was stirred in 50 ml. of distilled water with a glass rod. The pH of the sample mixture was measured by a standardized pH meter (model Hanna HI5521, and USA).

Moisture

The prepared soft buns were analyzed for moisture content by The Hot Oven method (A.O.A.C, 2000).Known weight (approximately 2 g.) ground soft bun sample was dried in a hot oven at 105 °C for 2 hr, cooled down in a desiccator and reweighed. Repeated the drying until a stable weight was obtained. The moisture content was calculated on a wet basis with the formula:, % MC = (wt. before drying – wt. after drying) x 100 / wt. before drying)

Color

The soft bun sample was ground before color measurement by a Colorimeter (model WF30, China). Color value of each sample was reported as L* (lightness), a* (+ red, - green), b* (+ yellow, - blue)

Texture

The texture of the soft buns was analyzed by a Texture Analyzer (model TA-XT Plus, USA) equipped with compression probe P/100. A compression-relaxation test with a 25% deformation setting was used for two cycles to simulate human chewing. The firmness and springiness were calculated from the TPA (Texture Profile Analysis) graph and reported.

4. Sensory evaluation of soft buns

Sensory evaluation of soft buns at various levels of PSP flour substitution for bread flour, including the control (0% PSP flour substitution), was conducted by a 9-point Hedonic test. A panel of 30 untrained panelists familiar with soft bun were recruited. The samples coded with three-digit random numbers were served in random order. Quality attributes: appearance, color, odor, flavor, texture and overall liking were scored (1 = dislike extremely, 5 = neither like nor dislike, 9 = like extremely) (Chompreeda, 2006). The panelists were requested to provide comments to support scoring. The soft bun with the highest overall liking score was selected as an appropriate product for further study.

5. Soft bun shelf-life determination

Quality of original and appropriate PSP flour substituted soft buns (so called PSP soft bun) were followed at 25°C (room temperature) and 4°C (refrigerator temperature) for 7 days. The soft buns samples were packed in polyvinylidene chloride (PDVC) bags provided with oxygen absorbers. Water activity (aw) of each soft bun sample was measured (aw Sprint Novasina TH-500, Switzerland) on days 1, 3, 5 and 7. Each soft bun sample of 3 pieces (25 g per pieces) by 1 piece:1 package was visually observed for sign of spoilage at the same scheduled times.

6. Soft bun nutritional values and energy determination

The nutritional values of the control soft bun and appropriate PSP soft bun were determined using the Nutrisurvey 2021 program (Version: 2.0.Bureau of Nutrition). The weight (in g.) of all ingredients of the soft bun (total weight of 1045 g., see Table 1) was entered into the program. After program execution, protein, fat, carbohydrate, dietary fiber, polyunsaturated fatty acid (PUFA), vitamins and minerals (in g.) were reported. Energy was calculated from protein, fat and carbohydrate contents and reported in kcal.

7. Statistical analysis

Soft buns preparation was under a Completely Randomized Design (CRD) experiment, while sensory evaluation was under a Randomized Complete Block Design (CBD) experiment. The data were statistically analyzed by SPSS version 19. Analysis of Variance (ANOVA) according to the experiment and Duncan's new multiple range test (DMRT) at a 5% significance level was used.

Results and discussion

1. Purple sweet potato flour

Prepared purple sweet potato (PSP) flour was grounded into a fine powder. It had a light purple color and a smell of purple sweet potato. In soft bun preparation, flour was usually sifted through a 140 - mesh screen before dough making, thus the size of PSP flour (140 - mesh or 0.105 mm.) would not cause any problem in the soft bun process and quality.

2. Properties of soft buns at various levels of PSP flour substitutions

Characteristics of soft buns

The soft bun shape was short cylindrical, with a round top surface. PSP flour affected the characteristics of the soft buns. When more PSP flour was used, the soft bun size was smaller, the texture of the crumb was firmer. Bread flour and PSP flour had different proximate compositions and different types of protein (Limrungruangrat,2004. Substitution PSP flour for bread flour changed the dough composition. Low wheat protein content caused a weak gluten network. Weak gluten network in the dough structure could not retain carbondioxide gas resulted in low oven - spring or size and high firmness of the soft bun (Sandstedt, 1961). The color of the crust changed from light golden brown (control formula, 0% PSP flour) to dark purplish brown (50% PSP flour) and the color of the crumb changed from off white (control formula, 0% PSP flour) to light purple (10% PSP flour) and dark purplish brown (50% PSP flour). The change in color was directly caused by the purple color of the PSP flour. Soft buns with PSP flour had a purple sweet potato aroma and sweet taste, which were stronger at higher substitutions.

pH

The pH of the control soft bun (0% PSP flour substitution) was 5.59, while that of 10 -50 % PSP flour substituted soft buns was between 5.47 – 5.65, as shown in Table 2. All samples were not significantly different, indicating that substitution with PSP flour for bread flour did not change the pH of the product and should not affect the product color. PSP flour contained anthocyanin, a pH relating pigment. Anthocyanin is purple at relatively neutral condition (pH of about 7-8), turns red at a high acidic condition (pH below 3) and turns blue at high base condition (pH is greater than 11). All soft buns had pH of mild acid, then had reddish purple color (Lazze et al., 2004).

Moisture

The moisture contents of the soft buns were 24.49 – 26.35%. (Table 2.) The substitution of bread flour with PSP flour while other ingredients were kept constant, resulted in a little increase in moisture content. It might be that PSP flour has a higher moisture content than bread flour. Higher moisture content might shorten the shelf-life of the product (Moore, 2023).

Table 2 pH and moisture content of soft buns at various levels of PSP substitution

PSP flour substitution (%)	pH^{ns}	Moisture (%)
0	5.59 ± 0.01	24.49^{c} ± 0.06
10	5.49 ± 0.01	26.35^{a} ± 0.04
20	5.54 ± 0.01	25.03^{b} ± 0.007
30	5.65 ± 0.04	25.58^{b} ± 0.94
40	5.47 ± 0.01	25.10^{b} ± 0.90
50	5.52 ± 0.02	25.37^{b} ± 0.73

Remark: The data are shown as mean value (n =3) ± standard deviation, different letters (a, b, c) in the same column showed a statistically significant difference at 5% significance level (P ≤ 0.05)

Color

Color was comprised of 3 dimensional values, L*, a* and b*. Different color value in any dimension resulted in different visual color observed. The soft buns had different colors confirmed by the significant differences (p ≤0.05) in either L*, a* and b* values. When PSP flour substitution increased, soft buns tended to become darker (L*value increasing). The combination of a* and b* values, indicated that the PSP purple color affected the hue color of the soft bun. Increasing PSP flour, the hue color changed from orange toward red and purple. The color values agreed with the visual color observation of the soft buns. If a* 40% or more then it tends to be green.

Table 3 Color values of soft buns at various levels of PSP substitution

PSP flour substitution (%)	L* Lightness	a* (+ red, - green)	b* (+ yellow,- blue)
0	48.33^{a} ± 0.01	-0.24^{e} ± 0.01	12.29^{a} ± 0.06
10	38.02^{b} ± 0.44	7.01^{b} ± 0.01	5.54^{b} ± 0.07
20	18.86^{d} ± 0.05	5.21^{d} ± 0.08	1.71^{c} ± 0.11
30	18.43^{d} ± 0.06	6.97^{c} ± 0.02	1.85^{c} ± 0.07
40	17.01^{e} ± 0.04	-0.10^{e} ± 0.03	0.33^{d} ± 0.04
50	20.19^{c} ± 0.14	9.17^{a} ± 0.10	-1.56^{e} ± 0.18

Remark: The data are shown as mean value (n = 3) ± standard deviation, different letters (a, b, c) in the same column showed a statistically significant difference at 5% significance level (P ≤ 0.05)

Firmness and springiness

The firmness and springiness of the soft buns are shown in Table 4. Compared to the original soft bun, the firmness of soft buns was lower at 10 – 30 % and higher at 40 – 50 % flour substitution. Usually, rigid dough structure takes part in product firmness. Composition of dough at 10 - 30 % PSP flour substitution might result in a dough with low rigidity. At higher PSP flour substitution, gluten was lower because PSP flour did not contain gluten (Tilman et al., 2003). The weak gluten network retained lower gas during baking and lost oven-spring property (Sroan et al., 2009). As expected, the springiness or elasticity was lower at higher PSP flour substitution. Zhu & Sun (2019) reported that when mantou was supplemented with 5-50 % PSP flour, it resulted in an increase of the hardness, while the adhesive and elasticity decreased as a result of gluten dilution by PSP flour. When increasing the amount of black glutinous rice flour, consumers' acceptance of the firmness and toughness decreased. Therefore, Mongkolthanawat and Bunna. (2023) found the appropriate ratio for processing daifuku products from native black glutinous rice is a ratio of white glutinous rice flour to black glutinous rice flour 50:50. (Mongkolthanawat and Bunna. 2023). Changing the wheat flour increases the retention of the flour structure, resulting in a softer texture. Although it does not make the brownie dense and juicy, the performance gains are noticeable through a decrease in the adhesive performance controlled by the brownie processor. This is observed before purifying purple sweet potatoes to the desired level of 50 (Hongpan, Chainarong and Kalawong, 2021).

Table 4 Firmness and springiness of soft buns at various levels of PSP flour substitution

PSP flour substitution (%)	Firmness (N/mm)	Springiness (mm)
0	$210.01^{c} \pm 4.30$	$53.57^{b} \pm 2.64$
10	$152.39^{e} \pm 4.51$	$56.81^{a} \pm 4.09$
20	$88.03^{f} \pm 4.10$	$51.72^{c} \pm 1.47$
30	$191.29^{d} \pm 2.56$	$51.50^{d} \pm 0.19$
40	$973.13^{b} \pm 3.55$	$49.79^{e} \pm 0.80$
50	$1619.57^{a} \pm 4.56$	$43.17^{f} \pm 0.44$

Remark: The data are shown as mean value($n = 3$) ± standard deviation, different letters (a, b, c) in the same column showed a statistically significant difference at 5% significance level ($P \leq 0.05$)

3. Sensory quality attributes of soft buns

The panel of 30 panelists for the sensory evaluation of soft buns were composed of lecturers, staff and students of the Culinary Technology and Service Department of Suan Dusit University. They were not trained in evaluating the quality attributes of soft bun but were familiar with soft bun quality. They scored by personal feelings toward the unknown sample served. The sensory evaluation scores are shown in Table 5. The control soft bun received the highest scores on appearance, color, odor and flavor, second on texture and overall liking. The 30% PSP flour substituted soft bun received the second highest scores on appearance, odor and flavor, the middle score on color and the highest score on texture and overall liking. Most panelists thought that, as a new product, the 30% PSP flour substituted sample was suitable in terms of color, aroma, taste and texture. The 30% PSP flour substituted soft bun was then selected as an appropriate soft bun (so called PSP soft bun) for further study on shelf- life and nutritional values.

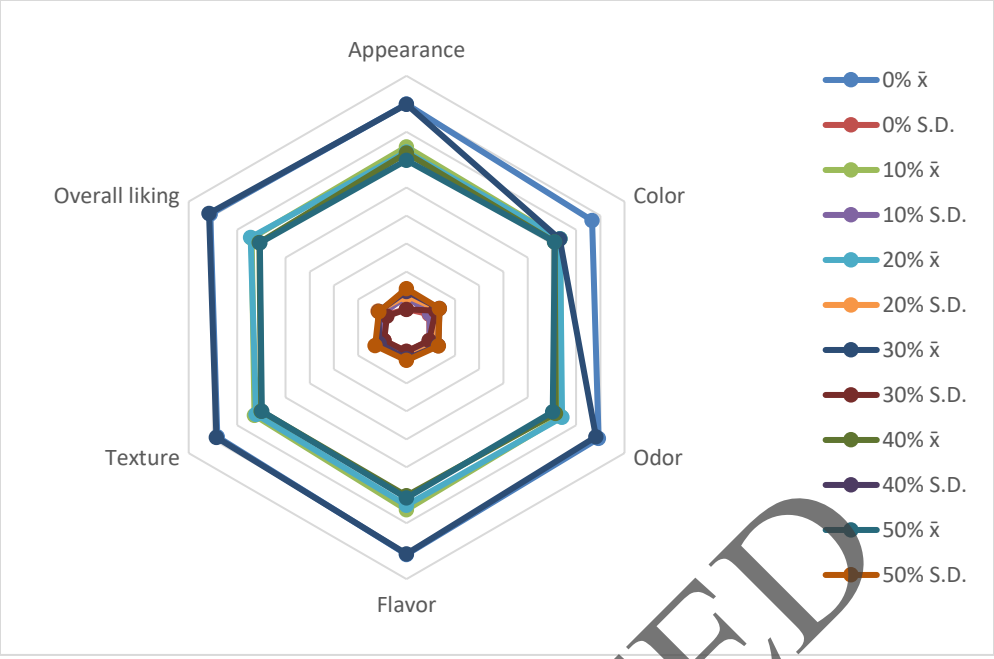

Fig 1. Sensory attribute scores of soft buns at various levels of PSP flour substitution

Remark: The data are shown as mean value (n = 30) ± standard deviation, different letters (a, b, c) in the same row showed a statistically significant difference at 5% significance level ($P \leq 0.05$)

4. Comparison of shelf-life of original soft bun and PSP soft bun (at 30% PSP flour substitution)

Both original and PSP soft buns had high water activity (a_w) of 0.87-0.88, which enables almost all bacteria and fungi to grow (Rattanapanone, 2006). When keeping temperature at 25°C, the a_w of both kinds of soft buns on day 1 to day 5 were not significantly different. The lower a_w of 0.53 and 0.71 of control and PSP soft buns, respectively., The result of lower a_w on day 7 might be caused by being stored for a long time resulting in the,bread drying out,which, makes the bread unappetizing. Therefore, it should be stored in a sealed container or packaging. in order to help extend the shelf life longer. Lower free water lowers the a_w value. At 4°C, the a_w of both soft buns on day 1 and 7 were not significantly different, because the water binding to other molecules is limited at low temperature. Free water which is related to a_w, remained constant. However, the a_w of all soft buns was still above that 0.70 that allowed mold growth (Rattanapanone, 2006). The temperature affected the quality of the soft bun. At 25°C, both the soft buns showed normal appearance on day 1 and 3, but moist surface with black spots of molds was observed on day 5. At lower temperature (4°C) both kinds of soft buns appear normally on day 1 and 7. Study within 7 days to compare with normal room temperature. Observe the changes in the bread, both inside and outside. By keeping it in the refrigerator, it will deteriorate the texture inside, which will help keep it hard and not soft. Keep it for a longer time to maintain the freeze condition.

In conclusion, the original soft bun and PSP soft bun had the same storage quality. They could be kept safely at 25°C for 3 days and at 4°C for 7 days in a polyvinylidene chloride (PDVC) bag with an oxygen absorber. These shelf-lives are normal for bread products without preservatives. Their shelf-lives are sufficient for sale. Which ensures good quality soft bun without food additives.

Table 5 Water activity of original soft bun and PSP soft bun kept at **25°C** and **4°C** for 1-7 days

Soft bun	Keeping time (day)	Water activity (a_w) at temperature	
		25°C	4°C
Original	1	$0.88^{a} \pm 0.00$	$0.88^{b} \pm 0.00$
	3	$0.87^{b} \pm 0.00$	$0.89^{a} \pm 0.00$
	5	$0.80^{c} \pm 0.01$	$0.89^{a} \pm 0.00$
	7	$0.53^{d} \pm 0.01$	$0.82^{c} \pm 0.04$
PSP soft bun	1	$0.87^{a} \pm 0.00$	$0.87^{b} \pm 0.00$
	3	$0.87^{a} \pm 0.00$	$0.88^{a} \pm 0.00$
	5	$0.84^{b} \pm 0.00$	$0.88^{a} \pm 0.00$
	7	$0.71^{c} \pm 0.09$	$0.86^{c} \pm 0.01$

Remark: The data are shown as mean value (n = 30) ± standard deviation, different letters (a, b, c) in the same row showed a statistically significant difference at 5% significance level ($P \leq 0.05$)

5 Comparison of nutritional values and energy

The quantity of nutrients per 1045 g. formulation, or nutritional values in the original soft bun and PSP soft bun (at 30% PSP flour substitution) are shown in Table 6.Thirty percents PSP flour substitution showed major increases in many nutritional values. The most pronounced nutritional values were vitamin A (from 981.0 mg to 3105.0 mg), carotene (from 0.7 mg to 13.4 mg), vitamin E (from 5.5 mg to 11.9 mg), vitamin C (from 0.2 mg to 45.2 mg) and potassium (from 520.4 mg to 1093.4 mg). The energy of the soft buns, calculated from fat, carbohydrate and protein in a formula (1045 g), were 3075.9 Kcal and 2719.2 Kcal. These nutritional values certainly came from PSP flour because the other ingredients were kept constant.

Table 6 Nutritional value comparison of control soft bun and PSP soft bun

Nutritional values	Original soft bun	PSP soft bun
Water (g)	377.2	461.9
Protein (g)	26.9	26.4
Fat (g)	97.6	97.6
Carbohydrate (g)	517.7	429.8
Dietary Fiber (g)	11.9	13.7
PUFA (g)	6.3	6.1
Cholesterol (mg)	636.0	636.0
Vit. A (ug)	981.0	3105.0
Carotene (mg)	0.7	13.4
Vit. E (eq.) (mg)	5.5	11.9
Vit. B1 (mg)	0.8	0.7
Vit. B2 (mg)	0.9	1.0
Vit. B6 (mg)	0.4	0.8
Vit. Fol. Acid. (ug)	478.0	493.0
Vit. C (mg)	0.2	45.2

Sodium (mg)	4056.3	4057.8
Potassium (mg)	520.4	1093.4
Calcium (mg)	159.3	198.3
Magnesium (mg)	107.3	128.3
Phosphorus (mg)	746.0	704.0
Iron (mg)	8.9	8.8
Zinc (mg)	7.4	7.3

Conclusion

The white wheat flour (bread flour) was substituted with PSP flour. The soft buns characteristics changed according to levels of PSP substitution. Color changes from off white to dark purple - brown was caused by the purple color of anthocyanin in PSP. PSP protein did not form gluten. At the same time, the composition of PSP flour might interfere with gluten development. When the content of PSP flour was increased from 10% to 50%, the amount of wheat flour decreased, resulting in the gluten content in the dough being diluted.

The rigid dough structure and weak gluten network contributed to smaller size, of the soft bun as well as, an increases in firmness and decrease in springiness of the soft buns. Soft bun with 30 % PSP flour substitution was appropriate for commercial production since the results showed an overall liking being the highest among all samples. The shelf-life of control soft bun and 30% PSP flour substituted soft bun in polyvinylidene chloride (PVDC) bags with an oxygen absorber, was 3 days at 25°C and 7 days at 4°C. Thirty percent substitution of PSP flour for bread flour increased vitamin A, carotene, vitamin E, vitamin C and potassium but decreased the energy. The result of substituting PSP flour for bread flour will be transferred to Home Bakery and local organization for commercial benefit and to add value for the local agricultural produce.

Acknowledgement

This research was supported by Suan Dusit University, Thailand.

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