Kasetsart J. (Nat. Sci.) 43 : 768 - 779 (2009)

Development of Instant Fried Noodles Made from Composite Flour of Wheat and Sweet Potato Flours

Suparat Reungmaneepaitoon

ABSTRACT

Orange, purple and yellow-fleshed cultivars of sweet potato were prepared to make uncooked (UC) and cooked (C) sweet potato flour. Different preparations of sweet potato flour were used to replace wheat flour in the production of instant fried noodle production. To determine the physicochemical properties and acceptability of instant fried noodles, different percentages (20, 30, 40%) (w/w) of each sweet potato flour sample were used. Total dietary fiber, antioxidant activity, total phenolic content and textural qualities of instant fried noodles were determined. The instant fried noodles with 40% replacement of sweet potato flour with each cultivar increased total dietary fiber more than 10% of the Thai recommended daily intake (RDI). The instant fried noodle with added purple-fleshed sweet potato flour had the highest antioxidant activities, which ranged from 8.27 ± 0.66 to 17.81 ± 0.42 mg vitamin C equivalent (VCE)/100 g, which compared to wheat noodles (3.61 ± 0.07 mg). The total phenolic content was in the range of 38.29 ± 0.81 to 55.58 ± 1.27 mg of gallic acid equivalent (GAE) per 100 g noodles, which was similar to wheat noodles (32.09 ± 0.31 mg). The tensile force and breaking distance of instant fried noodles containing uncooked sweet potato flour of each cultivar were significantly greater than for noodles containing cooked sweet potato flour ($p \leq 0.05$). The tensile force and breaking distance of instant fried noodles containing 20% uncooked purple-fleshed sweet potato flour were not significantly different from wheat noodles ($p \geq 0.05$). The sensory acceptability of instant fried noodles made with 20% sweet potato flour from each cultivar had the highest overall liking scores.

Key words: instant fried noodle, texture, sweet potato flour, total dietary fiber, antioxidant activity

INTRODUCTION

Sweet potato *(Ipomoea batatas* L.*)* is currently a minor root crop grown in Thailand, mainly for fresh market and domestic consumption. The bulkiness of sweet potato, its relatively low cash value per unit of weight and difficulties associated with storage and transportation could be solved by the production of sweet potato flour and utilization of the flour in the production of nutritious products. Commercial use of sweet potato flour and starch has been limited, although it would add economic value to this produce, increase revenue for farmers and processors, and help create new domestic and export market niches for new products. Instant fried noodles have become one of the food products regularly consumed by people from all socioeconomic levels in both urban and rural areas.

Fruits and vegetables are rich sources of phytochemicals, such as carotenoids, flavonoids and other phenolic compounds. Studies have

Institute of Food Research and Product Development, Kasetsart University, Bangkok 10900, Thailand.
E-mail : ifrsrr@ku.ac.th

Received date : 17/03/09 Accepted date : 20/07/09

indicated that these phytochemicals, especially polyphenols, have high, free radical scavenging activity, which helps to reduce the risk of chronic diseases, such as cardiovascular disease, cancer and age-related neuronal degeneration (Ames *et al*., 1993; Smith *et al*., 1996; Diaz *et al*., 1997). The free radicals are generated in the human body through aerobic respiration and exist in different forms, including superoxide, hydroxyl, hydroperoxyl, peroxyl and alkoxyl radicals. Generally, natural antioxidant enzymes in healthy individuals remove these free radicals (Rimbach *et al*., 2005). Increased intake of dietary antioxidants may help to maintain an adequate antioxidant status, defined as the balance between antioxidants and oxidants in a living organism (Halliwell *et al*., 1995). In recent years, several reports have indicated that the phytochemicals in sweet potatoes displayed antioxidative or radical-scavenging activity and exerted several health-promoting functions in humans (Yoshimoto *et al*., 1999; Oki *et al*., 2002; Konczak-Islam *et al*., 2003; Rabah *et al*., 2004). Sweet potato skin tissue, processed or raw, had the highest phenolic acid content and antioxidant potential among the different tissue types.

The possibility of utilizing sweet potato in noodles has been investigated by different researchers (Pangloli *et al*., 2000; Chen *et al*., 2003). Sweet potato flour is generally prepared by drying the peeled slices in a hot-air drier or by drum drying cooked sweet potato into flakes followed by milling and sieving (Woolfe, 1992). The physicochemical properties of sweet potato flour and starch from red and white sweet potato cultivars were compared (Osundhahunsi *et al*., 2003), as have the changes occurring in the characteristics of sweet potato flour as a result of processing in a drum dryer and a hot-air dryer (Yadav *et al*., 2006). Increased utility will depend on the development of proper processing technologies to prepare sweet potato flour with desirable functional properties and on a thorough understanding of the effect of processing on their properties. Researchers have tried to use wheat-sweet potato composite flour in the production of white, salted and yellow, alkaline noodles in raw noodle form (Collado and Corke, 1996; Collado *et al*., 1997). At the time of the current research, there is relatively little data available on the nutritional values of instant fried noodle products made from a composite flour of wheat and sweet potato and no data is available on the antioxidant activity of sweet potato flour and noodle products.

The objectives of this study were: 1) to develop instant fried noodles from wheat flour and sweet potato flour prepared by different techniques using cooked and uncooked flour; 2) evaluate the physical and chemical properties of the products; and 3) evaluate the antioxidant activities of the products.

MATERIALS AND METHODS

Preparation of raw materials and their properties

Wheat flour was purchased from Siam Flour Mill Ltd. Three cultivars of sweet potato were purchased from wholesale markets: orange-fleshed sweet potato from Kanchanaburi province, purple-fleshed sweet potato from Phetchabun province and yellow-fleshed sweet potato from Suphan Buri province.

Preparation of flour

Sweet potato flours were prepared by cleaning, peeling and shredding (4×4 mm cross section). One sample of sweet potato was dried in a dryer at 60°C for 5 hr (uncooked flour, UC). Another sample of sweet potato was cooked in water at 90 ± 5°C for 20 sec, then dried in a dryer at 60°C for 5 hr (cooked flour, C). Dried sweet potato was ground by a pin mill with a particle size of approximately 100-150 μm, according to the methods of Maneepun *et al*. (1992).

Instant fried noodle making

The experimental samples were prepared

according to the basic formulation (Moss *et al.*, 1986). Instant fried noodles were made from the prepared flours by mixing 40% water absorption, 1.5% salt and a 0.5% alkaline solution to make a uniform, smooth and non-sticky dough. The flours were formed into dough sheets of 3 mm thickness and rested for 30 min before further size reduction and cutting. The final cutting roll gap was adjusted to 1.0 mm and the noodle sheet was passed through a cutter and waver. The noodles were steamed in a steamer, placed into a wire basket fitted with a lid and the basket was dipped in hot palm olein at 150-160°C for 1 min, then cooled to room temperature (30 ± 5°C) before packing in a bag of metalized polyethylene. The sample size for one bag was 50 g.

Experimental design

Wheat flour in the noodle recipe was substituted with each type of sweet potato flour. Three levels of sweet potato flour based on total dry mix weight (sweet potato:wheat flour ratios of 20:80, 30:70 and 40:60) with the three cultivars were used, resulting in a total of nine instant fried noodle treatments. Each treatment was prepared in duplicate.

Pasting properties

Sweet potato flours were separately analyzed for pasting properties using a Rapid Visco Analyser (RVA), model 3 D (Newport Scientific Pty Ltd., Warriewood NSW 2102, Australia). A suspension of 3.0 g flour (dry basis) in 25 g of distilled water was heated from 50 to 95°C at the rate of 12°C/min with constant stirring at 160 rpm and held at 95°C for 2.5 min (break down), then cooled to 50°C at a rate of 13°C/min (set back) and held for 2 min. The total cycle was 12.5 min. Pasting temperature was recorded as the temperature at which an increase in viscosity was first observed. The values reported included pasting temperature (°C), peak viscosity (measured in RVU), final viscosity (RVU), trough (lowest viscosity, RVU), break down (the difference between peak viscosity and trough, RVU), set back from peak (the difference between final viscosity and peak viscosity, RVU) and set back from trough (the difference between final viscosity and trough, RVU).

Sweet potato extracts

The sweet potato flour and instant fried noodles were homogenized in 40 ml 100% aqueous methanol at room temperature and centrifuged at 4500 g for 30 min. The supernatants were made up to 100 ml, stored in capped bottles and kept at 4°C until further use to determine antioxidant activity and total phenolic content.

DPPH radical scavenging activity

DPPH scavenging activity was determined using a modified method of Ohnishi *et al.*, (1994). The free radical scavenging activity of food extracts were tested, indicated as bleaching of the stable 1,1 -diphenyl-2-picrylhydrazyl radical (DPPH). A diluted extract of the right concentration, 0.15 ml, was added to 0.85 ml of the methanolic DPPH solution, 0.1 mM. The mixture was vertexed and allowed to stand at room temperature. After 20 min, the absorbance was recorded at 517 mm. A control consisted of 0.15 ml of 95% aqueous ethanol and 0.9 ml of 0.1 mM DPPH solution. DPPH % scavenging activity (%SA) was calculated as %SA = (C-X) 100/C, where C is the absorbance of the control and X is the absorbance of the extract.

Antioxidant capacity

Interpretation of the antioxidant capacity was based on the ability of the sample extract to scavenge free radical DPPH compared to that of an antioxidant. In order to express the antioxidant activity of food extracts in familiar terms, antioxidant capacity as mg vitamin C equivalent (VCE)/g fresh weight was used. A standard curve of vitamin C (ascorbic acid, Fisher Scientific) was obtained from DPPH %SA (x) plotted against various vitamin C concentrations (y). Prepared concentrations of vitamin C solution were 0.5, 1.0, 1.5, 2.0 and 2.5 mg/100 ml distilled water. The resulting regression line was described by y = 0.0401x + 0.1286.

Determination of total phenolic content

Total phenolic content was determined using the Folin-Ciocalteau reagent, adapted from Singleton and Rossi (1965). Two milliliters of suitable diluted sample extracts was transferred and reacted with 10 ml of Folin-Ciocalteau reagent (previously diluted tenfold with distilled water) in a 25 ml volumetric flask. After 30 sec and before 8 min, 8 ml of 7.5% of sodium carbonate was added and mixed, and the contents of the flask made up to volume with distilled water. Solutions were heated in a 40°C water bath for 30 min. The color was developed and absorbance measured at 765 mm. The standard curve was prepared using 0, 0.5, 1.0 and 1.5 ml of gallate stock solution (8 mg/100 ml) in a 25 ml volumetric flask. The regression line between absorbance (y) and gallic acid content (x) was described by y = 0.0010x + 0.2033.

Color measurement

The color of the experimental flour and noodle was measured using the CIELAB 1976 L*, a* and b* color scale. The measurements were carried out in triplicate at three random locations on the surface of each sample using a spectrophotometer (Spectraflash 600 plus, Datacolor International, USA). The CIE color values were recorded as L* = lightness (0 = black, 100 = white), a* (-a* = greenness, +a* = redness) and b* (-b* = blueness, +b* = yellowness).

Texture measurement

The textural qualities of the cooked noodles, in tensile strength and breaking distance (extensibility) were measured on a Texture Analyser, model TA-XT_{2i} from Stable Micro System Ltd (Vienna Court, Lammas Road, Godalming, Surrey GU7 1YL England), using Spaghetti Tensile grips (A/SPR) at a pre-test speed of 3.0 mm/s, a test speed of 3.00 mm/s and a post-test speed of 5.00 mm/s. The noodles were tested individually within 5 min after cooking and the result of each sample was expressed as an average of ten measurements.

Chemical properties of instant fried noodle

Instant fried noodles were analyzed for moisture, protein, fat, ash and dietary fiber contents using the standard methods of AOAC (2000).

Sensory acceptability

The noodle samples were cooked in boiling water for 4 min and drained for 1 min. The cooked samples (50 g) were placed in covered, white plastic cups and were evaluated by 30 panelists using balanced in completed block design (t = 10, k = 3, r = 9, b = 30, λ = 2). A nine-point hedonic scale (1 = dislike extremely, 9 = like extremely) was used to evaluate acceptability of sensory attributes (color, flavor, elasticity, smoothness, firmness, and overall liking) of plain noodles. Evaluation was conducted mid-morning.

Statistical analysis

The physical and sensory data were analyzed using analysis of variance (ANOVA). Duncan's multiple range test (DMRT) was applied to determine the significant differences among the means at the 95% confident level.

RESULTS AND DISCUSSION

Color

Color measurements in terms of the L*, a* and b* values of the sweet potato flours were significantly different (Table 1). The color of cooked sweet potato flour was darker (lower L* value), with more chromaticity (higher a* and b* value) than uncooked sweet potato flour.

Pasting properties

The pasting temperature of UCO and

UCY flours were in the range of 83.95 to 86.35°C and were higher than UCP flour (79.20°C) (Table 2). This finding was similar to that of Noda *et al.*, 1996. Uncooked flour (UCO) had the highest breakdown value and UCP had the highest setback value. The UCP flour had a greater retrogradation tendency than the UCO and UCY flours. The setback values of all cooked flours were lower (8.80 to 13.25 RVU) than for uncooked flour (58.92 to 111.59 RVU) because starch was gelatinized in water at 90 ± 5°C for 20 sec. The setback value of uncooked purple flour (UCP) was the highest and it had the lowest breakdown value among uncooked flours.

Antioxidant component

The antioxidant components of the sweet potato flours from different treatments and different cultivars are shown in Tables 3 and 4. The total phenolic content of uncooked flour

Table 1 Color measurement of sweet potato flour from cooked (C) and uncooked (UC) sweet potato.

Sweet potato flour		L*	a*	b*
Orange	(UCO)	86.62 ± 0.01b	3.06 ± 0.02c	18.16 ± 0.02b
	(CO)	81.27 ± 0.02d	5.94 ± 0.03a	20.26 ± 0.02a
Purple	(UCP)	76.60 ± 0.01e	3.56 ± 0.01c	12.75 ± 0.03e
	(CP)	70.67 ± 0.02f	4.39 ± 0.01b	14.46 ± 0.01d
Yellow	(UCY)	89.69 ± 0.02a	0.62 ± 0.02e	12.22 ± 0.02e
	(CY)	83.07 ± 0.01c	1.39 ± 0.01d	15.30 ± 0.03c

Means within a column with the same letters are not significantly different (p ≥ 0.05) by ANOVA and DMRT.

Table 2 Pasting properties of sweet potato flour and wheat flour obtained from RVA measurement.

Flour		RVU					
		Peak Viscosity	Trough	Final viscosity	Break down	Set back from peak	Set back from trough
Wheat flour		344.08 ± 1.28a	186.25 ± 4.10b	326.50 ± 2.28a	157.83 ± 1.20a	-17.58 ± 0.51d	140.25 ± 2.00a
Orange	(UCO)	304.92 ± 1.51a	182.67 ± 2.10b	246.00 ± 2.54b	122.25 ± 2.20a	-58.92 ± 2.41a	63.33 ± 2.40b
	(CO)	22.62 ± 0.76d	22.08 ± 1.04d	32.67 ± 0.45d	0.58 ± 0.70d	10.05 ± 0.78d	10.59 ± 0.70d
Purple	(UCP)	265.33 ± 2.04b	200.33 ± 0.56a	311.92 ± 1.60a	65.00 ± 2.01c	46.58 ± 0.65b	111.59 ± 0.50a
	(CP)	18.75 ± 0.25d	18.58 ± 0.22d	27.42 ± 0.70d	0.17 ± 0.20d	8.67 ± 0.58d	8.84 ± 0.64d
Yellow	(UCY)	258.75 ± 1.20c	164.83 ± 1.24c	223.75 ± 0.75c	93.92 ± 1.20b	-35.00 ± 0.85c	58.92 ± 1.50c
	(CY)	25.42 ± 0.50d	25.42 ± 0.50d	38.67 ± 0.80d	0.00 ± 0.48d	13.25 ± 0.90d	13.25 ± 0.68d

Means within a column with the same letters are not significantly different. (p ≥ 0.05) by ANOVA and DMRT.

Table 3 Antioxidant capacity and total phenolic content of sweet potato flour.

Sweet potato flour		Antioxidant capacity (mg vitamin C equivalent VCE/ 100 g)	Total phenolic content (mg gallic acid equivalent GAE/ 100 g)
Orange	(UCO)	7.54 ± 0.44c	46.05 ± 3.22b
Purple	(UCP)	17.26 ± 0.20b	47.35 ± 2.20b
Yellow	(UCY)	4.63 ± 0.58c	43.04 ± 1.73b
Orange	(CO)	7.71 ± 0.16c	51.26 ± 2.23b
Purple	(CP)	35.86 ± 0.12a	73.39 ± 0.86a
Yellow	(CY)	6.02 ± 1.02c	47.59 ± 1.62b

Means within a column with the same letters are not significantly different (p ≥ 0.05) by ANOVA and DMRT.

ranged from 43.04 ± 1.73 to 47.35 ± 2.20 mg GAE/100 g of flour and the total phenolic content of the cooked flour was in the range 47.59 ± 1.62 to 73.39 ± 0.67 mg GAE/100 g flour. For each cultivar of sweet potato, the phenolic content of cooked flour was higher than that of uncooked flour. These findings were supported by the study of Huang *et al*., (2006), who reported that steam treatment increased the total phenolic content and scavenging DPPH radicals of sweet potato flours. Dewanto *et al*. (2002a) found that the free phenolic component of sweet corn increased with increasing heating temperature and time. Thermal processing had no effect on the phenolic content of tomato (Dewanto *et al*., 2002b). Antioxidant activities of cooked sweet potato flours (6.02 ± 1.02 to 35.86 ± 0.12 mg VCE/100 g) were higher than in uncooked flour (4.63 ± 0.58 to 17.26 ± 0.20 mg VCE/100 g). The cooked purple-fleshed flour (CP) had higher antioxidant capacity (35.86 ± 0.12 mg VCE/100 g) and phenolic content (73.39 ± 0.86 mg gallic acid equivalent GAE/100 g) than CO and CY flour because the purple flour had more anthocyanin than the other cultivars had (Huang, *et al*., 2006). Teow *et al*. (2007) also reported that the total antioxidant activity (hydrophilic + lipophilic ORAC) was the highest (27.2 μmole Trolox equivalent (TE)/g fresh weight) for NC 415

Table 4 Antioxidant capacity and total phenolic content of instant fried noodles with added sweet potato flour from different cultivars.

Instant fried noodles		% RSA (Radical Scavenging Activity)	Antioxidant capacity (mg vitamin C equivalent VCE/100 g)	Total phenolic content (mg gallic acid equivalent GAE/100 g)
Wheat noodle		16.09 ± 0.39f	3.61 ± 0.07g	32.09 ± 0.31d
Orange sweet potato flour				
UCO	20 %	23.52 ± 0.27e	5.27 ± 0.45e	35.15 ± 0.34c
	30 %	29.77 ± 1.13e	6.57 ± 0.24d	36.97 ± 1.68c
	40 %	39.39 ± 0.73c	7.92 ± 0.13d	37.33 ± 1.48b
CO	20%	29.05 ± 0.06e	6.04 ± 0.01d	36.41 ± 0.81c
	30 %	34.54 ± 0.79d	7.25 ± 0.15d	37.63 ± 0.65b
	40 %	43.52 ± 1.87c	8.13 ± 0.33c	38.14 ± 1.20b
Purple sweet potato flour				
UCP	20 %	38.29 ± 3.29d	8.27 ± 0.66c	38.29 ± 0.81b
	30 %	40.90 ± 9.47c	8.29 ± 0.27c	38.80 ± 0.58b
	40 %	43.63 ± 1.87c	8.93 ± 0.45c	39.87 ± 0.17b
CP	20%	56.13 ± 2.38b	11.45 ± 0.45b	49.86 ± 1.95a
	30 %	81.32 ± 2.21a	16.33 ± 0.44a	52.08 ± 1.56a
	40 %	92.84 ± 2.27a	17.81 ± 0.42a	55.58 ± 1.27a
Yellow sweet potato flour				
UCY	20 %	20.00 ± 1.18e	4.36 ± 1.82f	35.54 ± 1.20c
	30 %	22.99 ± 0.65e	4.48 ± 1.92f	35.20 ± 1.40c
	40 %	25.63 ± 1.80e	5.06 ± 0.89e	35.84 ± 1.62c
CY	20%	21.17 ± 0.56e	4.60 ± 0.01f	35.75 ± 1.68c
	30 %	26.28 ± 0.85e	5.89 ± 0.17e	36.05 ± 0.25c
	40 %	29.24 ± 0.51e	6.23 ± 1.07d	37.12 ± 0.81b

Means within a column with the same letters are not significantly different ($p \geq 0.05$) by ANOVA and DMRT.

(purple-fleshed) and lowest (2.72 μmole Trolox equivalent TE/g fresh weight) for Xushu 18 (white-fleshed).

Antioxidant capacity varied widely among the samples of instant fried noodles made with different cultivars of sweet potato flour. The instant fried noodles with cooked purple-fleshed sweet potato flour (CP) had the highest %RSA (56.13 ± 2.38 to 92.84 ± 2.27), antioxidant capacity (11.45 ± 0.45 to 17.81 ± 0.42 mg VCE /100 g) and total phenolic content (49.86 ± 1.95 to 55.58 ± 1.27 mg gallic acid equivalent GAE/ 100 g) among the three cultivars of sweet potato flour. The instant fried noodles made with sweet potato flour were significantly different in antioxidant capacity from the wheat noodles.

Chemical properties

The chemical properties of instant fried noodles made with different ratios of sweet potato flour are shown in Table 5. The results showed that as the amount of sweet potato flour increased, the protein content in the noodles decreased, while the ash content and total dietary fiber content of the noodles increased. The protein content and total dietary fiber content of the noodles were significantly different ($p \leq 0.05$). The instant fried noodles made from the composite flour of wheat flour and sweet potato flour 40% had a total dietary fiber content more than 10% of the Thai RDI (Table 5).

Table 5 Chemical properties of instant fried noodles.

Instant fried noodle		Moisture^{ns} %	Protein % db	Ash^{ns} % db	Total dietary fiber g/100g	Total dietary fiber % RDI
Wheat noodle		7.57 ± 0.24	13.30 ± 0.02a	2.16 ± 0.02	2.84 ± 0.01d	5.68d
Orange sweet potato flour						
UCO	20 %	7.79 ± 0.23	11.11 ± 0.02b	2.58 ± 0.12	2.58 ± 0.01d	5.16d
	30 %	7.93 ± 0.17	10.20 ± 0.08b	2.66 ± 0.06	3.88 ± 0.02c	7.76c
	40 %	7.88 ± 0.01	9.58 ± 0.12c	2.98 ± 0.06	5.20 ± 0.01b	10.40b
CO	20 %	7.41 ± 0.15	10.87 ± 0.01b	2.43 ± 0.02	2.40 ± 0.01d	4.80d
	30 %	7.13 ± 0.02	9.62 ± 0.01c	2.54 ± 0.02	3.80 ± 0.02c	7.66c
	40 %	7.74 ± 0.11	8.79 ± 0.03c	2.84 ± 0.03	5.20 ± 0.04b	10.40b
Purple sweet potato flour						
UCP	20 %	7.40 ± 0.12	10.72 ± 0.05b	2.23 ± 0.03	2.64 ± 0.02d	5.28d
	30 %	7.02 ± 0.04	9.60 ± 0.01c	2.28 ± 0.01	3.96 ± 0.04c	7.92c
	40 %	7.48 ± 0.01	8.55 ± 0.01c	2.41 ± 0.06	5.20 ± 0.07b	10.40b
CP	20 %	7.76 ± 0.05	10.50 ± 0.07b	1.94 ± 0.02	2.32 ± 0.02d	4.64d
	30 %	7.35 ± 0.08	9.17 ± 0.09c	1.99 ± 0.01	3.48 ± 0.01c	6.96c
	40 %	7.38 ± 0.06	9.02 ± 0.04c	2.10 ± 0.02	5.10 ± 0.04b	10.20b
Yellow sweet potato flour						
UCY	20 %	7.75 ± 0.10	11.06 ± 0.08b	2.55 ± 0.01	3.52 ± 0.03c	7.04c
	30 %	7.83 ± 0.11	10.90 ± 0.08b	2.68 ± 0.01	5.28 ± 0.02b	10.56b
	40 %	7.20 ± 0.15	9.10 ± 0.10c	2.80 ± 0.02	7.40 ± 0.02a	14.80a
CY	20 %	7.51 ± 0.13	10.56 ± 0.02b	2.39 ± 0.01	3.36 ± 0.04c	6.72c
	30 %	7.55 ± 0.10	10.33 ± 0.06b	2.53 ± 0.01	5.04 ± 0.06b	10.80b
	40 %	7.59 ± 0.18	9.00 ± 0.05c	2.64 ± 0.05	6.72 ± 0.03a	13.44a

Means within a column with the same letters are not significantly different ($p \geq 0.05$) by ANOVA and DMRT.

Texture measurement

The textural qualities of instant fried noodles are shown in Table 6 and Figure 1. The textural qualities of the noodles made with 20, 30 and 40% replacement with each cultivar of sweet potato flour were significantly different ($p \le 0.05$) and noodles with 20% replacement flour had higher tensile force and breaking distance than either of the other noodle mixtures. The instant fried noodles with sweet potato flour had considerably less tensile force than wheat noodles. The tensile force and breaking distance of noodles with 20, 30 and 40% replacement for each cultivar of sweet potato flour were significantly different from the wheat noodles at $p \le 0.05$. The tensile force and breaking distance of the noodles made with uncooked sweet potato flour decreased as the sweet potato flour content increased from 20 to 40% replacement as shown in Figure 1. As the amount of cooked sweet potato flour increased from 20 to 40% of the total composite flour, the tensile force decrease was not significantly different at $p > 0.05$ and there were lower values than in noodles made from uncooked sweet potato

Table 6 Textural qualities of cooked noodle with added sweet potato flour.

Instant fried noodles	Tensile force (g force)	Breaking distance (mm)
Wheat noodles	22.67 ± 0.93a	49.25 ± 6.38a
Orange sweet potato flour		
UCO flour		
20 %	16.15 ± 1.75b	32.44 ± 6.91ab
30 %	12.67 ± 1.21b	25.46 ± 4.15b
40 %	10.30 ± 0.95b	21.84 ± 4.15b
CO flour		
20 %	8.83 ± 1.63c	20.61 ± 4.59c
30 %	7.45 ± 1.00c	16.09 ± 4.60c
40 %	7.00 ± 1.40c	6.55 ± 5.52d
Purple sweet potato flour		
UCP flour		
20 %	21.34 ± 3.64a	46.93 ± 6.43a
30 %	14.00 ± 1.34b	30.46 ± 6.84ab
40 %	12.20 ± 1.61b	28.93 ± 6.77ab
CP flour		
20 %	9.51 ± 1.69c	22.54 ± 4.25b
30 %	8.03 ± 0.54c	18.59 ± 2.60c
40 %	7.01 ± 0.29c	7.74 ± 1.72d
Yellow sweet potato flour		
UCY flour		
20 %	18.51 ± 1.53b	38.48 ± 5.76a
30 %	14.68 ± 1.38b	32.16 ± 5.93ab
40 %	10.10 ± 1.50c	22.40 ± 4.20b
CY flour		
20 %	9.29 ± 0.82c	20.04 ± 3.40c
30 %	8.93 ± 1.37c	18.21 ± 2.24c
40 %	7.11 ± 1.21c	7.50 ± 1.58d

Means within a column with the same letters are not significantly different ($p \ge 0.05$) by ANOVA and DMRT.

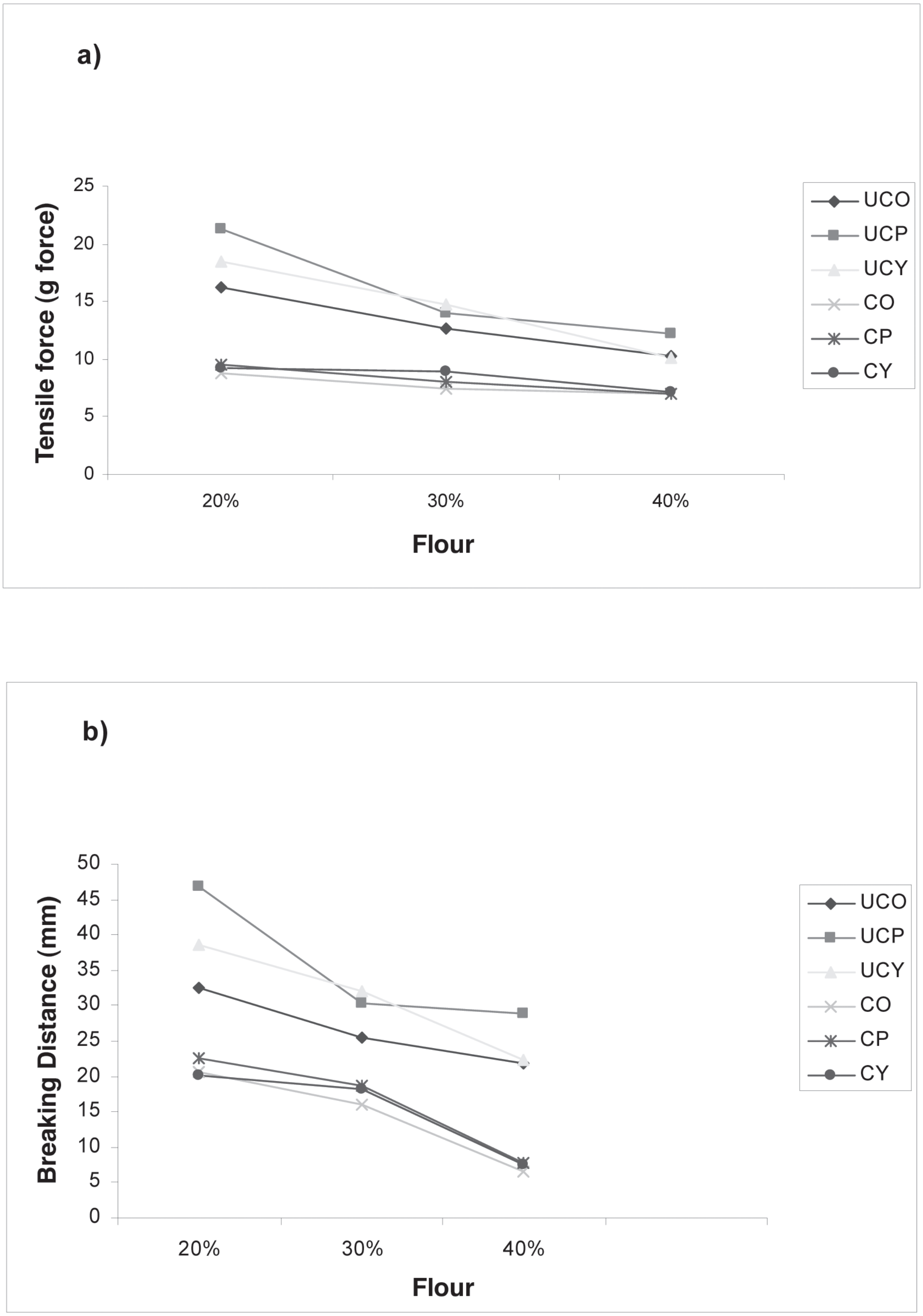

Figure 1 Textural qualities of cooked noodles with added sweet potato flour: a) tensile force; and b) breaking distance.

flour. Instant fried noodles made with uncooked purple-fleshed sweet potato had the highest tensile force and breaking distance values among the flour mixtures. The textural qualities of the noodles with 20% UCP were not significantly different from the control (p > 0.05). The instant fried noodles with uncooked sweet potato flour content of more than 20% had considerably lower tensile force and breaking distance than wheat noodles.

Sensory evaluation

The mean values of the hedonic scores for sensory attributes of cooked instant fried noodles samples are shown in Table 7. The amount of sweet potato flour from each cultivar affected ($p \leq 0.05$) the sensory acceptability of color, flavor, elasticity, smoothness, firmness and overall liking. For each sweet potato cultivar, the hedonic scale scores for elasticity, firmness, and overall liking of the products made with 20% uncooked flour were higher than those of products made with 30% and 40% replacement flour.

CONCLUSION

The study revealed that the cooked and uncooked treatment and cultivars of sweet potato flour affected the chemical properties by decreasing protein content and tensile force and breaking distance, and increasing total dietary fiber content and antioxidant capacity, compared with noodles made from 100% wheat flour. The textural qualities of instant fried noodles made with uncooked sweet potato flour were significantly higher than for noodles made with cooked flour. The sensory liking scores in terms of overall liking and firmness for the instant fried noodles with 20% replacement of uncooked sweet potato flour were higher than the scores for noodles made with 30% and 40% sweet potato flours. The results of this study indicated that instant fried noodle replacement with cooked purple-fleshed sweet potato flour showed good antioxidant properties. Consumption of these products might be beneficial for humans in preventing oxidative damage, with

Table 7 Sensory scores of instant fried noodle prepared from composite flour of wheat-sweet potato flour.

Instant fried noodles	Color	Odor	Flavor	Elasticity	Smoothness	Firmness	Overall liking
Wheat flour	7.51a	7.39a	7.55a	8.09a	7.75a	7.70a	7.61a
Orange sweet potato flour							
UCO							
20 %	7.64a	6.97b	6.85b	6.32b	6.98ab	6.93a	6.85a
30 %	7.10a	6.72b	6.24b	6.48b	7.06b	6.78b	6.39b
40 %	7.20a	6.20b	6.08b	5.50c	6.75b	5.32c	5.31c
Purple sweet potato flour							
UCP							
20 %	5.41b	6.51b	6.85b	7.38b	6.98ab	7.33a	7.22a
30 %	5.07b	6.97b	6.32b	6.78b	6.54b	6.98ab	6.42b
40 %	5.02b	6.99b	6.39b	5.80c	6.52b	5.93c	6.01c
Yellow sweet potato flour							
UCY							
20 %	7.40a	7.08a	6.85b	6.78b	7.12ab	7.30a	6.98a
30 %	7.12a	6.70b	6.70b	6.78b	6.51b	6.01c	6.55b
40 %	7.17a	6.85b	6.74b	5.40c	6.50b	5.30c	5.67c

Means within a column with the same letters are not significantly different ($p \geq 0.05$) by ANOVA and DMRT.

purple-fleshed sweet potato being a healthy food choice for consumers.

ACKNOWLEDGEMENTS

The research was financially supported by the Kasetsart University Research and Development Institute (KURDI).

LITERATURE CITED

Ames, B.M., M.K. Shigena and T.M. Hagen. 1993. Oxidants, antioxidant and the degenerative diseases of aging. **Proc. Nat. Acad. Sci. U.S.A.** 90: 7915-7922.

AOAC. 2000. **Official Methods of Analysis of AOAC International**. 17th ed, Horwitz, W. editor, Maryland, USA.

Chen, Z., H.A. Schols and A.G.J. Voragen. 2003. Starch granule size strongly determines starch noodle processing and noodle quality. **J. Food Sci.** 68: 1584-1589.

Collado, L. S., L. B. Mabesa and H. Corke. 1997. Genetic variation in color of sweet potato flour related to its use in wheat - based composite flour products **Cereal Chem.** 74: 681-686.

Collado, L. S and H. Corke. 1996. Use of wheat-sweet potato composite flours in yellow-alkaline and white-salted noodles. **Cereal Chem.** 73: 439-444.

Dewanto, V., X.Wu and R.H. Liu. 2002a. Processed sweet corn has higher antioxidant activity. **J. Agric. Food Chem.** 50: 4959-4964.

Dewanto, V., X.Wu, K.K. Adom and R.H. Liu. 2002b. Thermal processing enhances the nutritional value of tomatoes by increasing total antioxidant activity. **J. Agric. Food Chem.** 50: 3010-3014.

Diaz, M.N., B. Frei, J.A. Vita and J.F. Keaney. 1997. Antioxidants and atherosclerotic heart disease. **N. Engl. J. Med.** 337: 408 - 416.

Halliwell, B., M.A. Murcia, S. Chirico and O.I. Aruoma. 1995. Free radicals and antioxidants in food and *in vivo*: what they do and how they work. **Crit. Rev. Food Sci. Nutr.** 35: 7 - 20.

Huang, Y.C., Y.H. Chang and Y.Y. Shao. 2006. Effect of genotype and treatment on the antioxidant activity of sweet potato in Taiwan. **Food Chem.** 98: 529-538.

Konczak-Islam, I., Y. Yoshimoto, D. Hou, N. Terahara, N. Terahara and O. Yamakawa. 2003. Potential chemopreventive properties of anthocyanin-rich aqueous extracts from in vitro produced tissue of sweet potato. **J. Agric. Food Chem.** 51: 5916-5922.

Maneepun, S, S. Reungmaneepaitoon and M. Yunchalad. 1992. Sweet potato starch and flours research in Thailand, pp. 229-241. *In* **Product Development for Root and Tuber Crops, Volume Asia,** *CIP.*

Moss, H.J, D.M. Miskelly and R. Moss. 1986. The effect of alkaline conditions on the properties of wheat flour dough and Cantonese-style noodles. **J. Cereal Sci.** 4: 261-268.

Noda, T., Y. Takhata, T. Sato, H. Ikoma and H. Mochidas. 1996. Physicochemical properties of starches from purple and orange fleshed sweet potato roots at two levels of fertilizer. **Starch / Starke** 48: 395-399.

Ohnishi, M., H. Morishita, H. Iwahashi, S. Toda, Y. Shirataki, M. Kimura and R. Kido. 1994. Inhibitory effects of chlorogenic acids on linoleic acid peroxidation and hemolysis. **Phytochemistry** 36: 579-583.

Oki, T., M. Masuda, S. Furuta, Y. Nishiba, N. Terahara and I. Suda. 2002. Involvement of anthocyanins and other phenolic compounds in radical-scavenging activity of purple-fleshed sweet potato cultivars. **J. Food Sci.** 67: 1752-1756.

Osundhahunsi, O. F., T. N. Fagbemi, E. Kesselman and E. Shimoni. 2003. Comparison of the physico-chemical properties and pasting characteristics of flour and starch from Red and White sweet potato cultivars. **J. Agric. Food Chem.** 51: 2232 - 2236.

Pangloli, P., J. Collins and M.P. Penfield. 2000. Storage conditions affect quality of noodles with added soy flour and sweet potato. **Int. J. Food Sci. and Technol.** 35: 235-242.

Rabah, I.O., D.X. Hou, S.I. Komine and M. Fujii. 2004. Potential chemopreventive properties of extract from baked sweet potato (*Ipomoea batatas* lam. Cv. Koganesengan). **J. Agric. Food Chem.** 52: 7152-7157.

Rimbach, G., J. Fuchs and L. Packer. 2005. Application of nutrigenomics tools to analyze the role of oxidants and antioxidants in gene expression, pp. 1-12. *In* G. Rimbach, J. Fuchs and L. Packer (eds.). **Nutrigenomics**. Boca Raton, FL: Taylor and Francis.

Singleton, V.L. and J.A. Rossi. 1965. Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. **Am. J. Enol. Vitic.** 16: 144-158.

Smith, M.A., G. Perry, P.L. Richey, L.M. Sayre, V.E. Anderson, M.F. Beal and N. Kowal. 1996. Oxidative damage in Alzheimer's **Nature** 382: 120 - 121.

Teow, C.C., V.D. Truong, R.F. Mefeeters, R.L. Thomson, K.V. Pecota and G.C. Yencho. 2007. Antioxidant activities, phenolic and b-carotene contents of sweet potato genotypes with varying flesh colours. **Food Chem.** 103: 829-838.

Woolfe, J. 1992. **Sweet Potato: An Untapped Food Resource.** Cambridge University Press. Cambridge, U.K. 643 p.

Yadav, R., A. Guha, M. Tharanathan and R. S. Ramteke. 2006. Changes in characteristics of sweet potato flour prepared by different drying techniques. **LWT.** 39: 20 - 26.

Yoshimoto, M., S. Okuno, M. Yoshinaga, O. Yamakawa, M. Yamaguchi and J. Yamada. 1999. Antmatanicity of sweet potato (Ipomoea batatas) roots. **Biosci. Biotechnol Biochem.** 63: 537-541.