Physicochemical Properties of Dried Noodle with Tomato Lycopene Supplement

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Abstract : Dried noodle is a favourite food; however, it contains high carbohydrates and sodium but low in fibre, vitamins and antioxidant. Thus, the aim of this study was to develop healthy noodle with tomato lycopene supplement. Lycopene of locally grown tomatoes was obtained by hydrolyzing pectinase and cellulase enzymes. The lycopene extract was added in noodle at 0. 5. 10. 15, and 20% by weight of wheat flour. Physicochemical properties and sensory attributes of the dried noodles were investigated. Results revealed that the dried noodle supplemented with 5-20% of lycopene received higher overall acceptability score by 30 panelists than that of the control sample. Lycopene contents in the developed dried noodle ranged between 1.41 and 26.50 mg/100g sample (db). Twenty percents of lycopene supplement in dried noodle had the highest score of overall acceptability, whereas the color value, cooking loss, tensile strength, hardness, adhesiveness, springiness, cohesiveness, gumminess and chewiness were 61.92, 13.56, 51.73, 10.28% 0.108 N, 1.45 N, -3.18 g/sec., 0.89, 0.48, 0.70 and 0.62, respectively.

Keywords : lycopene, pectinase enzyme, cellulase enzyme, texture properties

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1. Introduction

The consumption level of noodles has become one of the fastest growing sectors in Asian countries, due to their ease to cook and long shelf-life. Noodles are available both in fresh and dried forms at Asian markets and they are often available in dried form elsewhere. Traditional dried noodles are claimed to lack on dietary fiber, vitamins and minerals. Dried noodles are made from well mixture of hard wheat flour, salt, eggs, corn starch, and oil that forms stiff dough. The dough is rolled and cut into strips about 1-2 millimeters in width and then cut to 2-4 meter in length and hung on rods. The noodles drying process is controlled through a three-stage process from semidried (18-25% moisture content), pre-dried and final dried to less than 14%wee moisture content. Cooked noodles of good quality should remain firm, not lose solidity in cooking water, and not become sticky and soggy when standing after cooking. Noodle texture is also an important attribute of noodle quality. Consumers prefer noodle with medium firmness and strong chewiness texture [1]. Some researchers found that good quality Japanese noodles may be produced by flour with amylose content between 22-24% [2]. Flour with lower amylose content gave noodles smooth surface and soft texture. In addition, flour protein content is corrected with cooked noodle texture. Low protein content causes noodles to have soft texture which is easily broken during the drying process [3]. The gluten network is responsible in giving noodles cohesive integrity and structural strength during processing. Therefore, the higher protein content leads to lower cooking losses in traditional and extrudated wheat noodles [4] and takes longer cooking times by slowing down water penetration into the noodle [5].

The development of food-products for consumers has two main properties. The first is traditional nutritional aspects of the food, and the second is the expected, additional health benefits from its regular ingestion. Several studies have suggested that consumption of tomato lycopene has beneficial effect on human health [6][7]. Lycopene, the main carotenoid found in tomatoes and tomato-based products, has been reported to be protective against several types of cancer. It has attracted attention due to its biological and physicochemical properties, especially its effect as a natural antioxidant. Although it has no provitamin A activity, lycopene does exhibit a physical quenching rate constant with singlet oxygen almost twice as high as that of β-carotene [7]. The bioavailability of cis-isomers in food is higher than that of all-trans isomers. Lycopene bioavailability in processed tomato products is higher than in unprocessed fresh tomatoes [8]. Lycopene has been under considerable investigation for its antioxidant benefits in treating various chronic human diseases like cancer, cardiovascular diseases, osteoporosis and diabetes [9]. Lycopene could be extracted from biological sources, preferably from genetically-engineered cells or ripe fruit portions, such as skins and tissues, with an appropriate organic solvent or a mixture of solvents that are themselves readily removable from the extract. Tomatoes are an excellent source of lycopene because they contain one of the highest known concentrations of lycopene in nature. Kanyakam & Uriyapongson [10] reported that lycopene extracted from tomato paste industry waste hydrolyzed with pectinase, cellulase and hemicellulose for 50 min incubation time with ethyl acetate gave the highest lycopene yield (50.3 mg/100 g sample). Furthermore, Pongjanta et al. [11] also reported that lycopene extraction from local tomatoes puree by using 0.2% pectinase and cellulase enzyme hydrolysis for 3 h had the highest lycopene content between 18 to 25 mg/100 g sample, wet basis, depended on varieties of local grown tomato. Thus, the objectives of this study were to utilize tomato lycopene supplement in dried noodle and determine the sensory attribute, color value, texture characteristic and cooking quality of the dried noodles.

2. Materials and Methods

Raw materials used were No. 1 variety of local grown tomatoes harvested from experimental field at Agricultural Technology Research Institute, Lampang, Thailand. Wheat flour, commercial wheat starch and corn starch used for this study were obtained from F.A. Group of Company, Bangkok, Thailand. Salt, eggs, vegetable oil and baking powder were purchased from Big C. Supermarket, Lampang Branch, Thailand. The enzymes used, pectinase (Ultra-SPL) and cellulase (Celluclast, 700 EGU/g) were purchased from Novozyme, Denmark. All chemicals and reagents used were of analytical grade from Merck, Germany.

2.1. Tomato lycopene extraction

Lycopene was extracted from ripe local grown tomato according to the method described by [11]. The production of lycopene caked for food application was involved of 4 steps. Firstly, ripened tomatoes were subjected to blanching at 95°C for 5 min and passed through screw press to produce puree. Secondly, the tomato puree was hydrolyzed by 0.2% pectinase enzyme in shaker water bath at 50°C for 2 h and then continued to hydrolyze with 0.2% cellulase enzyme at 50°C for 3 h. Thirdly, the tomato solution was immediately inactivated by heating at 95ºC for 10 min. Finally, the tomato solution was centrifuged at 5,000 rpm for 10 min to remove water and produced a fresh lycopene cake. The fresh lycopene cake obtained was analyzed for moisture content, lycopene content and color value before utilization in dried noodle.

2.2. Preparation of dried noodle with tomato lycopene supplement

Different levels of tomato lycopene cake; i.e. 0, 5, 10, 15, and 20% of wheat flour, were added into wheat flour. The functional ingredients, such as guar-gum (0.47%), tapioca flour (2.97%), and baking powder (0.13 %), were also added into wheat flour (100%). The dried ingredients were initially mixed at low speed with dough hook in a mixer bowl (KitchenAid KSM500PS Kenwood) prior to the addition of solution that contained 17.85, 14.88, 1.19 and 2.87% of water, whole eggs, salt and vegetable oil, respectively. Then, the ingredients were mixed at two speeds for 3-5 minutes to give uniform, smooth, non-sticky noodle dough. The noodle dough was left for 20 min and kneaded by hand for 1 min. The kneaded dough was folded and sheeted through a manual noodle maker (SHH-Food machine, China) to get the final thickness of noodle sheet at about 1.00 mm. The noodle sheet was cut into noodle strands of 0.90 mm width with a slitter for 1 m in length. The fresh noodle strands were hung on the rods in a controlled temperature and relative humidity room. The drying process had 3 stages of air drying to prevent the noodles from cracking. In the first stage, the fresh noodles were dried at low temperature (15°C) with high humidity (75%) for 1 hour. The moisture content of the noodle stands were reduced from 30-35% to 20 – 25%. In the second stage, air was removed from the interior of the noodle strands to outside surfaces by drying over night at room temperature (35°C) for 16 h to reduce moisture content from 20-25% to 15 – 20%. The pre-dried noodle strands were then cut into 20 cm length. Finally, the noodle samples were further dried at 60°C in a tray dryer to reduce moisture content to 8-10%. The dried noodles were kept in aluminum foil bag, stored at room temperature (30°C) before sensory evaluation and physiochemical analyses. All noodle samples were produced in triplicates.

2.3. Sensory evaluation

Dried noodles were presented to the panelists as boiled with soup. The dried noodles were placed in wire mesh baskets and boiled for 8 min, then cooled in water and drained for 30s. About 3-4 g portions were put into soup cup before serving to panelists within 15 min. The cooked noodle samples were evaluated by 30 semi trained panelists based on appearance, color, odor, taste and overall acceptance on a 9-point hedonic scale (1 = extremely dislike, 9 = extremely like) [12].

2.4. Color measurements

Color changes of dried and cooked noodle samples were measured by performing color meter (JS 555, Japan) evaluation, which involved the measurement of the following 3 parameters: lightness/brightness or whiteness, (*L**), in which black had no reflection and white had perfect diffuse reflection; greenness-redness (a*), in which the negative values indicated green and positive values indicated red; and blueness-yellowness (b*), in which negative values indicated blue and positive values indicated yellow color.

2.5. Texture properties analysis

Dried noodle of each sample (20 g) was cooked in 500 ml boiling water for 7 min and then rinsed with cold water. Ten replicates of cooked noodles were evaluated by a TA.XT2 texture analyzer (Stable Micro Systems, Ltd., Godalming, Surrey, UK) at 15 min after cooking. A set of six strands of cooked noodles was placed in parallel on a flat metal plate and compressed crosswise twice to 75% of their original height using a 3.175 mm metal blade at speed of 2.5 mm/sec. From force-time curves of the Texture profile analysis (TPA), hardness, springiness, cohesiveness, and adhesiveness were determined according to the description of [13]. The TPA values reported are the averages of 10 different determinations. Tensile strength of noodles was measured by using Texture Analyzer (TA-XT Plus, Stable Micro Systems, Surre, UK) as described by [14]. A strand of cooked noodle was wound around parallels of the tensile tester. The upper arm was set to travel apart from the lower arm at the speed of 1 mm/s. The maximum force (N) required to break the noodles gave an indication of the sample's resistance to breakdown, and the distance (mm) to breakdown indicated the extensibility. The experiments were replicated 20 times and calculated by TA software.

2.6. Analysis of Lycopene content

Lycopene content in tomato, tomato lycopene and dried noodle were quantified using the colorimetric method proposed by [15]. Weight of 0.5 g of sample were added into 20 mL of extraction solution (25% ethanol: 50% hexane: 25% acetone + 0.05% of BHT) in a dark flask. The lycopene solution was agitated at 5 speed levels for 15 min. then intermediately 3 mL of deionized water was added. The upper red-orange solution was separated by standing for 5 min. in dark container. The absorbance of the hexane layer at 503 nm wave length was determined and the lycopene content was calculated using an extinction coefficient of 17.2 x 104 /M cm.

2.7. Cooking quality of dried noodles

The optimum cooking time of the five treatments of dried noodles was determined according to AACC Method 66-50 [16]. Approximately 5 g of dried noodles were cooked in 200 mL of distilled water in a 500 mL beaker until the white core of un-gelatinized starch in the center just disappeared. Cooking loss of the noodles was determined as described in the [16]. Five grams of noodles were added into a beaker containing about 200 mL of boiling water and the beaker was covered with a glass window. The noodles were cooked for 8 min with slight agitation. The cooked noodles were allowed to drain for 5 min and then weighed. The gruel was poured into a 200 mL volumetric flask and adjusted to volume with distilled water. Twenty milliliters of the solution was pipetted into an aluminum dish and dried to a constant weight at 105 $^{\circ}$C and evaporated to dryness. The residue was weighed and calculated for: Cooking loss = (residue in cooking water [g]/noodle weight before cooking [g]) x 100. The volume increase coefficient was calculated as a ratio of volume of the cooked dried noodle to that of raw dried noodle.

2.8. Statistical Analysis

A Completely Randomized Design was used to evaluate means of physicochemical analysis of the dried noodle samples. A Randomized Completely Block Design (RCBD) was applied to the sensory evaluation with the panelists as a blocking factor. Data obtained for the physic-chemical properties and sensory evaluation were subjected to Analysis of Variance (ANOVA), followed by Duncan’s Multiple Range Test procedure for difference between treatments using a computer program.

3. Results and Discussions

3.1. Physiochemical properties of tomato lycopene

Moisture content, lycopene content and color values of fresh ripe tomato and lycopene extract from ripened tomatoes are shown in Table 1. Results revealed that moisture content in the fresh ripe tomato (93.34%) was not significantly different ($p>0.05$) from tomato lycopene (93.72%). On the other hand, lycopene content in tomato lycopene cake was 5 times greater than that of fresh ripe tomato which were 21.53 and 4.82 mg/100g sample (wet weight basis), respectively. The result from this study was in agreement with the results reported by Zuorro et al. (2011) that lycopene content in tomato peel was increased by 11 times after hydrolysis with pectinase and cellulose enzyme [17]. This result showed that lycopene was mainly found in tomato cellulose and hemicelluloses. Furthermore, color values (*a* b**) of tomato lycopene were significantly different ($p<0.05$) from the fresh ripe tomato which was the highest of *a** and *b** values in tomato lycopene, while *L** value of tomato lycopene was decreased from the fresh ripe tomato.

Table **1:** Physiochemical properties of fresh ripe tomato and lycopene extract from local tomatoes

Tomato samples	Physiochemical properties				
	Moisture content (%)	Lycopene content (mg/100g, wb.)	Color value		
			*L**	*a**	*b**
Fresh tomato	93.34±0.06 ns	4.50 ± 0.39 b	34.00±1.41 ns	23.84±3.61 b	26.32±2.72 b
Tomato lycopene	93.72± 0.56	21.53± 0.12 a	32.60±0.40	30.53±0.28 a	39.62±0.40 a

a,b : Means in a column with a different upper script letter are significantly different ($p<0.05$)

ns : not significantly different ($p>0.05$)

3.2. Sensory evaluation of cooked lycopene noodle

Sensory attributes (appearance, color, odor, flavor, texture, and overall acceptance) of cooked lycopene noodle were presented in Table 2. Results revealed that the scores of cooked noodle treatments with 10- 20% of tomato lycopene added were significantly higher (7.33-7.47) than that of the control and of 5% tomato lycopene added (6.23-6.53). Color preference of the noodle was significantly affected ($p<0.05$) by the addition of tomato lycopene, which was increased with the high level of added lycopene. In addition, appearance, odor, flavor, texture, and overall acceptance scores were not different ($p>0.05$) among treatments. However, the sample with 10% of tomato lycopene added in noodle received the highest scores (7.03) for the overall acceptance.

Table 2: Sensory evaluations of cooked dried noodle at different levels of wheat flour enriched with tomato lycopene cake by using 9- point Hedonic scale.

Added lycopene (%)	Appearance	Color	Odor	Taste	Texture	overall acceptance
Control	7.13 ±1.10 ns	6.23±1.36 b	6.67±1.15 ns	6.60±1.19 ns	7.00±1.26 ns	6.90±0.99 ns
5	7.07±0.91	6.53±1.01 b	6.33±0.92	6.43±0.90	6.60±1.10	6.63±0.93
10	7.50±0.68	7.37±0.85 a	6.23±0.97	6.77±0.86	6.97±1.16	7.03±0.72
15	7.53±0.57	7.47±0.57 a	6.27±0.91	6.63±0.89	6.67±1.09	6.93±1.01
20	7.40±1.00	7.33±1.06 a	6.53±1.31	6.80±0.92	6.70±1.12	7.10±0.99

a,b,c : Means in a column with a different upper script letter are significantly different ($p<0.05$)

ns : not significantly different ($p>0.05$)

3.3. Color value and lycopene content of dried noodles

One of the first quality parameters that consumers consider is color of the product. Recently, most consumers prefer food products with natural color, especially noodle product. Color value results of the dried noodle enriched with tomato lycopene suggested that the color *a** and *b** values were dramatically increased from 0.18 - 12.14 to 19.58 - 39.90, respectively, with the increasing levels of tomato lycopene cake (0-20% of wheat flour) in the dried noodle formula. The color value of dried noodle related with lycopene content in the dried noodle increased from 1.41 to 26.50 mg/100g on dry weight basis. Furthermore, the color value (*a** and *b**) of cooked noodle had a similar trend with the dried noodle but with greater values. The color *a** and *b** value of cooked noodle ranged between -1.60 to 13.56 and 16.76 to 51.73, respectively

Table 3: Color value of raw and cooked dried noodle and lycopene content of dried noodle

Added lycopene (%)	Color of dried noodle			Color of cooked noodle			Lycopene content (mg/100g)
	*L**	*a**	*b**	*L**	*a**	*b**	
Control	85.51±0.01^{a}	0.18±0.04^{e}	19.58±0.11^{e}	76.59±0.04^{a}	-1.60±0.04^{e}	16.76±0.13^{e}	1.41+0.01^{c}
5	80.82±0.01^{b}	7.44±0.04^{d}	31.20±0.21^{d}	69.55±0.03^{b}	7.32±0.04^{d}	35.26±0.18^{d}	11.54+0.30^{b}
10	77.38±0.01^{c}	9.94±0.05^{c}	36.24±0.13^{c}	66.81±0.01^{c}	10.20±0.04^{c}	42.98±0.23^{c}	13.38+0.10^{b}
15	75.25±0.06^{d}	10.38±0.06^{b}	37.92±0.25^{b}	66.03±0.10^{d}	11.52±0.07^{b}	47.10±0.35^{b}	24.83+0.10^{a}
20	73.62±0.01^{e}	12.14±0.06^{a}	39.90±0.20^{a}	61.92±0.01^{e}	13.56±0.07^{a}	51.73±0.55^{a}	26.50+0.20^{a}

^{a,b,c}: Means in a column with a different upper script letter are significantly different (p<0.05)

^{ns} : not significantly different (p>0.05)

3.4. Moisture content and cooking qualities

Moisture content and cooking times of all dried noodle samples were not significantly different (p>0.05) among treatments which ranged between 6.62-7.60% and 7.14-7.38 min, respectively. Tomato lycopene supplemented in noodle formula caused significant differences (p<0.05) in cooking loss, volume increase coefficient and tensile strength of samples (Table 4). The noodle samples with 10–20% tomato lycopene enrichment had significantly (p<0.05) higher cooking loss than those of the 0-10% addition. This cooking loss values could occur because of a disruption of protein-starch matrix from a diluted gluten fraction in the noodle flour. According to the Croatian Official Regulation, noodle cooking loss should not exceed 12%. The volume increase coefficient was decreased with higher levels of added tomato lycopene in the range of 3.19-3.92. In addition, tensile strengths of the cooked noodle samples were significantly different (p>0.05) among treatments (Table 4). The lowest tensile strengths were in the cooked noodles that contained 20% of tomato lycopene supplement. Tomato lycopene could not function as an effective ingredient to fortify network structures of the noodle. Park & Baik [18] reported on a rapid decrease of tensile strength which indicated a significant correlation with protein content. These results are in line with Limroongreungrat et al. [19] who reported that the noodle with Moringa leaves powder addition had tensile strengths between 0.085- 0.103 N.

Table 4: Moisture content and cooking quality of cooked dried noodles with different levels of tomato lycopene supplement

Added lycopene (%)	Moisture content (%)	Cooking time (min.)	%Cooking loss	Volume increase coefficient	Tension (N)
Control	6.62 ± 0.79^{ns}	$7.14+0.19^{ns}$	9.14 ± 0.02^{c}	3.92 ± 0.02^{a}	0.205 ± 0.01^{a}
5	7.08 ± 0.79	$7.16+0.16$	9.26 ± 0.06^{b}	3.76 ± 0.04^{b}	0.120 ± 0.01^{b}
10	7.34 ± 0.74	$7.23+0.11$	10.26 ± 0.03^{a}	3.48 ± 0.04^{c}	0.118 ± 0.00^{bc}
15	7.21 ± 0.83	$7.38+0.04$	10.24 ± 0.01^{a}	3.56 ± 0.02^{c}	0.111 ± 0.02^{bc}
20	7.60 ± 0.28	$7.38+0.04$	10.28 ± 0.02^{a}	3.19 ± 0.08^{d}	0.108 ± 0.01^{c}

^{a,b,c} : Means in a column with a different upper script letter are significantly different ($p<0.05$)

^{ns} : not significantly different ($p>0.05$)

3.5. Texture characteristic of cooked noodle

Texture attributes of cooked noodle were determined by hardness, springiness, cohesiveness, gumminess, chewiness, and adhesiveness using a TPA Texture Analyzer. The hardness, gumminess and chewiness of the experimental cooked noodles were significantly different ($p<0.05$) among the five treatments (Table 5). Results showed that the hardness, gumminess and chewiness values of the noodle with lycopene supplement were higher than that of the control. However, as the amount of tomato lycopene cake increased, the hardness, gumminess and chewiness values tended to decrease. The enrichment of noodle with different levels of tomato lycopene showed insignificant difference ($p>0.05$) in springiness, cohesiveness, and adhesiveness of the cooked noodle samples. Results of springiness (which indicated recovery percentage) of noodle indicated that when the levels of tomato lycopene cake addition increased, the noodle required more time to recover its shape. Gumminess and chewiness were secondary parameters, whereas determination of gumminess was calculated by multiplying hardness with cohesiveness. Results showed that gumminess decreased with an increased amount of tomato lycopene in the noodles.

Table 5: Texture profile analysis of control cooked dried noodle and tomato lycopene dried noodle

Added lycopene (%)	Texture profiles					
	Hardness (N)	Springiness	Cohesiveness	Gumminess	Chewiness	Adhesiveness (g/sec.)
CONTROL	**1.22±0.04^{D}**	**0.85±0.04^{NS}**	**0.48±0.01^{NS}**	**0.59±0.03^{B}**	**0.50±0.04^{B}**	**-2.52±1.54^{NS}**
5	**1.65±0.12^{A}**	**0.84±0.04**	**0.47±0.01**	**0.77±0.07^{A}**	**0.64±0.06^{A}**	**-3.60±1.04**
10	**1.62±0.05^{AB}**	**0.89±0.04**	**0.45±0.03**	**0.73±0.06^{A}**	**0.65±0.08^{A}**	**-3.77±1.36**
15	**1.51±0.07^{BC}**	**0.88±0.06**	**0.48±0.03**	**0.73±0.04^{A}**	**0.64±0.07^{A}**	**-2.51±1.04**
20	**1.45±0.11^{C}**	**0.89±0.02**	**0.48±0.02**	**0.70±0.08^{A}**	**0.62±0.06^{A}**	**-3.18±1.32**

^{a,b,c} : Means in a column with a different upper script letter are significantly different (p<0.05)

^{ns} : not significantly different (p>0.05)

4. Conclusions

Results of the present study showed that dried noodles with health promoting components from tomato lycopene could improve qualities of the product. As the tomato lycopene cake from 5 - 20% of wheat flour was added in dried noodle formula, more observations showed superior lycopene content, sensory acceptance, volume increase coefficient hardness, gumminess and chewiness. Thus, the lycopene extracted from local grown tomato could be a new ideal ingredient for application in other food products, especially in bakery product, to help people who are suffering from degenerative diseases associated with today's changing life styles and environment.

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