OPTIMIZATION OF DRUM DRYING PROCESS PARAMETERS FOR PUMPKIN POWDER PRODUCTION AND ITS SUBSTITUTION IN RICE NOODLES

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ABSTRACT

Drum drying condition for pumpkin powder was optimized by using response surface methodology. These values were determined at 313.54kPa steam pressure and 1.27rpm rotation drum speed which produced powder with low moisture, small differences in color but high in crude fiber, β-carotene content, WAI and good sensory score. The second-order polynomial fitted equations for each powder quality parameters showed high R2 and insignificant lack of fit. Moreover, pumpkin powder was added to rice noodle to study its effects on quality and sensory of noodle. The noodle with 7.5% pumpkin powder was considered as the best option due to its high amount of fiber and β-carotene, higher rehydration ratio, low cooking time and cooking loss, while sensory scores were highest.

1. INTRODUCTION

Pumpkins are a delicious fruit with sweet taste and natural fragrance, so they have commonly been processed to juice, puree, pickles and dried products. However, the main factor that leads to the various utilizations of pumpkin is due to their high nutritional value of the fresh mass as a good source of carotene, water-soluble vitamins, minerals and dietary fiber. Therefore, in agriculture, food-processing, pharmaceuticals and the feed industry, the interest in pumpkin fruit and pumpkin-derived products increased in recent years. Although pumpkins have a good shelf-life, there are various changes in the chemical composition during pumpkin storage due to a relative high in water content which causes unfavorable changes in biological quality and sensory qualities. So, to the raw material needs to be applied a proper process to improve the quality and prolong the storage of the finished product.

For powder production from fruit or vegetable, drum drying is considered a special method for numerous materials with many benefits such as good characteristics of product and economic efficiency of the process. The pumpkin powder may be a finished product as instant drinking product after mixing with water or a half-finished product which can be used for further processing as ingredients in pies, soups, stews, breads or baby foods. Although the double drum performance is affected by all of the feeds’ concentration, steam pressure, rotation speed of drum and the gap between drums (Taruna, 1998 & Puntigo, 2006), the most important variables of drum drying process are steam pressure and drum speed (Rodriguez G. et al., 1996).

The main objective of optimization is determining the levels of independent variables that lead to best characteristics of a particular product, such as physicochemical, colorimetric, sensory and nutritional properties, without extending
excessively experiment time with a large number of assays (Granato, Branco & Calado, 2011). Response surface methodology is more and more used by researchers for developing, improving and optimizing processes in food science due to its high efficiency, comprehensive theory, and simplicity (Pua, Hamid, Mirhosseini, Rahman & Rusul, 2009).

According to a recent Health Focus International survey, one of the top ten nutrition trends nowadays is that consumers are becoming very interested in the health benefits which are provided by certain foods. Due to their wide use, the noodles can be important vehicles for fortification with various nutrients such as lysine fortified noodle, soybean milk noodle or noodle fortified with palm powder (Fu, 2008). Beside their nutritional value with high amount of β-carotene, dietary fiber and some mineral, pumpkin also performed as a substitute in some foods, for example, instant fried wheat noodle (Lee, Cho, Lee, Koh, Park & Kim, 2002) or wet noodle (Rustanti, 2009). However, studies on effects of pumpkin powder on rice noodle are not available.

Therefore, the research was conducted to identify the optimum condition of laboratory scaled drum dryer for pumpkin powder production. Moreover, due to their functional value of β-carotene and dietary fiber content, this study also investigated the incorporation of pumpkin powder into rice noodle quality for nutritious as well as health-care products.

2. MATERIALS AND METHODS

2.1 Materials

The hard and dark green skin pumpkin varieties were purchased at Talat Thai market in Thailand.

Rice flour brand name Thai Barn Sam Sian was purchased from the supermarket.

Chemicals used for analysis and construction of the standard curve were purchased from U&V Holding (Thailand) Co., Ltd. in Bangkok, Thailand.

2.2 Preparation of sample

Puree: Pumpkins were cleaned in water, peeled and seeds removed. The pumpkin pulp was cut into 1.5x1.5cm and then blanched in boiling water (1% NaCl) to inactivate enzymes. The puree was made by blender from pulp mixed with 40% v/w filtered water to reduce the solid content and viscosity.

Powder: The pumpkin flake was obtained from each stage of the drying process after one complete drum cycle was ground by blender to reduce its particle size. A powdered pumpkin was then sieved to allow less than or equal to 60 mesh screen size. The powder was finally packaged in impermeable plastic and kept at room temperature.

Noodle: the procedure followed Boonyanipat with a slight modification as described. Forty percent of flour suspension (dry weight basis) was prepared and allowed to absorb water for 1 hour. Forty ml of suspension was transferred into a 13x20cm tray and then steamed for 3 minutes. After cooling at room temperature for 2 minutes, it was removed from the tray and then dried in the oven at 50°C for 10 minutes to reduce the moisture content. The noodles were placed on a plastic sheet and covered with half-dry unbleached cloth for 4.5 hours and cut into 7mm strands. The noodle strands were dried at 50°C for 3 hours. The dried noodles were stored in plastic bags.

2.3 The drum dryer

The structure of this dryer can be divided into three main units.

The drum was made from stainless steel. Both drums had an outside diameter cylinder of approximately 166 mm and 235 mm of length. These drums were equipped with scrapper blades that were made from brass which were of the same length as the drums.

Source of heat for drums was generated and supplied by Hung-Lin autoclave model 35-7D.
made in Taiwan. The steam entered the drum dryer through the pipes inlet where was placed in the bottom side adjacent to the steam outlet and was circulated by way of insulated piping system. Double drum was driven by rotator unit which consisted of an electrical motor (3 phases), speed reducer, pulley, gear and belt.

2.4 Experimental design
The response surface methodology was applied in this experiment. By using Stat graphic Century XV.I program, the experiment was based on a face-centered central composite (CCD) design with a total of 13 experimental conditions as in Table 1.

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Symbol</th>
<th>Coded values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam pressure (kPa)</td>
<td>SP</td>
<td>300 350 400</td>
</tr>
<tr>
<td>Rotation speed (rpm)</td>
<td>RS</td>
<td>0.5 1.0 1.5</td>
</tr>
</tbody>
</table>

The behavior of response surface was investigated for the response function \( Y_i \) using the polynomial regression equation. The generalized response surface model is given:

\[
Y = \beta_0 + \beta_1x_1 + \beta_2x_2 + \beta_{11}x_1^2 + \beta_{22}x_2^2 + \beta_{12}x_1x_2
\]

Where:
\( Y \): the estimated response calculated by the model
\( \beta_0 \): a constant term;
\( \beta_1 \) and \( \beta_2 \): the linear coefficients;
\( \beta_{11} \) and \( \beta_{22} \): the quadratic coefficients;
\( \beta_{12} \): the interaction coefficients.

2.5 Analysis methods
2.5.1 \( \beta \)-carotene
\( \beta \)-carotene content was determined by AOAC Official Methods using UNICAM UV/ Vis Spectrophotometer UV2 model with some modifications.

Sample was ground using mortar and passed through sieve No.40. Accurately weighed sample of 2.0000g and put into 100ml volumetric flask which was wrapped with aluminum foil preventing light exposure. 20ml extractant (mixed solvent of hexane-acetone-absolute alcohol-toluene: 10+7+6+7) was pipetted into flask, stoppered and swirled for 1 minute. For low moisture sample as mixed powder, also pipette 1 ml H2O/2g sample into flask, stoppered and swirled for 1 minute. Then, sample was saponified to eliminate foreign materials.

Hot saponification (for rapid extraction): 2ml methanolic KOH 40% was pipetted into flask; swirled for 1 minute and placed in 56°C water bath for 20 minutes. Air condenser or cool neck of flask was attached to prevent loss of solvent. After that, the mixture was cooled and let stand in the dark 1 hour. Then 30ml hexane was added to the flask; swirled for 1 minute, and let stand in the dark 1 hour. Then 30ml hexane was added to the flask; swirled for 1 minute, and let stand in the dark 1 hour before measuring the absorbance of upper phase.

\( \beta \)-carotene concentration of the sample solution was determined by measuring their absorbance at 436nm and 460nm on spectrophotometer and substituted in standard equation which was set up by using 98.17% \( \beta \)-carotene.

2.5.2 Crude fiber
Crude fiber content was determined by Fibertec System M 1020 Hot Extractor as described in AOAC (1984). A lipid-free sample in crucible was digested with boiling H2SO4 (0.128 M) and thereafter by NaOH (0.313 M). The remaining
residue was dried at 1300°C for 2 hours and then incinerated at 5000°C for 3 hours.

2.5.3 Water absorption index (WAI)

WAI was determined according to Mariotti et al (2005). 2.5g sample was suspended in 30 ml distilled water at 30°C in a previously weighed 50 ml centrifuge tube, stirred intermittently over 30 min and then centrifuged at 3000g for 10 min.

2.5.4 Cooking quality

Cooking time: 5 g of rice noodle was cooked in 200 ml distilled water to study their cooking time. After every 30 seconds the noodle strands were removed from boiling water and pressed between two pieces of watch glass. Optimum cooking time was achieved when the center of the noodles was fully hydrated.

Rehydration ratio and cooking loss: 60 ml of distilled water were heated in 250 ml beaker, and then 1 gram of dried noodles was added to the boiling water. The samples were washed with 20 ml distilled water, drained for 5 minutes and weighed immediately. The combination of filtrate and washing was placed in 100 ml volumetric flask then the volume was adjusted to 100 ml with distilled water. 25 ml of solution was transferred into a Petri dish and dried at 105°C for 18 hours to determine dry matter contents.

2.5.5 Texture quality

Texture of noodles was evaluated by using compression test of Texture Analyzer. One strand of cooked noodle which was prepared as described was placed on a Plexiglas plate and compressed to 65% of noodle height using a 20 mm cylinder stainless steel probe (P/20) with a plate end. The pause between the first and second compression was 0.5 sec. The typical force-time curve obtained by Texture Profile Analysis was used to determine the texture of starch noodles in term of hardness, springiness, stickiness and cohesiveness.

2.5.6 Sensory test

Both Multiple comparison test and Hedonic test were used in this experiment.

2.6 Data Analysis

The experiments are performed in triplicates. Data was subjected to statistical analysis of variance (ANOVA) test and Fisher’s Least Significant Difference (LSD) test or Duncan Multiple Range Test (DMRT) to compare between treatments at 5% significant level by using SPSS version 12. Software MS. Excel 2007 and Statgraphic Century XV.I also used to analyze the optimization drying process.

3. RESULTS AND DISCUSSION

The drum surface temperature obtained stability after nearly 15 minutes connected to autoclave as steam source. Although the surface temperature really increased with the increase of steam pressure, temperature was not uniform over drum surface, so it is difficult to determine the exact temperature corresponding to each level of steam pressure. It is also noted that the position which was nearer the steam inlet of the drum had the highest temperature, and it gradually decreased along the distance of drum.

3.1 Effect of drum drying process on powdery dried pumpkin qualities

The effect of steam pressure (SP) and rotation speed of drum (RS) on the physical properties and sensory quality of pumpkin powder are shown on Table 2.

3.1.1 Moisture contents

After one revolution of the drum which was equivalent to drying time of 25.17 - 75.5s, the moisture content of puree reduced rapidly from a very high initial moisture content of 89.47% to range of 3.01% to 8.42%. There was a slight increase in moisture content of all pumpkin powder (4.002-10.020%) compared to the pumpkin flake removed from drum dryer due to absorbing water of powder when the relative humidity of the surrounding air is increased which formed liquid bridges between powder particles.
and resulted in greater powder cohesion and reduced flow ability (Teunou & Fitzpatrick, 1999). However, the change in moisture of powder was similar among experimental conditions. These results showed that final moisture content of powder was reduced with the decrease of (RS) and conversely with the increase of (SP).

Table 2. Experiment design and data obtained for the response variables

<table>
<thead>
<tr>
<th>SP</th>
<th>RS</th>
<th>MC (% wb)</th>
<th>Fiber (% db)</th>
<th>Carotene (mg/g db)</th>
<th>Color ΔL*</th>
<th>Δa*</th>
<th>Δb*</th>
<th>WAI (g/g db)</th>
<th>Sensory test</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>8.423</td>
<td>10.233</td>
<td>0.870</td>
<td>1.224</td>
<td>-1.777</td>
<td>11.808</td>
<td>4.289</td>
<td>4.387</td>
</tr>
<tr>
<td>-1</td>
<td>-1</td>
<td>6.420</td>
<td>10.103</td>
<td>0.778</td>
<td>7.539</td>
<td>-3.783</td>
<td>20.071</td>
<td>4.068</td>
<td>4.207</td>
</tr>
<tr>
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<td>-1</td>
<td>4.793</td>
<td>10.157</td>
<td>0.723</td>
<td>8.497</td>
<td>-3.870</td>
<td>23.202</td>
<td>4.066</td>
<td>4.033</td>
</tr>
<tr>
<td>-1</td>
<td>1</td>
<td>1.020</td>
<td>10.437</td>
<td>0.915</td>
<td>0.633</td>
<td>-0.680</td>
<td>10.509</td>
<td>4.215</td>
<td>4.503</td>
</tr>
<tr>
<td>-1</td>
<td>0</td>
<td>7.827</td>
<td>10.319</td>
<td>0.836</td>
<td>1.524</td>
<td>-1.157</td>
<td>10.972</td>
<td>4.174</td>
<td>4.457</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>7.280</td>
<td>9.603</td>
<td>0.858</td>
<td>2.533</td>
<td>-2.080</td>
<td>13.465</td>
<td>4.272</td>
<td>4.569</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>6.093</td>
<td>10.323</td>
<td>0.792</td>
<td>2.309</td>
<td>-2.103</td>
<td>13.167</td>
<td>4.180</td>
<td>4.267</td>
</tr>
<tr>
<td>0</td>
<td>-1</td>
<td>6.100</td>
<td>10.193</td>
<td>0.792</td>
<td>2.309</td>
<td>-1.900</td>
<td>13.169</td>
<td>4.210</td>
<td>4.267</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
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<td>0.803</td>
<td>2.302</td>
<td>-2.077</td>
<td>13.158</td>
<td>4.185</td>
<td>4.333</td>
</tr>
<tr>
<td>1</td>
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<td>9.717</td>
<td>0.789</td>
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</tr>
<tr>
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<td>0</td>
<td>6.073</td>
<td>10.202</td>
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<td>-1.967</td>
<td>13.181</td>
<td>4.240</td>
<td>4.298</td>
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<tr>
<td>0</td>
<td>0</td>
<td>6.207</td>
<td>6.283</td>
<td>0.793</td>
<td>2.298</td>
<td>-2.147</td>
<td>13.174</td>
<td>4.173</td>
<td>4.248</td>
</tr>
</tbody>
</table>

3.1.2 Crude fiber content

The effect of processing on dietary fiber composition of foods products was described in some conflicting reports (Ramulu & Rao, 1997). In this study, the fiber content of all powder was lower than raw pumpkin. The reason was a small amount of soluble cell content, including soluble dietary fiber lost into the surrounding medium as water when blanching due to the damage of plant cell walls (Reistad & Frolich, 1984).

Although, it was reported that an increased temperature leads to a breakage of weak bonds between polysaccharide chains, and also glycosidic linkages in the dietary fiber polysaccharides may be broken, resulting in a decreased content of dietary fiber. However, the relationship between fiber content in pumpkin powder with (RS) and (SP) cannot be summarized as increasing or decreasing because the data was quite variable. This may be due to the difference in the operating process among all treatments was not enough to cause a significant effect on fiber content.

3.1.3 β-carotene content

The blanched pumpkin had higher β-carotene than the un-blanched one due to the blanching inactivating the enzyme lipoxygenase or removing the intracellular air and establishing a continuous liquid phase to protect β-carotene. However, β-carotene is known to be sensitive to light and heat, so, the thermal degradation of β-carotene with increase in temperature followed the first order reaction kinetics. As cited by [5] the reduction in β-carotene during drying at the elevated temperature could be attributed to increased oxidation rate of unsaturated chemical structure of β-carotene which is in agreement with the result...
of this experiment. It is obviously seen that the amount of β-carotene in the sample was reduced when dried at higher temperature or longer time which directly related to higher (SP) and smaller (RS) respectively.

### 3.1.4 Color

The Colorimeter was used to measure the color in term of three parameters namely L* value (lightness), a* value (redness) and b* value (yellowness). The difference in terms of color between pumpkin puree and powder was expressed as ΔL*, Δa* and Δb*. The general trend was that the value of ΔL*, Δa* and Δb* increased with the decrease of (RS) or the increase of (SP), however, Δa* had negative value. This means that all samples had a change in color compared to pumpkin puree, more specifically, the dried pumpkin powder was darker (L* value decreased), less yellow (b* value decreased) and more red (a* value increased) than pumpkin puree. It also indicated that when the drying time increased or drying temperature increased, the dried powder was redder along with the decrease in lightness and yellowness.

The reasons for changes were explained by alteration of material surface characteristics when exposed to high temperature in the drying process which caused a change of reflectivity and so the color attributes of product. Beside this, thermal treatment in drying process can induce caramelization which led to the formation of brown color. In addition, it was also found that the change in color is correlated with the change in β-carotene concentration of the pumpkin puree which was a major pigment responsible for color, but, visual color (L*a*b*) degradation during thermal processing was more heat sensitive than pigment degradation (Dutta, Dutta, Raychaudhuri & Chakraborty, 2006).

### 3.1.5 Water absorption index (WAI)

WAI of pumpkin powder is one of the most important considerations when incorporating it into other products. The results showed that WAI decreased along with the increase of drying time or drying temperature. It is stated that the long heat treatment caused damage to the cell wall’s structure even though the temperature is low (Puntigo N., 2006). So, “the long period of drying and the high temperature may contribute to a decrease in rehydration because the product surface was destroyed as were the pores that allowed water reenter into sample (Mongpraneet, Abe & Tsurusaki, 2002).

### 3.1.6 Sensory test

For processed flavor, all dried powder had sensory score in range of good scale. There was similar trend that the powder processed at high RS which applied to shorter drying time had a higher score than samples with low speed at the same SP. Drying often brings a better flavor for fruit products compared with original material by forming volatile aroma compounds, but drying with long time created off-flavor compounds which gave the over-cooking smell resulted in the lower sensory score. However, it was difficult for panelists to identify the difference between samples based on applied steam pressure level due to the gap among three level of steam pressure being not enough to cause the apparent difference for powder samples. Beside this, Hedonic test showed that flavor and color were considerable factors contributing to panelist’s acceptability. Hedonic score of samples increased with the increase of (RS) and the decrease of (SP), except for case of 300 kPa and 350 kPa at 0.5rpm. It means that powder with lighter-yellow color and less over-processed flavor was preferred.

| Table 3. Regression coefficients for the 2nd order polynomial response models |
|----------------------------------|----|----|----|----|----|-----------------|-----|
| Moisture contents               | β₀ | β₁  | β₂  | β₁₁ | β₂₂ | β₁₂             | R²  |
| Moisture contents               | 6.118 | -1.315 | 1.751 | 0.336 | 0.481 | -0.081 | 0.2094 | 0.999 |

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There was a relationship of two independent factors (SP and RS) on each powder quality parameter which was fitted by the second-order polynomial equation. All of the models had the high value of multiple correlation coefficients $R^2$ from 0.9504 to 0.9999 which means that these models were suitable for explaining the relationship of two independent factors on nine responses. Moreover, the analysis of variance was applied to test the property of these second order response surface models which give the $p$-values of lack of fit of models were insignificant (0.0780-0.9173). This indicated that all models as fitted adequately represented the observed data at the 95.0% confidence level.

Optimum conditions based on goals of all responses were not similar. Overall, the desirable powdery pumpkin which was produced from optimum drum drying condition had the lowest moisture content, highest crude fiber and $\beta$-carotene, the smallest difference in color ($\Delta L^*$, $\Delta a^*$ and $\Delta b^*$) along with the largest value of WAI, flavor and acceptability score.
Figure 1. The estimated response surface of pumpkin powder qualities

Results for optimization of drum drying process gave the value of steam pressure and rotation drum speed were -0.73 and 0.53 which corresponded to the true value of them was 313.54 kPa and 1.27 rpm respectively. In this condition, the desirable powdery pumpkin was predicted at low moisture (8.359% db), small difference in color (ΔL*, Δa* and Δb*) but high in crude fiber (10.398% db), β-carotene content (0.864 mg/g db), WAI (4.220 g/g db) and high sensory score as flavor and acceptability.

3.3 The effects of substituted ratios of drum dried pumpkin powder on rice noodle quality

3.3.1 Chemical properties

By adding pumpkin powder at four different levels of 2.5%, 5%, 7.5% and 10%, the moisture of noodle was slightly higher (11.99-12.49%wb) than rice noodle (11.41% wb). The result showed that the more pumpkin powder was added, the higher content of crude fiber (0.58-1.56% wb) and β-carotene (0.002-0.068 mg/ g wb) present in the noodle. These differences were significant at 95% confidence. As reported by Wanyo (2009), the fiber contained in rice flour was 0.61% which was higher than 0.58% of rice noodle in this study. Although the rice noodle had an amount of fiber which came from the rice flour, there was a significant difference in fiber content among noodles (Wanyo, Chomnawang & Siriamornpun, 2009).

Moreover, the study on wheat noodle that incorporated freeze-dried pumpkin powder at level 2.5%, 5% and 10%, gave the value of β-carotene in range of 0.72 - 5.52 mg/100g dried noodle respectively which was lower than the results of the present study (0.019 - 0.068 mg/g product). They mentioned that by comparing the content in other products such as cakes (2.31mg/100g), cookies (3.65mg/100g) and bagels (2.69mg/100g) which added synthetic β-carotene, the amount of 2.35mg/100g can be acceptable at noodle with added 5% pumpkin powder. This study also concluded that “single serving of these

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products would enable a person to obtain the desired amount of 5-6 mg of β-carotene in the daily diet if the person also consumes a normal diet” and “the consumption of noodles supplemented with pumpkin powder would have a nutritional benefit as a natural source of β-carotene in the diet" (Lee, Yusof, Hamid, & Baharin, 2006)

3.3.2 Cooking quality

During cooking, the starch granule in noodle will absorb water and become slippery and weaker while small parts of noodles separated into water resulting in cooking water that was thick and cloudy. Generally the less cooking time, high weight and low loss after cooking would be the desirable characteristics for high quality of Asian noodle. The cooking quality tests indicated that rice noodles with pumpkin powder need more time to fully hydrate (about 0.66-1.5 minutes) than rice noodle. Moreover, the higher level of pumpkin powder added to noodle, the longer time needed to completely cook it. This can be explained by insufficient water for starch to completely gelatinize as starch concentration in starch slurry was too high, resulting in long cooking process.

Table 5. Some quality parameters of rice noodle added pumpkin powder

<table>
<thead>
<tr>
<th>Sample</th>
<th>Fiber (% wb)</th>
<th>β - carotene (mg/g)</th>
<th>Cooking time (min)</th>
<th>Rehydration ratio (%)</th>
<th>Cooking loss (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>0.58 ± 0.04e</td>
<td>0.002 ± 0.001e</td>
<td>4.67 ± 0.29a</td>
<td>205.25 ± 9.19c</td>
<td>4.22 ± 0.22a</td>
</tr>
<tr>
<td>2.5%</td>
<td>0.88 ± 0.04d</td>
<td>0.019 ± 0.001d</td>
<td>5.33 ± 0.29b</td>
<td>235.37 ± 4.49b</td>
<td>5.46 ± 1.01ab</td>
</tr>
<tr>
<td>5%</td>
<td>1.12 ± 0.04c</td>
<td>0.033 ± 0.002c</td>
<td>5.67 ± 0.29bc</td>
<td>246.26 ± 4.56b</td>
<td>6.99 ± 0.31c</td>
</tr>
<tr>
<td>7.5%</td>
<td>1.39 ± 0.02b</td>
<td>0.054 ± 0.006b</td>
<td>6.00 ± 0.50c</td>
<td>275.86 ± 11.61a</td>
<td>5.66 ± 0.56b</td>
</tr>
<tr>
<td>10%</td>
<td>1.56 ± 0.05a</td>
<td>0.068 ± 0.005a</td>
<td>6.17 ± 0.29c</td>
<td>206.87 ± 22.50c</td>
<td>7.60 ± 1.01c</td>
</tr>
</tbody>
</table>

(*) All values are mean of three replications which were reported in form of mean ± standard deviation. Within the same row, the values with different letters are significant difference at p < 0.05 by LSD test.

Beside this, there was an increase in both rehydration ratio and cooking loss of noodle by adding pumpkin powder due to the difference in starch swelling and solubility as well as noodle inside structure between pure rice noodle and noodle with pumpkin. However, the variation of these values among all noodles cannot be summarized as increasing or decreasing with amount of pumpkin powder added. However, Thao (2010) cited that the cooking loss of starch noodles should be less than 10% and 9% according to Chinese Agriculture Trade Standards and Thai Standards respectively. So, in this experiment the cooking loss of all rice noodles added pumpkin powder was still acceptable while their rehydration ability was much more than the pure rice noodle except for case of 10% level. This is due to the weak linkage between rice flour and pumpkin powder particles at very high concentration of noodle solution which was easy to break when immersed in hot water during cooking.

3.3.3 Color

The similar trend in color change of both dried and cooked noodle form was that a* value and b* value significantly increased along with a decrease in L* value as amount of pumpkin powder added to noodle increased. However, after cooking their redness and yellowness was markedly decreased, while the lightness increased compared to dried noodle at the same level of pumpkin powder. This was due to the dissolution of pigments into cooking water and absorption water of noodles during cooking.
Table 6. The texture quality ties of cooked rice – pumpkin noodle

<table>
<thead>
<tr>
<th>Sample</th>
<th>Hardness (g)</th>
<th>Adhesiveness (g.sec)</th>
<th>Springiness</th>
<th>Cohesiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 %</td>
<td>2208.96 ± 45.68&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.26 ± 0.10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.85 ± 0.03&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.76 ± 0.03&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>2.5 %</td>
<td>2089.77 ± 37.03&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.81 ± 0.06&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.86 ± 0.12&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.62 ± 0.14&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>5 %</td>
<td>2529.69 ± 257.07&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.14 ± 0.18&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.94 ± 0.05&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.67 ± 0.03&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>7.5 %</td>
<td>2635.23 ± 220.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.18 ± 0.33&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.99 ± 0.02&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.70 ± 0.02&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>10 %</td>
<td>3299.74 ± 140.15&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.62 ± 0.78&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.98 ± 0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.72 ± 0.01&lt;sup&gt;b&lt;/sup&gt;</td>
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</table>

(*) All values are mean of three replications which were reported in form of mean ± standard deviation. Within the same row, the values with different letters are significant difference at p < 0.05 by LSD test.

3.3.4 Texture quality

The Texture Profile Analysis showed that there was a slight increase in hardness, springiness and cohesiveness values of noodle with the increase of powder level added while the adhesiveness of noodle cannot conclude as increasing or decreasing with the level of pumpkin powder.

3.3.5 Sensory quality

The sensory evaluation is the most important criteria to express the customer acceptance of the product although it may be difficult to obtain reliable results due to variability from person to person and distinguishing capability of panelists.

For dried noodle, it was evaluated in term of appearance, hardness and overall acceptability. In noodle production, any pigment remaining in starches’ flour would be carried into noodles causing undesirable color in noodle which would decrease quality and acceptability of noodles and by adding pumpkin powder the color of noodle can be altered. However, at low level of pumpkin powder, it cannot form a homogeneous appearance of noodle while a very high level of pumpkin powder caused a very dark color of product. Results show that both of these kinds cannot obtain the high sensory score in appearance evaluation and so affected their acceptability. These also indicated that the panelists cannot recognize the difference in hardness of noodles which was illustrated by the statistical analysis. Therefore, the noodle added 7.5% pumpkin powder had the highest score for both appearance and overall acceptability than others.

Figure 2. The change in lightness and yellowness between dried and cooked noodles
Cooked noodle was evaluated in term of appearance, flavor, texture and overall acceptability. It is apparently seen that the appearance of both noodle with 7.5% and 10% had the highest score compared to others due to their yellowness evenly distributed throughout the strands which made the noodle look smoother. Beside this, the higher pumpkin powder level gave more pleasant smell for the noodle which released after cooking. Although there was some variation in the texture score of these noodles, it was not significant at 95% confidence. This indicated that the panelists could not recognize the difference in texture among pumpkin noodles. This result in overall acceptability was similar to the sensory test of the dried noodle, except for the case of 10% level which had a greater increase in sensory score after cooking. However, with the highest score, the noodle added with 7.5% pumpkin powder was the most preferred sample by panelists due to their better appearance and acceptable flavor compared to others.

Although the main objective in using drum-dried pumpkin powder as a source of fiber and β-carotene was to incorporate in noodle which holds good quality in terms of both physicochemical and sensory properties, the economic efficiency factors are also important. So, the desirable rice-pumpkin noodle should have the higher amount of fiber and β-carotene, higher rehydration ratio but less cooking time and cooking loss, while the color and texture was positively contributed to give the good score of sensory test especially of their overall acceptability. So, the 7.5% pumpkin powder level performed as the best option to substitute into rice noodle.

4. CONCLUSION

The study found that the optimum condition of drum drying process for pumpkin powder production with good physical characteristic and aroma sense was at 313.54 kPa of steam pressure and 1.27 rpm of rotation drum speed. Regarding the main objective with the economic efficiency factor, the noodle with 7.5% pumpkin powder was considered as the best option due to their high amount of fiber and β-carotene, good cooking qualities and highest sensory scores. Based on results of this study, drum dryer is a suitable method to produce pumpkin powder with good characteristic. Moreover, pumpkin powder can be served as a good additional source of fiber and β-carotene for rice noodle or other products.

REFERENCES


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