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# The properties of pea slowly digestible starch noodles

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***Abstract:*** *Substituting pea slowly digestible starch for 5%, 10%, 15%, 20% and 25% of wheat flour to prepare slowly digestible starch noodles. The cooking quality, color analysis and texture analysis of the noodles are carried out. The main conclusions are as follows: With the pea slowly digestible starch added increases, the water absorption rate of the corresponding noodles decreases, and the loss rate increases; the hardness of the pea noodles increases, but the adhesiveness does not change significantly, and the cohesiveness, resilience and breaking force are significantly increased; the L* values of the slow-digesting starch noodles are all Increased, the a* and b* of pea noodles increase; the total sensory evaluation score of noodles decreases.*

***Key words:*** *slowly digestible starch, noddle, cooking properties, color properties, texture properties*

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## I. Introduction

British scientist Englyst[1] proposed the concepts of rapidly digestible starch (RDS), slowly digestible starch (SDS) and resistant starch (RS) in 1992. RDS refers to the starch that can be quickly digested and absorbed in the small intestine (0-20min), which can quickly raise blood sugar for the human body and predict the glycemic index [2-3], which is mainly found in freshly cooked foods with high starch content, such as rice, noodles, potatoes, etc. SDS refers to the starch that is slowly digested and absorbed in the small intestine (20~120min), which can slowly release glucose into the blood, which can prevent diseases and obesity. Modification treatment can significantly increase the content of SDS; RS is a new type of dietary fiber, refers to the part of the human small intestine that is not digested and absorbed at all (>120min), which can promote gastrointestinal motility and digestion. It is mainly found in immature bananas, aging starch, and raw potatoes. The resistant starch content in peas is relatively high (53.4%)[4]. Extrusion and enzymatic hydrolysis can destroy the intact starch granules and convert the resistant starch that is difficult to enzymolyze into slowly digesible starch, which improves the slowly digestible of pea starch.

Extrusion is a common method of starch modification and food pretreatment. It has the advantages of high efficiency, continuous, low energy consumption, and low pollution. It has been widely used in the production and processing of cereals. Starch is subjected to high temperature, high pressure, high shear force, and friction in the extruder, and its amylose, amylopectin, crystalline structure will undergo a series of changes [5]. Noodles are one of the three staple foods of Chinese residents. Potato starch, highland barley, quinoa, pumpkin, oats, etc. are all used to improve the quality of noodles. The addition amount is generally 5%-20%, and they have achieved good results[6-10]. However, very few scientists choose pea starch, pea and dehulled pea hydrolysates with higher slow digestion starch content instead of wheat flour to prepare enzymatic hydrolysate noodles; therefore, the research in this chapter is of great significance.

## II. Material And Methods

2.1 Sample preparation

Pea flour (starch: 52.00±3.16%, protein: 19.11±0.01%, ash: 2.40±0.03%, fat: 1.77±0.09% and moisture: 11.32±0.02%) was kindly provided by Shandong Jiayuan Biological Engineering Co., Ltd .. Pullulanase (EC 3.2.1.41, 1500 U/ml) Jiangsu Ruiyang Biotechnology Co., Ltd.; Porcine pancreatic α-amylase (A 3176, 19.6 × USP/mg) Sigma-Aldrich Co., Ltd.; Amyloglucosides Enzyme (EC 3.2.1.3, 100,000 units/mL) Shanghai Yuanye Biotechnology Co., Ltd. Other reagents are of analytical grade.

2.2 Pea slowly digesible starch noddles preparation

Crush the peas, set the extrusion conditions as: 15 kg/h feeding speed, adjust the moisture content to 45%, the screw speed to 160 r/min, and the temperature setting as: 60°C in the feeding zone, 90°C in the mixing zone, shearing 70°C in cutting zone, 50°C in conveying zone and 50°C in discharge zone. The extrudate was dried at room temperature and crushed through a 100-mesh sieve, and stored in a sealed bag at room temperature. Weigh 200 g (dry basis) of squeezed pea flour into 1000 ml 0.1 mol/L, pH 5.2 acetic acid buffer,

stir well and gelatinize in boiling water bath; cool the starch paste to 55℃ and add 120 U/L g of pullulanase, shake in a water bath for 10 h, then boil the water bath to inactivate the enzyme, then wash the enzymatically hydrolyzed pea flour with distilled water three times and centrifuge at 3000 r/min for 10 min; collect the precipitate and place it at 4° C Refrigerate in refrigerator for 24 h, then dry in 40 ℃ oven for 24 h, then crush it through 100 mesh sieve, seal and store for later use.

Noodles are made in accordance with GB/T 17320-2013 "Wheat Variety Quality Classification"; the addition amount of pea flour after enzymatic hydrolysis is 0%, 5%, 10%, 15%, 20%, and 25% respectively; it is for enhancing noodles for gluten network, add 3% gluten; add 35% water. Weigh a certain amount of wheat flour, enzymatic hydrolysate and gluten, add appropriate water, and mix the dough until evenly mixed; leave the dough at room temperature to proof for 30 minutes; repeat the rolling 5-8 times with the rolling machine, and the rolling speed; Put the noodles into the noodle machine and cut them into noodles of 1mm, 2mm wide and 220mm long, and put them in a sealed bag for refrigeration.

2.3 Determination of cooking quality of noodles

Take 20 noodles and weigh m1, put them in 500ml boiling water and cook until the white heart disappears, then drain the water for 5 minutes, and weigh m2

$$\text{Dry Matter Water Absorption}\ (\%) = \frac{m2 - m1}{m1} \times 100$$

Cool the noodle soup to normal temperature, transfer it to a 500 ml volumetric flask to make the volume constant, mix well, take 50 ml noodle soup into a beaker weighing m3, place the beaker on the electric stove to evaporate most of the water, and then repeat 3 times to take 50 ml noodle soup and evaporate Measure the water at least, put it in a 100℃ oven to dry the water to a constant weight, and weigh the beaker m4.

$$\text{Dry matter loss rate}\ (\%) = \frac{2.5 \times (m4 - m3)}{m1} \times 100$$

Repeat 3 times and take the average value.

2.4 Noodle color determination

The color of the noodles was measured with an automatic colorimeter. First calibrate the instrument, set the measurement area MWA to 8mm, and set the UV to 100%. The result L* represents the brightness; the a value represents the red-green value, the a value is positive, which means reddish, the a value is negative, which means greenish; the b value means the yellow-blue value, the b value is positive, which means yellowish, and the b value Negative, it means bluish.

2.5 Noodle texture determination

2.5.1 TPA （Texture Profile Analysis）test

Rinse the cooked noodles in cold running water for 30 s and quickly perform the TPA test. Cut the noodles into equal lengths and place 4 noodles in parallel on the test bench. This experiment uses the HDP/90 probe, and the parameter settings are: pre-test speed: 2.0 mm/s，test speed: 0.8 mm/s，post-test speed: 0.8 mm/s，strain: 70%，trigger type: auto 3 g。

2.5.2 Tensile test

Wrap the noodles (22 cm) washed with cold water on the upper and lower rods and perform a tensile test. This experiment uses an A/SPR probe, and the parameter settings are: pre-test speed: 2.0 mm/s，test speed: 2.0 mm/s，post-test speed: 10 mm/s，trigger distance: 120 mm，trigger type: auto 0.5 g。

2.6 Statistical analysis

All experiments were repeated three times, and the data were shown as mean ± standard deviation. SPSS 25 was used to analyze the significance of the experimental data.

## III. Results And Discussion

3.1 Effect of addition of slowly digested pea starch on cooking quality of noodles

The interaction of protein and starch in wheat has an important impact on the water absorption and loss rate of noodles [11]. The dry matter water absorption rate of the control group without adding any enzymatic hydrolysate was 90.34%; as the amount of pea slowly digestible starch added increased, the dry matter water absorption rate gradually decreased. The water absorption rate of noodles mainly depends on starch gelatinization and gluten network expansion and water absorption [12]. A small amount of enzymatic hydrolysate is mixed with wheat flour. The gluten network formed by the gluten protein in wheat flour can tightly wrap the

enzymatic hydrolysate, so the water absorption rate of slow-digested starch noodles at 5% addition is higher than that of the control group; pea flour After the extrusion enzymatic hydrolysis treatment, the complete starch granule structure has been destroyed and its water absorption capacity is also reduced. Therefore, as the amount of enzymatic hydrolysate increases, the water absorption rate of the noodles tends to decrease. The cooking loss of noodles is related to the exudation of a large amount of amylose and amylopectin [13], and the higher the amylose content, the greater the cooking loss [14].

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**Table 3.1** cooking quality of noodles

| | Adding amount (%) | Dry matter water absorption rate (%) | Dry matter loss rate (%) |
|---|---|---|---|
| Pea slowly digestible starch | 0 | 90.34±2.35$^{b}$ | 5.96±0.35$^{c}$ |
| | 5 | 97.07±1.27$^{a}$ | 5.15±0.22$^{d}$ |
| | 10 | 76.92±2.54$^{c}$ | 6.86±0.31$^{b}$ |
| | 15 | 66.83±1.87$^{d}$ | 7.42±0.53$^{b}$ |
| | 20 | 66.62±2.61$^{d}$ | 7.44±0.64$^{b}$ |
| | 25 | 63.58±2.26$^{e}$ | 10.00±0.39$^{a}$ |

3.2 Noodle color analysis

Table 3.2 shows the color of the bar under different addition levels. In the control group, wheat gluten was added to make the noodles darker. After adding slowly digestible starch, the brightness value L* of the noodles increased significantly; the a* and b* of the pea enzymatic hydrolysate noodles increased significantly. Color is one of the important basis for consumers to choose noodles. The larger the noodles L*, the more popular they are; because the peas are still yellow after enzymatic hydrolysis and extrusion, the red and yellow values of the noodles increase.

**Table 3.2** color of noodles

| | Adding amount (%) | L* | a* | b* |
|---|---|---|---|---|
| Pea slowly digestible starch | 0 | 76.24±0.28$^{c}$ | 0.49±0.07$^{f}$ | 13.21±0.56$^{e}$ |
| | 5 | 75.86±0.52$^{c}$ | 1.37±0.09$^{e}$ | 16.93±0.39$^{d}$ |
| | 10 | 77.44±0.08$^{b}$ | 2.16±0.12$^{d}$ | 18.04±0.31$^{c}$ |
| | 15 | 77.62±0.46$^{b}$ | 2.72±0.22$^{c}$ | 19.34±0.59$^{b}$ |
| | 20 | 78.11±0.53$^{b}$ | 3.13±0.11$^{b}$ | 19.17±0.48$^{b}$ |
| | 25 | 79.29±0.48$^{a}$ | 3.74±0.23$^{a}$ | 20.95±0.94$^{a}$ |

3.3 Noodle texture quality analysis

Table 3.3 shows the texture data of the bottom bar with 0-25% pea slowly digestible starch substitution level. The noodles without adding any slow-digested starch are mainly composed of wheat flour and gluten. The addition of 3% gluten increases the hardness of the noodles, but has no significant effect on adhesiveness, cohesion and Resilience [15]. Hardness indicates the amount of force required to deform the noodles, indicating the softness of the noodles; the hardness of the noodles is mainly related to glutenin and gliadin [16], that is, the degree of gluten formation. The addition of gluten increases the content of glutenin and gliadin in the noodles, and promotes the formation of a stronger network structure in the noodles, which leads to an increase in hardness. After adding pea slowly digesible starch, the hardness of noodles increased significantly; pea flour contains starch, protein and cellulose. When making noodles, the cellulose in pea slowly digesible starch may have a significant impact on the hardness of noodles. With the addition of pea starch enzymatic hydrolysate, the adhesiveness of the noodles was significantly reduced, and the starch regenerated by enzymatic hydrolysis could not form a stable amylose-based network [17]. The adhesiveness of pea hydrolysate and peeled pea hydrolysate noodles basically did not change significantly. The protein in the enzymatic hydrolysate of peas and dehulled peas is combined with wheat flour to improve the texture characteristics of noodles.

**Table 3.3** texture properties of noodles

| | Adding amount (%) | TPA | | | | Stretch |
|---|---|---|---|---|---|---|
| | | Hardness (g) | Adhesiveness (%) | Cohesiveness (%) | Resilience (%) | Breaking force (g) |
| Pea slowly digestible starch | 0 | 6219.04±287.52$^{c}$ | 0.83±0.03$^{a}$ | 0.64±0.01$^{b}$ | 0.31±0.01$^{c}$ | 14.18±0.23$^{c}$ |
| | 5 | 7559.13±477.58$^{ab}$ | 0.78±0.06$^{a}$ | 0.67±0.02$^{a}$ | 0.37±0.02$^{b}$ | 13.77±0.72$^{c}$ |
| | 10 | 7697.15±409.35$^{ab}$ | 0.80±0.04$^{a}$ | 0.67±0.01$^{a}$ | 0.38±0.01$^{ab}$ | 17.31±1.05$^{b}$ |
| | 15 | 8005.61±536.22$^{a}$ | 0.78±0.02$^{a}$ | 0.66±0.01$^{ab}$ | 0.39±0.01$^{ab}$ | 17.28±1.11$^{b}$ |
| | 20 | 7859.53±655.21$^{a}$ | 0.84±0.01$^{a}$ | 0.65±0.01$^{ab}$ | 0.38±0.01$^{ab}$ | 19.22±1.03$^{ab}$ |
| | 25 | 7092.37±638.05$^{b}$ | 0.79±0.02$^{a}$ | 0.67±0.02$^{a}$ | 0.40±0.02$^{a}$ | 21.27±0.69$^{a}$ |

## IV. Conclusion

Substituting pea slowly digestible starch for 5%, 10%, 15%, 20% and 25% of wheat flour to prepare slowly digestible starch noodles. The cooking quality, color analysis and quality analysis of the noodles are carried out. The main conclusions are as follows: With the pea slowly digestible starch added increases, the water absorption rate of the corresponding noodles decreases, and the loss rate increases; the hardness of the pea noodles increases, but the adhesiveness does not change significantly, and the cohesiveness, Resilience and breaking force are significantly increased; the L* values of the slow-digesting starch noodles are all Increased, the a* and b* of pea noodles increase; the total sensory evaluation score of noodles decreases.

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