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Optimisation of cassava dried noodle using hydrocolloid and protein isolates: a tropical noodle

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Cassava flour has the potential to be used as a substitute for wheat flour to make dry noodles. This study aims to obtain the optimum cassava noodle formulation developed with cassava flour, hydrocolloid content, and protein isolate. The ingredients evaluated for cassava noodle formulation were native and pre-gelatinised flour, food additives such as hydrocolloid (xanthan gum and konjac glucomannan), and pea protein isolate. The design of the formulation and optimisation was done by the D-optimal combined design method and response surface method by using Design Expert 7.0® software. There were 31 different formulas for a test response: hardness, tensile strength, and cooking loss. Based on the test response, the recommended optimum noodles formulation was composed of pre-gelatinised cassava flour, 2% xanthan gum, and 4% protein isolate. The selected formula of cassava dried noodles constituted 5.92% water, 87.03% carbohydrate, 4.29 protein, 1.34% fat, and 0.79% ash. The level of consumer acceptance of texture, aroma, colour, and overall parameters ranged from 3 (regular) to 4 (like). The optimum formula may be used for the development of cassava dried noodles.

1. Introduction

Cassava (Manihot esculenta) is one type of tuber native to Indonesia. As the third staple food, following rice and corn (Murniati et al., 2020), the cassava productivity in various regions in Indonesia (2012 to 2016) increased by 2.85%, and production reached 22.819,484 tons (Nuryati et al., 2016). This fact proves that Indonesia is the largest cassava producer in Asia, with a production rate of 44 kg per capita per year, or more than 37.3 kg of the regional average (Howeler et al., 2013). Cassava is considered inferior because its presentation as a ready-to-eat food is less attractive, and it is a perishable food (Hariyadi, 2011). Cassava flour has the potential to be used as a substitute for flour to make dry noodles. It has similar characteristics to wheat flour, although it has a lower protein content (Maforimbo et al., 2008). Noodles contain protein, carbohydrates, minerals, and low fat. The nutrients of 100 g fine dried noodles are 10.3 g protein, 75.6 g carbohydrates, just 0.6 g fat, 129 mg potassium, 18.45 mg sodium, and 11.8 µg selenium (Zhang & Ma, 2016). The application of cassava flour in pasta products has advantages, namely gluten-free protein (gluten-free) that can benefit consumers with celiac disease (Fasano & Catassi, 2012).

In Indonesia, instant noodle demand amounted to 12,520 million USD in 2019 (World Instant Noodles Association, 2020). Despite claims it has the second-highest country in instant noodle consumption (Gulia et al., 2014), Indonesia must import wheat flour from abroad. That is because wheat only grows well in a four-seasoned and sub-tropical region, unlike Indonesia (Pato et al., 2016). The utilisation of cassava flour for noodles can reduce wheat flour consumption in Indonesia (Novelina et al., 2014; Tan et al., 2009). Cassava flour is produced from dried cassava by grinding (Niba et al., 2006). Its starch can be used as an emulsifier and thickener (Gaouar et al., 1997). Cassava flour used in the manufacture of noodles requires the addition of other ingredients such as hydrocolloid, protein isolates, and enzymes as a binder for forming a dough structure so that it is cohesive enough to resemble flour (Purnomo et al., 2015; Padalino et al., 2016).

One of the most commonly used hydrocolloids is xanthan gum. Xanthan gum is a polysaccharide secreted by Xanthomonas campestris and is generally used as a thickener in various food products (Kaur et al., 2015). In addition to xanthan gum, other hydrocolloids such as konjac glucomannan flour can improve paste characteristics by increasing the hardness of noodles, elongation, tensile strength, and cohesiveness (Husniati & Devi, 2013). Xanthan gum and konjac glucomannan can be used simultaneously, the interaction can produce gelation viscosity better than its single-use (BeMiller, 2008). Cassava has a low protein content, plus the siege process causes protein levels in the ingredients to decrease. Protein addition can improve the characteristics and nutrition of gluten-free food products through the interaction of starch with protein (Detchewa et al., 2016). Therefore, it is essential to know the effect of hydrocolloid use in combination with protein isolates to native cassava-based gluten-free noodles and pregelatinised-modified noodles to find out the quality of the final product.

2. Materials and Methods

2.1. Materials

Cassava flour, both native and pre-gelatinised, were produced from Manihot esculenta var. Manggu was provided by Balitbang Pascapanen, Bogor, Indonesia. Xanthan gum commercially obtained from Balitbang Pascapanen. Konjac glucomannan flour was obtained from Amorphillus sp., and isolated pea protein was obtained from PT Lissom Indonesia.

2.2. Methods

Pasting properties of cassava flour
The starch gelatinisation profile was analysed using Rapid Visco Analyzer (RVA). This analysis shows the viscosity properties of starch by measuring the resistance of flour and water mixture during stirring. A sample of 3 grams of flour was mixed with 25 ml of water to form the mixture. The sample of the mixture was stirred for 6 minutes on RVA with a heating temperature of 60-95°C. When heated, starch granules experience swelling, and the mixture thickens. From this analysis, temperature, time, and peak viscosity of the flour were determined (Wheat Marketing Center, 2004).

Production of cassava noodle
The fixed and optimised ingredient amounts are shown in Table 1. Cassava noodle was produced using two types of flour, native and pre-gelatinised. Pea protein isolates and hydrocolloid (xanthan gum and konjac) are variables that can affect the textural quality of noodles. Response Surface Method (RSM) was used to optimise the formulation of cassava noodles. D-optimal Combined Design was generated through the software of Design Expert 7.0 ®.

Table 1. The proportions of ingredients included in the formulation of cassava noodle

Ingredients	Unit	Amount
Cassava flour (native or pregelatinized)	gram	200
Pea protein isolates	%	6
Water	mL	50
Hydrocolloid (xanthan gum or konjac glucomannan)	%	2

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Noodles were made using an automatic noodle maker, Re-noodle (type RN-88 Premium from RBShop). Before forming noodles, the flour mixture was first stirred in the appliance for about 1 minute. The noodles were then dried in an oven with a temperature of 60°C for 5 hours. The process of making noodles began with mixing the main ingredients (flour) with the other ingredients (xanthan gum, konjac glucomannan, and protein isolates). The concentration of additional ingredients varied according to the experimental design (Table 2). Next, the dry ingredients were mixed with 25% water, or as much as 50 ml in one recipe. The dough was steamed over boiling water for 7 minutes. Noodles were formed using Re-noodle with standard dye.

Characteristics of cassava noodle

Texture: Hardness and tensile strength

The texture profile of the noodles was evaluated using the CT3 Brookfield texture analyser. The string of noodles was cooked in 300 mL of water for 9 to 10 minutes, removed and then drained. The analysis was carried out using a cylinder probe (TA-AACC36). Samples were compressed twice to 25% of the original sample height. Three replicate samples were tested. Tensile strength analysis was conducted using a single strand of noodles (± 5 cm) that had been rehydrated, was wrapped around a Dual-Grip Fixture (TA-DGF) probe with a probe distance of 2 cm and a velocity of 0.3 cm/sec.

Cooking loss

Cooking loss was determined by Kim et al. (2014) methods. Approximately 3 g of dried noodle samples were cut to 5 cm and weighed. Dry noodle samples were cooked in 100 ml of boiling water for 10 minutes. Cooking time was determined based on the time needed to remove the white centre core when pressed between two Petri dishes. Checking was done every minute, from the 3rd minute to the 10th minute. Boiled water from the cooking was collected in a beaker glass and cooled for 3 minutes at room temperature. Cooking loss was calculated as the number of solids lost in the water during cooking, expressed as the ratio of the weight of the residual in cooking water to the sample weight on a dry basis. The weight of the residual cooking water was obtained by drying the beaker in an oven at 98°C for 24 hours. The cooking loss was expressed as the ratio of residue weight in the cooking water to the weight of the noodle on a dry weight basis.

Proximate analysis

Proximate analysis was conducted by using AOAC (2005) method, with type number of 32.5.02, 32.5.03, 32.5.05, 32.5.07 for water, ash, fat, and protein (conversion factor of 6.25) respectively. Carbohydrate content was analysed using the differences method.

Sensory analysis

Samples (100 g) were cut into approximately 15 cm of length and cooked according to optimal time (the time when the white core in the cross-section disappeared). The cooked noodle was drained for a maximum of 10 minutes before analysis. Sensory analysis was carried out using a hedonic rating test with 30 untrained panellists. Parameters observed were a taste, colour, texture, and overall with a range of assessment scores from numbers 1 (dislike) to 5 (like).

3. Results and Discussion

3.1. Cassava flour characteristics

The maximum viscosity is the highest viscosity achieved before the starch granules break due to the inability of holding water. The high viscosity of native flour shows high water binding ability and high swelling process. In pre-gelatinised flour, starch granules have been damaged so they can quickly gelatinise. As a result, when flour is given by pre-gelatinised treatment, a continuous increase in heat will reduce the viscosity of the paste (Wadchararat et al., 2006). Based on Ahmed et al. (2012), pre-gelatinised flour, which is processed by extrusion, reduces viscosity and decreases the ability of cold-water-swelling because of the degradation of amylose and amylopectin due to high-temperature treatment and shear stress. Once at a maximum point, the viscosity of the starch decreases suddenly as the temperature increases (Mojiono et al., 2016). The breakdown viscosity shows the level of stability of the starch to heating. The lower the breakdown viscosity value, the more stable the starch paste is to heating. Starch granules that have been swelled are easily destroyed by heating and stirring (Pomeranz, 1991). Setback viscosity shows the value of the paste viscosity after cooling, and can also be used in determining the retrogradation and syneresis properties of starch. Native cassava flour had a setback viscosity value of -2783 cP, while pre-gelatinised cassava flour was 852 cP. The high setback viscosity value indicates that the starch was more accessible to retrograde compared to pre-gelatinised flour.

Table 2. Experimentl design for cassava noodle with the actual level of variable evaluated (flour hydrocolloid and protein isolates)

Formula	Variable			
	Flour	XG (%)	KG (%)	PPI (%)
F1	A	0.00	2.00	4.43
F2	A	0.00	2.00	4.61
F3	A	0.00	2.00	6.00
F4	A	0.33	1.67	5.36
F5	A	0.55	1.45	6.00
F6	A	0.58	1.42	4.00
F7	A	0.72	1.28	4.00
F8	A	0.81	1.20	4.69
F9	A	0.98	1.02	4.47
F10	A	1.04	0.96	4.55
F11	A	1.13	0.87	5.25
F12 (1)	A	1.45	0.55	6.00
F12 (2)	A	1.45	0.55	6.00
F13	A	1.50	0.50	4.00
F14	A	2.00	0.00	4.42
F15	A	2.00	0.00	5.37
F16 (1)	A	2.00	0.00	6.00
F16 (2)	A	2.00	0.00	6.00
F17 (1)	B	0.00	2.00	4.00
F17 (2)	B	0.00	2.00	4.00
F17 (3)	B	0.00	2.00	4.00
F18	B	0.00	2.00	4.79
F19	B	0.00	2.00	6.00
F20	B	0.46	1.54	5.36
F21	B	0.56	1.44	4.43
F22	B	0.81	1.20	4.11
F23	B	0.82	1.12	6.00
F24	B	0.96	1.04	5.28
F25	B	1.14	0.86	4.86
F26	B	1.17	0.83	4.20
F27	B	1.38	0.64	5.60
F28	B	1.48	0.52	4.19
F29	B	2.000	0.00	4.42
F30	B	2.000	0.00	4.64
F31 (1)	B	2.000	0.00	6.00
F31 (2)	B	2.000	0.00	6.00

A: Pre-gelatinized flour; B: Native flour; XG: Xanthan gum, KG: Konjac glucomannan, PPI: Pea protein isolates

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Table 3. Gelatinization profile of cassava flour using rapid visco analyzer (RVA)

Parameter	Unit	Native Cassava Flour	Pregelatinized Cassava Flour
Temperature at 20 cP	°C	75.8	73.6
Time at 20 cP	s	374	187
Peak viscocity	cP	5956	3954
Temperature at peak viscosity	°C	84.3	92.2
Time at peak viscosity	s	452	230
Cold paste viscocity	cP	3174	4806
Breakdown	cP	3409	1414
Setback	cP	-2783	852

3.2. Characteristics of cassava noodle

Hardness

Hardness is a quantitative calculation of the amount of load (grams) needed to break the sample (Sundararajan & Roy, 2001). The harder sample will increase the weight of the load. Figure 1 shows that the use of 2% xanthan gum and 0% konjac glucomannan, accompanied by the smallest percentage of protein isolates, produced the maximum hardness value of native flour-based noodles. The maximum hardness in pre-gelatinised cassava-based noodles also leads to 2% xanthan gum, 0% konjac glucomannan, and 4% protein isolates. The addition of hydrocolloid is reported to improve the quality of hardness in pasta (Rossel et al., 2001). The hardness response of the noodles reached the maximum value when the addition of xanthan gum increased. This can be caused by the formation of complexes due to the interaction of hydrophilic groups on starch, xanthan gum, fat, and protein. Xanthan gum has a double helix structure between hydrogen bonds, and the structure of secondary polymers can increase water holding capacity and stability of noodle texture (Pan et al., 2016). Hardness is influenced by high levels of amylose in starch (Guo et al., 2003). Pregelatinized flour has a higher amylose content than native flour due to the partial gelatinisation treatment, which causes amylose to come out of starch granules. Through the gelatinisation profile, cassava flour pre-gelatinisation also showed a more dominant amylose character compared to the properties of amylopectin (Kaur et al., 2016).

Tensile strength

Figure 2 shows that the addition of hydrocolloid concentration, both xanthan gum and glucomannan, increased the response value for the lowest level of protein isolate used. As the protein isolate level increases, the plot graph shows a blue colour, which means a lowering in the tensile strength of the noodles. In contrast, noodles with pre-gelatinised cassava flour show most of the yellow to orange-green, meaning the use of pre-gelatinised flour increases tensile strength. The maximum response value was obtained when the concentration of xanthan gum: konjac glucomannan is 0:2%, plus 4% protein isolates. The factor that influences the tensile strength of noodles is the amylose content in cassava flour, which ranged from 15 to 25% (Eliasson, 2004). Based on Eliasson and Gudmundsson (1996), the high dissolved amylose and the swelling of a starch granule during gelatinisation will increase the elasticity of noodles, while the high amylopectin dissolved in water will interfere with gelation formation.

Cooking loss

Good quality noodles have a low-value cooking loss because high cooking loss indicates the weak bond between the components marked by the loss of starch and other solid components (Kim et al., 2014). Hydrocolloid functions as a binding material to maintain the structure of the noodles, so that the noodles did not easily decompose during cooking. The use of pre-gelatinised cassava flour in making noodles significantly decreased the amount of cooking loss. The lowest value of cooking loss in pre-gelatinised cassava flour-based noodles was obtained when added 2% xanthan gum, 0% konjac glucomannan, and 5.37% protein isolates. The lower cooking losses can be caused by the high amount of amylose in pre-gelatinised cassava flour. The addition of xanthan gum and konjac glucomannan can significantly affect the cooking.

3.3. Formulation optimisation

Formula optimisation was determined after the interpretation of response surfaces. The determination of the optimum formula was based on the highest desirability value. Desirability is based on the transformation of all the obtained responses from different scales into a scale-free value. Desirability shows the value of the optimisation objective function, which shows the ability of the program to fulfil the desires based on the criteria set in the final product, to obtain a satisfactory compromise (Jeong & Kim, 009). The criteria were determined based on responses to hardness, tensile strength, and cooking loss. A good quality noodle has a high level of hardness and tensile strength, so the criteria target for both responses is maximum. Noodle with a compact and homogeneous structure shows good cooking quality, so the response to cooking loss is minimum. Based on the desirability for the responses, the recommended formulation of the noodle was cassava flour pre-gelatinised based (100%), 2% xanthan gum, and 4% protein isolates. Noodles with this formula have a desirability value of 0.840. The formula had been verified by preparing noodles with the optimum ingredient of 200 g pre-gelatinised flour, 2% of xanthan gum, and 4% of protein isolate. The noodle had a hardness of 130.6 g, a tensile strength of 13.2 g, and cooking loss of 7.7%. The noodles quality in terms of cooking loss was found to be lower than those of noodle prepared from modified cassava flour (14.3%), as reported by Affifah and Ratnawati (2017). Low cooking loss is essential for noodles.

3.4. Proximate and sensory evaluation

The content of water, ash, protein, fat, and carbohydrate of the selected formulation was 5.92%; 0.79%; 4.29%; 1.34%; and 87.02%, respectively. The level of consumer acceptance for texture, aroma, colour, and overall parameters had a range of 3 (regular) to 4 (like).

4. Conclusion

Based on the research, it can be recommended that the optimum formulation for a noodle is pre-gelatinised cassava flour with the addition of 2% xanthan gum, 0% konjac glucomannan, and 4% pea protein isolates with a hardness value 130.6 g, tensile strength 13.2 g, and cooking loss of 7.7%. The content of water, ash, protein, fat, and carbohydrate of the selected for-

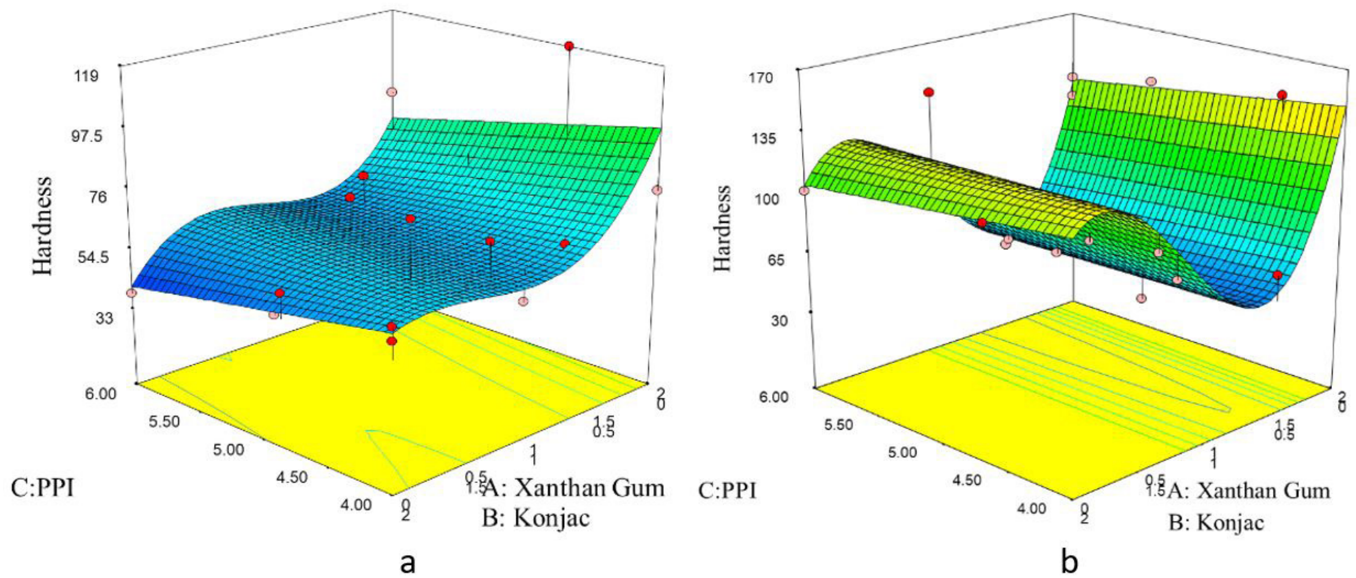

Figure 1. Effects of the component level hardness of native flour-based noodle (a) and pre-gelatinised flour-based noodle (b)

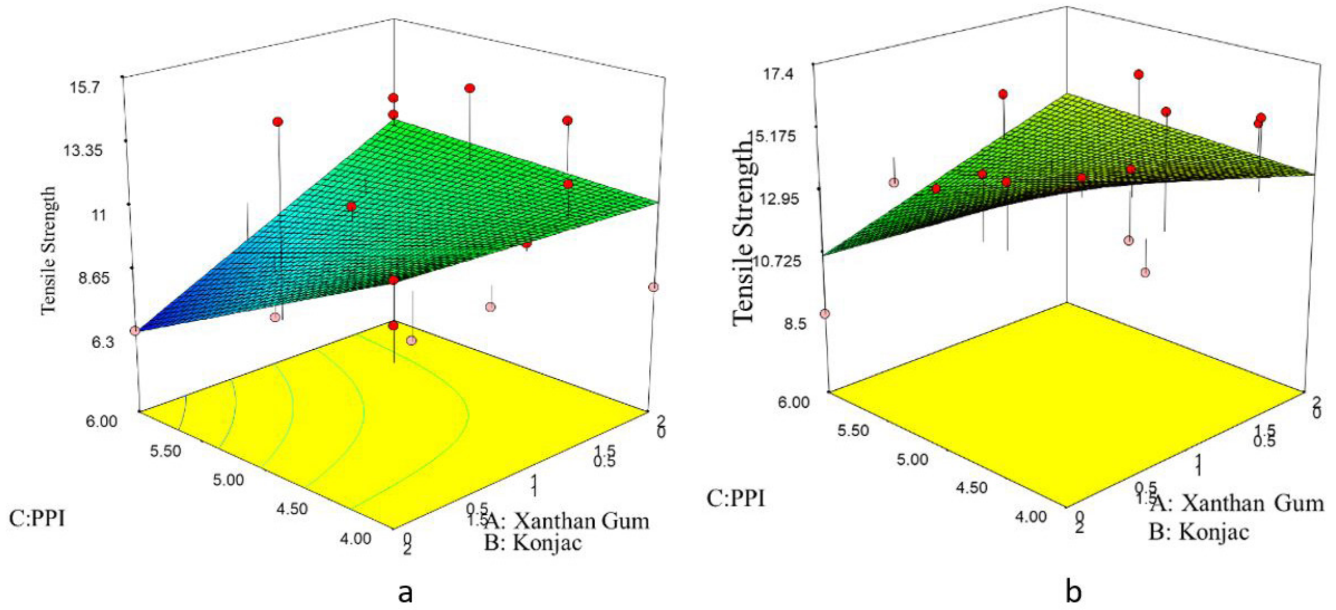

Figure 2. Effects of the component level tensile strength of native flour-based noodle (a) and pre-gelatinised flour-based noodle (b)

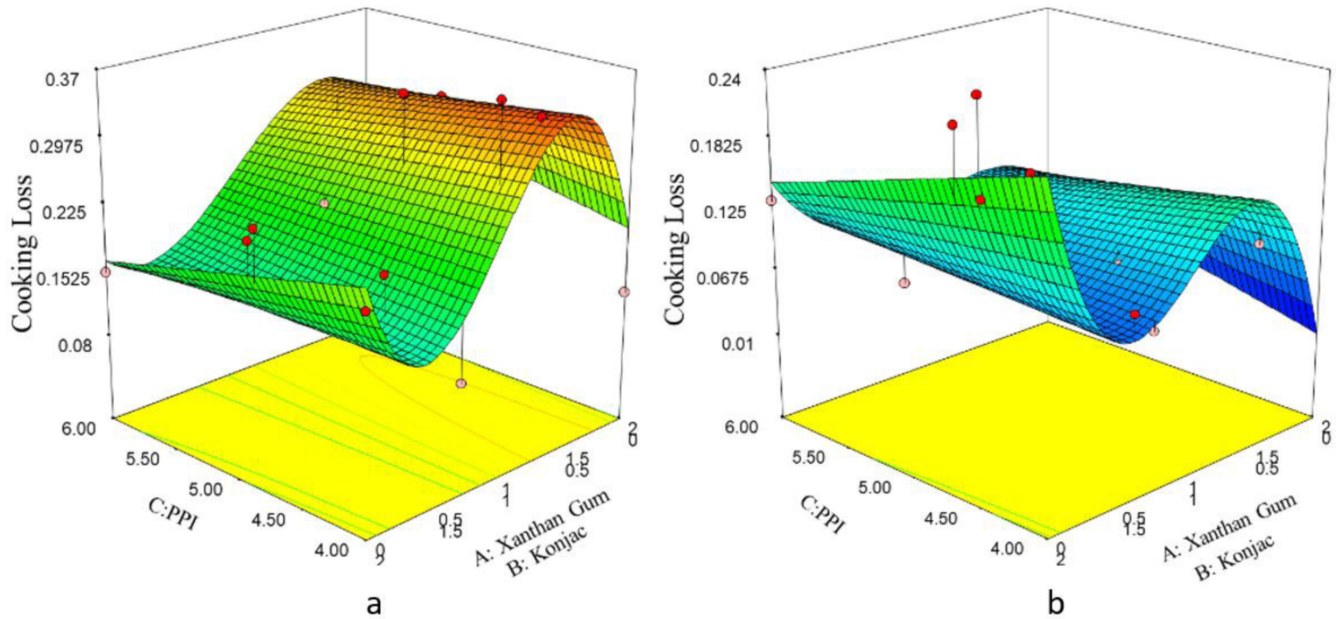

Figure 3. Effects of the component level cooking loss of native flour-based noodle (a) and pre-gelatinised flour-based noodle (b)

mulation was 5.92%, 0.79%, 4.29%, 1,34%, and 87.0%, respectively. For the sensory evaluation, the parameters tested were texture, aroma, colour, and overall. A total of 30 panellists participated. On average, panellists selected a level of preference with a range of 3 (regular) to 4 (likes).

Conflicts of interest

All the authors declared that they have no conflict of interest.

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