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Comparison of physical and chemical properties of high pressure- and heat-treated Lychee (*Litchi chinensis* Sonn.) in syrup

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Lychee usually has white flesh, but its flesh is very sensitive to thermal and enzymatic impairment and ultimately changes in color. This investigation was intended to study the magnitude of color change in lychee by high pressure and thermal processing. The lychee was packed in syrup prior to being processed. Pressurized lychee was performed at 600 MPa at 30°C or 50°C for 20 min, while the pasteurized sample was heated at 90°C for 3 min. It was found that pressurization induced lower color L*, a* and b* values, including low anthocyanin content. For enzymatic activities, high pressure could reduce the activity of polyphenoloxidase by 33–51%, whereas pasteurization markedly reduced that activity by 90%.

Keywords: lychee; high pressure; pasteurization; polyphenoloxidase activities; anthocyanin content

1. Introduction

Lychee (*Litchi chinensis* Sonn.), a non-climacteric fruit, that popularly grows in the Chiangmai province in northern Thailand, has white juicy aril with a pleasant aroma and sweet taste. In general, the lychee fruit is consumed fresh; however, with a limited shelf life and its short production period, the processed products such as canned lychee in syrup are focused. Thermal process is the conventional method for preserving the quality of the canned fruit. However, nutritional losses, undesirably cooked flavor and particularly pink discoloration occur in canned lychee [1]. To overcome these problems, a non-thermal process such as high pressure is preferred to generate better food quality. Phunchaisri and Apichartsrangkoon [2] reported superior visual color quality of pressurized lychee in syrup than those of the thermal processed fruit. However, pressurized fruits still confront a high amount of enzyme activity retained in the product, causing degradation. It was evident that pressure up to 600 MPa at 60°C could only partially inactivate polyphenoloxidase (PPO) in lychee. Therefore, enzymatic browning still proceeded even during storage and caused discoloration [2]. More inactivation of grape PPO by high pressure was reported at 900 MPa at 15°C [3]. Besides PPO degradation, formation of anthocyanins (pink pigment) from precursor

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leucoanthocyanidins (colorless) is another factor affecting color of lychee. Several circumstances induce the conversion of anthocyanins such as temperature, enzymes, sugars, ascorbic acid, pH, oxygen, sulfur dioxide, as well as the presence of co-pigments and metallic ions [4]. This study was aimed to investigate the magnitude of lychee color alteration by high pressure and thermal processing with or without the addition of potassium metabisulfite (KMS) to improve color of the products.

2. Materials and methods

2.1. *Sample preparation*

Lychee fruit (*L. chinensis* Sonn. cv. Guang Jao) was obtained from Chiangmai orchard, Thailand. Lychee was washed, deseeded, peeled and soaked in a mix solution of 1% calcium chloride and 0.1% citric acid for 15 min. After decanting, 100 g of lychee was packed in a laminated bag, and subsequently 100 mL of syrup (pH 3.8) which consisted of sucrose (300 g/L), citric acid (1.3 g/L) and with or without KMS (100 mL/L) was added. The sealed bag was subjected to pressure 600 MPa at 30°C or 50°C for 20 min in a prototype (Stansted Fluid Power Ltd., Stansted, UK). For pasteurized lychee, the fruit and syrup with the same composition were packed in a retort pouch and heated for 90°C for 3 min. All the processed lychees were stored at 4°C until use.

2.2. *Color measurement*

The color L*, a* and b* values of treated lychees were determined using a colorimeter Minolta (Chroma Meter CR-300 Series, Japan). Each treatment was carried out in triplicate and five fruits were measured per replicate.

2.3. *Determination of PPO activity*

Extraction of PPO from treated lychees followed the method described by Huang et al. [5]. Ten grams of lychee was homogenized at 4°C with 40 mL of 50 mM potassium phosphate buffer (pH 6.2) plus 1 M potassium chloride and 2% (w/v) polyvinylpolypyrrolidone. The homogenate was centrifuged at 4°C and 16,000*g* (Sorvall® RC5 C Plus) for 30 min. The supernatant was then collected as the crude enzyme extract. PPO activity was assayed spectrophotometrically (Perkin Elmer series Lambda 35, UK) using catechol (Sigma-Aldrich Co., St. Louis, MO, USA) as substrate according to Flurkey and Jen [6]. A 0.05 mL aliquot of crude enzyme extract was added into a mixture of 2.2 mL of 0.1 M potassium phosphate buffer, pH 6.5 and 0.25 mL of 0.2 M catechol, and absorbance was measured at 420 nm for at least 5 min. One unit of PPO activity was defined as an increase of 0.1 unit of absorbance per minute at 420 nm. All measurements were done in triplicate.

2.4. *Quantitation of anthocyanins*

The analysis of lychee anthocyanin was followed using the method of Ranganna [7]. Nine grams of ground lychee was extracted with 10 mL ethanolic-HCl (95% ethanol plus 0.15% HCl) for 24 h at 4°C. The extract was filtered and absorbance was measured at 535 nm (Perkin Elmer series Lambda 35, UK). Total anthocyanin content was expressed as milligram per 100 g flesh. All measurements were done in triplicate.

2.5. *Statistical analysis*

All data were subjected to the analysis of variance and the Duncan's multiple range test was used to compare significant difference of means at the level of $P \leq 0.05$. All experiments were performed in duplicate and results were expressed as means ± standard deviation.

3. Results and discussion

3.1. *Effects of high pressure and thermal processing on the color characteristics*

Table 1 shows that each individual processing condition significantly altered L*, a* and b* values ($P \leq 0.05$), while the addition of KMS in the syrup did not improve color of the treated lychee. In comparison with fresh lychee, the value L (lightness) increased significantly from 47.40 in fresh fruit to 52.07 in pressurized sample at 600 MPa and even higher to 59.87 in heated samples. Furthermore, pressurized lychee at 600 MPa with a combined temperature (50°C) caused significant increase in lightness ($P \leq 0.05$) suggesting that mild heating and pressure are the key factors to increase lightness of the products. Similar results were also obtained for pressurized lychee of a different variety [2] and pressurized guava purees [8]. The color changes (L*, a*, b* ΔE) of pressurized (200–600 MPa for 5–15 min) blueberry juice were not visually noticeable [9].

For color parameter a* (redness), mild heating and high pressure caused decrease in redness as compared with a* value (4.48) of fresh lychee. Pasteurization induced significantly ($P \leq 0.05$) higher redness of the products than pressurization did. This was also coincidental to a greater amount of existing anthocyanin (pink pigment) in the pasteurized samples (Table 2). Similar results were also found in the report of Phunchaisri and Apichartsrangkoon [2].

For color parameter b* (blueness), high pressure affected significantly ($P \leq 0.05$) lesser than heat did. Overall high pressure could better retain the color parameters a* and b* of the products. Chaimoon et al. [10] pressurized longan in syrup with pressure 400–500 MPa at 30–40°C for 40 min and found that pressurized products exhibited increasing lightness with a* −0.37 to −0.66 and b* 0.2–0.5. Panyada et al. [11] also demonstrated a comparable result with pressurized carrot juice, using pressure 400–600 MPa for 15 min.

3.2. *Effects of high pressure and thermal processing on PPO activity and anthocyanin content*

The activities of residual PPO, causing major brown pigment of lychees in syrup were displayed in Table 2. As comparison to heat treatment, high pressure was less affective to alleviate PPO, since

Table 1. Color values L*, a* and b* of lychee in syrup processed by high pressure and pasteurization.

Processing conditions	Addition of KMS in syrup	Color values		
		L*	a*	b*
Fresh lychee (control)		47.36 ± 0.98 d	4.48 ± 0.84 a	−1.44 ± 0.77 bc
Pasteurization at 90°C/3 min	Not added	59.14 ± 1.32 a	3.70 ± 0.14 b	−2.40 ± 0.32 a
	Added	59.87 ± 1.22 a	3.16 ± 0.14 b	−2.34 ± 0.13 a
Pressurization at 600 MPa/30°C/20 min	Not added	53.33 ± 0.90 c	0.52 ± 0.56 c	−1.44 ± 0.90 bc
	Added	52.07 ± 0.80 c	0.44 ± 0.67 c	−1.93 ± 0.24 a
Pressurization at 600 MPa/50°C/20 min	Not added	57.05 ± 0.44 b	−0.16 ± 0.08 c	−0.20 ± 1.27 c
	Added	55.63 ± 0.85 b	−0.03 ± 0.76 c	−0.32 ± 0.95 cb

Note: Means in the same column with different letters are significantly different ($P \leq 0.05$). Values are means ± SD ($n = 2$).

Table 2. Chemical qualities of lychee in syrup processed by high pressure and pasteurization.

Processing conditions	Addition of KMS in syrup	Residual activity of PPO (unit/mL)	Residual activity of PPO (%)*	Anthocyanin contents (mg/100 g)
Fresh lychee (control)		154.13 ± 16.72 a	100 ± 0.00 a	0.155 ± 0.03 a
Pasteurization at 90°C/3 min	Not added	15.77 ± 3.14 e	10.23 ± 2.04 e	0.168 ± 0.04 a
	Added	7.60 ± 2.17 f	4.93 ± 1.41 f	0.169 ± 0.02 a
Pressurization at 600 MPa/30°C/20 min	Not added	54.24 ± 2.91 d	35.19 ± 1.89 d	0.132 ± 0.02 ab
	Added	50.62 ± 2.20 d	32.84 ± 1.43 d	0.110 ± 0.01 b
Pressurization at 600 MPa/50°C/20 min	Not added	79.20 ± 8.78 b	51.38 ± 5.70 b	0.130 ± 0.02 b
	Added	61.54 ± 3.33 c	39.93 ± 2.16 c	0.111 ± 0.02 b

Note: Means in the same column with different letters are significantly different ($P \leq 0.05$). Values are means ± SD ($n = 2$).
*Calculated based on quantity of 154.13 unit/mL PPO in fresh lychee as 100%.

the pressure of 600 MPa could only partially inactivate PPO by 49–67%, whereas pasteurization markedly reduced PPO by 95%. Thus, browning of the pressurized lychee was inevitable to impair the keeping quality. Phunchaisri and Apichartsrangkoon [2] applied pressure 600 MPa at 60°C for 20 min to inactive PPO by 60% and noticed that pressure resistant property of PPO was due to some baroprotective effect of the syrup. Seyderhelm et al. [12] also affirmed that the thicker syrup (60°Brix) showed better baroprotective behavior than light syrup (30°Brix) with pressurized orange juice. Furthermore, Castellari et al. [3] used pressure of 900 MPa to lessen PPO in grape by 1–16%. In addition, the effects of KMS on PPO activity were clearly shown by significantly ($P \leq 0.05$) lowering the quantity in pasteurized and pressurized samples at 50°C (Table 2). This might be due to the competitive effect of bisulfite which could rapidly interact with the sulfhydryl group of the PPO active site. As a consequence, PPO irreversible sulphoquinones were formed and made the enzyme relatively stable [13].

In thermal processing of lychee, anthocyanins, the predominant flavonoid, are formed in the acidic condition via the degraded leucoanthocyanin [1]. Table 2 showed that pressurized lychee displayed significantly ($P \leq 0.05$) lower anthocyanin content than those pasteurized samples, while the addition of KMS had no effect on the treatment condition. Usually the conversion of colorless leucoanthocyanidins to pink anthocyanins is accelerated by heat. However, these anthocyanins were also detected in non-thermal processed lychee, due to an oxidative reaction of residual PPO [14].

4. Conclusion

Combination of pressure plus temperature could better maintain the color parameters L*, a* and b* of lychee in syrup than heat did. The addition of KMS into the syrup did not play a vital role in improving product color. Pressurization 600 MPa at 30°C or 50°C of lychee in syrup could only partially inactivate PPO activity, whereas pasteurization markedly reduced PPO by 90%. Pressurized lychee had significantly less anthocyanins than pasteurized samples.

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