LWT - Food Science and Technology 72 (2016) 447–456

Contents lists available at ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

Effects of modified starches on the processing properties of heat-resistant blueberry jam

Lu-Lu Zhang, Jing-Nan Ren, Yan Zhang, Jia-Jia Li, Ya-Li Liu, Zi-Yan Guo, Zi-Yu Yang, Si-Yi Pan, Gang Fan*

Key Laboratory of Environment Correlative Dietology, Ministry of Education, College of Food Science and Technology, Huazhong Agricultural University, Wuhan, 430070, China

ARTICLE INFO

Article history:
Received 24 January 2016
Received in revised form
6 May 2016
Accepted 7 May 2016
Available online 8 May 2016

Keywords:
Heat-resistant
Blueberry jam
Modified starch
Anthocyanins

ABSTRACT

This paper focused on the effects of modified starches on the processing properties of heat-resistant blueberry jam. The optimum conditions of bakery jam was studied. The effect of modified starch on the protection of the jam color was also analyzed by using IR, NMR and X-ray. The results showed that the optimal thickening agent was 10% modified corn starch (MS3), and the baking temperature and time were 180 °C and 20 min respectively. After adding the modified starch, the bakery jam had good stability without syneresis, and had good spreadability and texture after baking. The modified starch played an obviously positive role in the color, baking resistance, WHC, appearance and spreadability of the blueberry jam. It might be because the addition of modified starch made the jam system form a fine and homogeneous network. The results of IR spectra, X-ray diffraction and ^{1}H NMR analysis showed that modified starch and anthocyanins might be held together by hydrogen bonding. And this endowed the heat-resistant characteristics of the blueberry jam after the addition of modified starch.

1. Introduction

Blueberry belongs to the Ericaceae family. The fruit is blue in color, hence the name blueberry. Mature blueberry fruit is dark blue and spherical in shape with a particular sweet and sour taste (Pritts & Hancock, 1992). During the natural ripening process, fresh fruits have a very short shelf life due to their sensitivity to fungal attack and excessive texture softening (Cordenunsi et al., 2005). Jam production is an excellent way to meet the needs of off-season supply for the blueberry products (Scibisz & Mitek, 2009; Terefe, Delon, Buckow, & Versteeg, 2015).

Blueberry jam is a popular food with intermediate moisture which is prepared by boiling blueberry pulp, sugar, pectin and acid (Basu & Shivhare, 2013). The jam is usually used as fillings and toppings in bread and cake production. This requires great heat resistance of blueberry jam during the baking process of these bakery products, in order to prevent the serious deterioration on the quality of the jam. This is highly dependent on the ingredients of the jam, such as the thickener (Javanmard, Chin, Mirhosseini, & Endan, 2012). Additionally, the quality of the blueberry jam during baking is also decided by the baking temperature and time.

The jam quality is usually evaluated either objectively through color, textural and rheological or subjectively using sensorial and computer vision techniques (Basu & Shivhare, 2013; Javanmard, Chin, Yusof, & Endan, 2012). The rheological and textural properties of fruit jams have been studied widely (Basu, Shivhare, & Raghavan, 2007; Basu & Shivhare, 2010; Basu, Shivhare, Singh, & Beniwal, 2011). Color is, next to texture, rheology and aroma, one of the most important quality parameters of jam products (Javanmard, Chin, Mirhosseini, et al., 2012; Poiana, Alexa, & Mateescu, 2012). Anthocyanins contribute to the blue color of the jam. Blueberries have a high content of anthocyanins, while they are unstable during processing and storage (Martynenko & Chen, 2016; Pilizota, Kopjara, Zupanic, & Balija, 2011). It has reported that modified starch had protective effects to anthocyanin (Dong, Liu, Ju, Lin, & Lian, 2015; Liu, Dong, Lian, Wang, & Lv, 2015). There may be exist hydrogen bonding interaction between polar group of anthocyanin and hydroxyl group of starch (Sang-aroon, Saekow, & Amornkitbamrung, 2012).

Modified starch is produced from natural starch using physical, enzymatic or chemical treatments with more great properties, such as heat-resistance. And it is widely used as gelling, thickening,

* Corresponding author.
E-mail address: fangang@mail.hzau.edu.cn (G. Fan).

http://dx.doi.org/10.1016/j.lwt.2016.05.018
0023-6438/

stabilizing and filling agents in prepared foods (Galanakis, Tornberg, & Gekas, 2010; Javanmard, Chin, Mirhosseini, et al., 2012). The addition of modified starch is extremely important to assure that the jam product has a reasonable thick consistency and to help to maintain the quality of jam during heating (Javanmard, Chin, Mirhosseini, et al., 2012).

Blueberries have been applied extensively in baked products such as bread, cakes and cookies, and received much attention due to their possible health benefits (Beekwilder, Hall, & de Vos, 2005; Rodriguez-Mateos, Cifuentes-Gomez, George, & Spencer, 2014). However, information on heat-resistant blueberry jam is not well documented, and the protection effect of modified starches on anthocyanins in blueberry jam has seldom been reported. The aim of the present study was to study the effects of modified starches on the processing properties of heat-resistant blueberry jam. The protection effect of modified starches on anthocyanins in blueberry jam was also investigated.

2. Materials and methods

2.1. Materials

Fresh blueberries from Xiangyang Baidi Biotechnology Co., Ltd. were harvested at the commercial maturity stage. Immediately after harvesting, blueberries were frozen at −18 °C until further use.

Modified tapioca starch (MS1, Shanghai Rand starch technology Co., Ltd, Shanghai, China) and modified corn starch (MS2, Ting Hsin International Group, Hangzhou, China) were acetylated distarch phosphate with great solubility, swelling power and viscosity stability at high temperature and low pH value. Another modified corn starch (MS3, Changchun Dahua starch Technology Co., Ltd, Changchun, China) was distarch phosphate with low gelatinization temperature, good emulsibility and water holding capacity. The modified starches, pectin (Yantai Andeli pectin Co., Ltd., Yantai, China) and citric acid (Zhengzhou Yunsheng Biological Technology Co., Ltd., Zhengzhou, China) used were of food grade. The solvents (i.e., ethanol, sodium hydroxide, hydrochloric acid, and potassium bromide, Sinopharm Chemical Reagent Co., Ltd., Shanghai, China) were of analytical reagent grade.

2.2. Preparation of heat-resistant blueberry jam

Blueberries were washed and soaked in water for 20 min. The fruit was blanched in hot water at 100 °C for 5–6 min, and then cooled quickly. Afterwards, the modified starch, 25% sugar, 1% pectin and 0.2% citric acid were added. The mixture was heated with continuous stirring until the soluble solids content was 40%. The jams were hot-packed in glass jars, and then were sterilized at 100 °C for 25 min.

2.3. The optimum conditions for the retention of anthocyanins in the blueberry jam during baking

2.3.1. Orthogonal experiment

Orthogonal experiment was conducted to determine the optimum conditions for the retention of anthocyanins in the blueberry jam during baking. The different varieties and amounts of modified starches, as well as baking time and temperature were the four factors, which comprised three levels each (Table 1). Based on the result of orthogonal test, the single-factor experiment was conducted by controlling the other three factors. The effects of the amounts of modified starch, baking time and baking temperature on anthocyanins content were analyzed, respectively.

2.3.2. Determination of anthocyanins content of heat-resistant blueberry jam

The anthocyanins content was measured using colorimetric assay (Fuleki & Francis, 1968). Two grams of blueberry jam were fully crushed and transferred to a flask. A 1:4 hydrochloric acid/ethanol mixture (40 mL) was added. The flask was covered with a rubber plug and placed in a 40 °C water bath. The extraction time was 2 h. Then, the filtrates were collected in 100 mL volumetric flask by suction filtration and diluted with hydrochloric acid/ethanol to volume. The filtrates were measured using spectrophotometer (Shimadzu Corporation, Kyoto, Japan) at 535 nm absorbance. Hydrochloric acid/ethanol solution was used as reference. Each experiments were performed in triplicate. The content of anthocyanins was calculated using the following equation:

$$W = \frac{A_{535} \times V \times N}{98.2 \times m}$$

where W is the content of anthocyanins (mg/g), A_{535} is the filtrate absorbance at 535 nm, V is the constant volume of anthocyanin extracts (mL), m is the mass of jam (g), N is the dilution multiple, and 98.2 is the extinction coefficient of anthocyanins at 535 nm.

2.4. Effects of the modified starch on the qualities of heat-resisting blueberry jam

The variety of modified starch, baking temperature and times were determined by the optimum results of the orthogonal tests. The heat-resistant blueberry jam was made under the condition that the amounts of the modified starch were 0%, 10%, 15%, and 20%, respectively. The color, baking resistance, water-holding capacity, appearance and spreadability, and the microstructure of the jam were measured, observed and analyzed.

2.4.1. Color analysis

CIELAB color parameters were recorded as L^* (brightness), a^* (red-green chromaticity coordinate), and b^* (blue-yellow chromaticity coordinate) using a Color-Flex 45/0 spectrophotometer (Hunter Associates Laboratory Inc., Reston, VA, USA). C^* (chroma) and ΔE (Chromatic aberration) were calculated using the following equation (Felice et al., 2004; Sun, Bai, Zhang, Liao, & Hu, 2001).

$$C^* = \sqrt{a^{*2} + b^{*2}}$$

$$\Delta E = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}}$$

where ΔL^* is the differences of the brightness before and after baking.

Δa^* and Δb^* are the differences of the red-green and blue-yellow chromaticity before and after baking respectively.

2.4.2. Baking resistance analysis

Jams (20 g) were evenly filled in a ring mold with a diameter of 40 mm, and then they were taken out and baked in an oven. The temperatures of the surface and bottom of the oven were set at 200 °C and 180 °C respectively, and the baking time was 12 min. Baking resistance was calculated using the following equation (Xu & Deng, 2013).

$$N = \left(2 - \frac{S_1}{S_0}\right) \times 100$$

where N is the baking resistance (%), S_0 is the bottom area of the