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Retarding effects of organic acids, hydrocolloids and microwave treatment on the discoloration of green tea fresh noodles

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ABSTRACT

Superfine green tea powder (SGTP) was premixed with organic acids (ascorbic acid, citric acid) and hydrocolloids (sodium alginate, curdlan), and then mixed with microwave-treated wheat flour to produce green tea fresh noodles (GTFN). Darken-retardant effects of organic acids, hydrocolloids and microwave treatments on GTFN were evaluated, as well as pH, polyphenol oxidase activity, sensory and microstructure characteristics. The results revealed that organic acids exhibited a suppressive effect on discoloration, among which citric acid (CA) displayed more efficient influence with lower pH. After adding hydrocolloids and microwave treatments, retardant effects exhibited more significant ($P < 0.05$). Specifically, employing citric acid 0.6 g/100 g, sodium alginate 0.2 g/100 g, and 800 W microwave (MW) 50 s would contribute to lower darkening index ΔE^* (24 h, 25 °C) at 3.88 ± 0.314, 4.94 ± 0.297, 2.78 ± 0.212, respectively. Furthermore, the combined effect of the above process restrained discoloring rate considerably ($\Delta E^* = 1.92 \pm 0.101$), also provided pleasant sensory characteristics. The confocal scanning laser microscopy (CSLM) images demonstrated the microstructure of the noodle was strengthened compared with blank GTFN, and sodium alginate could serve as a binding agent to parcel SGTP and starch granules.

1. Introduction

Noodle is a kind of popular staple food throughout history normally, and among which fresh noodle (FN) has gained preference wide spreadly for its delightful taste and mouthfeel, as well as convenience. Traditional FN is made from *Triticum aestivum* (common wheat) flour, water and salt, and reckoned to lack some essential nutrients, such as dietary fibers, minerals and vitamins (Choo & Aziz, 2010).

With the fast pace of modern life, people are so overwhelmed with stress that junk foods which contain high levels of fat, salt and sugar are well received. This results in a rapid rise in the number and proportion of individuals who suffered from chronic disease such as diabetes, high blood pressure, high cholesterol, heart disease and stroke (Roberts & Barnard, 2005). According to World Health Organization (WHO, 2009), high blood pressure, abnormal blood glucose and overweight are three major risks for mortality in the world, respectively responsible for 13%, 6% and 5% of deaths globally. Therefore, with the intention of manufacturing healthy diet, additional ingredients which can serve as essential nutrients and fiber supplement can be introduced into prevalent stable foods, such as FN.

Green tea is high in dietary fibers, minerals and vitamins, especially tea polyphenols, polysaccharides and proteins, all of which exhibit outstanding antioxidant and anti-carcinogenic activities (Lu, Lee, Maud, & Lin, 2010; Tsubaki, Iida, Sakamoto, & Azuma, 2008; Yang, Lambert, & Sang, 2009; Yu, Sheng, Xu, An, & Hu, 2007). As a superfine grinded food ingredient, superfine green tea powder (SGTP) with an average particle size of approximate 20 μm almost keeps the entire composition of organic green tea, such as tea polyphenols, polysaccharides and amino acids (Hu, Chen, & Ni, 2012). At the same time, SGTP has already been used as a new type of natural additive in wheat dough matrix. Besides, SGTP can also contribute to particular dough behaviors. Li et al. (2012) found that SGTP lead to slight but significant improvement of stability and viscoelasticity of wheat dough.

However, FN is susceptible to time-dependent darkening, resulting in product's undesirable appearance (Bhattacharya, Luo, & Corke, 1999; Hatcher, Symons, & Manivannan, 2004), which is a principal problem arising during the storage of FN, including common green tea fresh noodles (GTFN) products. In resent years, there is a universal consensus that discoloration occurred in FN

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storage is primarily contributed by polyphenol oxidase (Baik, Czuchajowska, & Pomeranz, 1995; Fuerst, Anderson, & Morris, 2006; Mares & Campbell, 2001). Also, Asenstorfer, Appelbee, and Mares (2009) suggested that soluble protein fraction plays a role in the non-polyphenol oxidase (non-PPO) darkening course.

In order to restrain PPO darkening during storage, extensive work has been done in the last few years. Previous studies have indicated that heat treatments on wheat flour and raw noodle could be used to fulfill this task because it would denature proteins and thereby stop enzyme activity (Asenstorfer et al., 2009; Neill, Al-Muhtaseb, & Magee, 2012). Aside from heat treatments, a few organic acids such as ascorbic acid (AA) and citric acid (CA) could suppress the darkening of fresh-cut fruits and vegetables. These organic acids can reduce quinones to phenolic compounds, lower pH value of circumstance, and chelate cooper at the active PPO site (Iyengar & McEvil, 1992; Martinez & Whitaker, 1995). Pilizota and Sapers (2004) reported that a pH 2.9 dip consisted of AA and CA could retard the browning rate of fresh-cut apples.

In addition, the improving effects of different hydrocolloids on noodles or wheat doughs have been reported. Cho, Shim, and Lee (2007) found that hydrocolloids together with appropriate amylase/amylopectin ratio would improve freeze-thaw stability of wheat dough, and Silva, Birkenhake, Scholten, Sagis, and van der Linden (2013) found that the hydrocolloids with high water binding capability could regulate dough rheology. Based on these benefits, hydrocolloids also contribute to noodle texture. Inglett, Peterson, Carriere, and Maneepun (2005) reported that by adding 10% Nutrim-5 (an oat cereal hydrocolloid), 50% rice flour could be incorporated in Asian noodles with satisfactory cooking loss and tensile strength. Similarly to research conducted by Oishi et al. (2009) who reported that hypoallergenic wheat flour noodles with sodium alginate and curdlan possessed better rupture strength and hardness. However, little attention was paid to the potential inhibiting effect of hydrocolloids on the discoloration of FN.

The suppressive effects of particular organic acids, hydrocolloids and microwave treatments on the darkening of GTFN stored in 24 h under ambient conditions were investigated in order to develop a creative and feasible process for this FN product with healthy benefits.

2. Materials & methods

2.1. Materials

High-protein *T. aestivum* (common wheat) flour was manufactured by China Oil & Foodstuffs Corporation (Qinhuangdao, China), and it's moisture, protein and ash contents were 13.5 ± 0.04, 13.1 ± 0.14 (dry basis) and 0.57 ± 0.04 g/100 g flour, respectively. Superfine green tea powder (SGTP) with an average particle diameter of 20 ± 1.9 μm was supplied by Hangzhou Tea Research Institute of All China Federation of Supply and Marketing Co-operatives (Hangzhou, China). Citric acid (CA), ascorbic acid (AA), sodium alginate (SA) and curdlan (CL) of food-grade were supplied by Wuxi Shanzilingyun Trading Company. Sodium phosphate and pyrocatechol were provided by Sinopharm Chemical Reagent Co., Ltd (SCRC). Table salt was purchased from the local market. Fluorescein isothiocyanate (FITC) and Rhodamine B were produced by German Ruibio Chemicals Co., Ltd.

2.2. Methods

2.2.1. Premix treatment of superfine green tea powder

SGTP (2 g/100 g flour), table salt (2 g/100 g flour), citric acid (0.2, 0.4, 0.6, 0.8, or 1.0 g/100 g flour) or ascorbic acid (0.2, 0.4, 0.6, 0.8, or 1.0 g/100 g flour), sodium alginate (0.05, 0.10, 0.15, 0.20, or 0.25 g/100 g flour) or curdlan (0.05, 0.1, 0.15, or 0.20 g/100 g flour) were mixed evenly, then dripped with 22 mL sterile water (deionized water was kept boiling in a pot for 15 min) meanwhile stirring to make a slurry. After that, the slurry was blended with a magnetic stirring apparatus (Model RHB1S25, IKA, Germany) for 30 min. Then, the slurry was stocked in a freezer for refrigerating overnight.

2.2.2. Microwave treatment of wheat flour

Wheat flour (300 g) was evenly dispersed in a round plastic container, covered and then was treated in a conventional microwave oven (Model NJL07-3, Jiequan, China) at 800 W (2450 MHz) for 20, 40, 50, 60, 70, 80, or 90 s, or a ultraviolet-microwave oven (Model JHWB-MF4, Jiahua, China) at 2000 W (2450 MHz) for 20 or 40 s. Afterward, the container with flour was kept still until it felt cool.

2.2.3. Preparation of green tea fresh noodles

Noodle dough was prepared in a dough mixer (Model 5K5SSWH, Kitchen Aid, USA) for 7 min to ensure uniform blending. The pre-formed green tea slurry was poured into the microwave-treated wheat flour slowly while starting the mixer, and then 6 mL of sterile water was added into it while stirring. After resting under ambient environment for 40 min, the dough was flattened gradually into a sheet with 0.9 mm in thickness by a noodle machine (Model JMTD-168/140, Dongfujiuheng, China), and cut into noodle strands of 22 cm in length. Noodles were stored in plastic bags at 25 °C among different characteristics assessment periods.

2.2.4. pH measurement

FN was mashed with a pestle in a mortar. Then 10 g noodle crumbs was homogenized with distilled water (90 mL) in an Erlenmeyer flask, using a magnetic stirring apparatus (Model RHB1S25, IKA, Germany) for 30 s. After a static period lasted 15 min, the pH value of the noodle was measured with a pH meter (Model FE20, Mettler Toledo, China).

2.2.5. Color measurement of noodle sheets

The color of noodle sheet (CIE color parameters L^*, a^*, and b^*) was measured using a Minolta Chroma Meter (Model CR-400, Minolta, Japan) equipped with D65 illuminant according to the description of Fuerst et al. (2006). All chroma assessments were conducted with the same white cardboard as background. L^* denotes brightness (white-black) of noodle sheet, while a^* and b^* indicating red (+)–green (−) and yellow (+)–blue (−) tendency, respectively. Samples were cut into pieces of 9 × 13 cm, and measured within 5 min straight after the noodle sheets were produced. Eight spots were chose randomly from both front and back sides of the sheet to be measured on. Color changes (ΔL^*, Δa^*, Δb^*) were described by calculating the absolute difference between 24 h and zero-time readings during the storage period of FN sheets, and total color change ΔE^* was calculated from the values of ΔL^*, Δa^* and Δb^* as shown in Eq. (1).

$$\text{Total color change index } \Delta E^* = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} \quad (1)$$

2.2.6. Determination of polyphenol oxidase (PPO) activity

The activity of polyphenol oxidase was measured with a spectrophotometric method employing by Yadav, Patki, Sharma, and Bawa (2008) with some modifications. FN (2 g) was ground with 30 mL sodium phosphate-citric acid buffer (pH 5.6) in a mortar. Then the mixture was shook for 12 h, using a constant temperature