

Effect of Instant Tea Powder with High Ester-catechins Content on Shelf Life Extension of Sponge Cake

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ABSTRACT

In this research, a novel formulation of sponge cake was studied. Instant Tea Powder (ITP) with high ester-catechins content was used to replace 0, 7.5, 12.5, and 17.5% of flour to make sponge cakes, hereafter referred to as the control, ITP1, ITP2, and ITP3, respectively. The microbiological analysis and lipid oxidation experiments were conducted and the odor, flavor, color, chewiness, and overall acceptability of different samples were assessed by sensory evaluation. There was significant difference between ITP2 and the control in hedonic sensory evaluation results, whereas, ITP3 was rated lowest in sensory evaluation results. The results also showed the sponge cakes with ITP had good antimicrobial and antioxidant activity compared with the control, and the shelf life of ITP-treated cakes could be extended as a consequence.

Keywords: Antimicrobial activity, Lipid oxidation, Sensory evaluation, Shelf life, Sponge cake.

INTRODUCTION

Sponge cake is made of flour, sugar, and eggs, mixed to make various categories, and has become a kind of worldwide snack. Sponge cakes are usually sold without hermetically sealed packaging; consequently, they can be stored at room temperature for a brief shelf life (about 1 or 2 days) depending on atmospheric temperature and humidity. The microbiological spoilage and lipid oxidation are two major factors affecting the sensory properties and shelf life of sponge cakes. Several studies have been investigated to improve the quality of sponge cakes. Çelik *et al.* (2007) revealed that soapwort extract can be used to partially substitute for egg white in the formation of sponge cakes with sensorial enhancement. It was also found that the use of silky fowl eggs could improve the quality and oxidative stability

of baked cakes (Toyosaki and Koketsu, 2007).

Tea is one of the most popular drinks in the world and its medicinal properties have been proved by numerous researches. Utilization of tea in food have drawn increased attention in recent years because of its potential health benefits such as antioxidative, antitumour, anti-irradiation and antimicrobial activity (Munoz-Munoz *et al.*, 2008; Sagara *et al.*, 2010; Xu *et al.*, 2010; Fan *et al.*, 2011; Haghparast *et al.*, 2011; Siripatrawan *et al.*, 2012). In recent years, there is a tendency of combining traditional food with tea in market for quality improvement or shelf life extension. The main components in tea including catechins, theanine, and ascorbic acid are abundant and could contribute to extend the shelf life of food products without damaging their organoleptic or nutritional qualities (Fan *et al.*, 2008; Li *et al.*, 2011). Tsong

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analyzed the antioxidative effect of green tea powder on sponge cakes and the results showed that cakes combining with green tea powder could be developed as a food with more effective antioxidant properties (Lu *et al.*, 2010). Martín-Diana used green tea extracts as a preservation agent to prolong the storage period of fresh-cut lettuce (Martín-Diana *et al.*, 2008).

However, information on the effect of instant tea powder (ITP) on the shelf life of sponge cakes is still unavailable. The objective of this work was to evaluate the antioxidant and antimicrobial activities of a kind of innovative sponge cake with ITP during a long period. To this end, ITP with high content of ester-catechins was added to the cake batters to determine antimicrobial activity, lipid oxidation, and sensory properties as well as the shelf life extension of sponge cake.

MATERIALS AND METHODS

Chemical Materials

ITP with high ester-catechins content was purchased from Fujian Lixin Food Co., Ltd (Zhangzhou, China) and its composition was determined (Table 1). All-purpose flour (Lisheng food Co., Ltd. Shandong, China), sucrose, fresh eggs, baking powder (Orion Food Co., Ltd Shanghai, China), cream of tartar and soybean oil were purchased from Wal-Mart Stores in Fuzhou, China. Water, purified by reverse osmosis, was used throughout the study.

Preparation of Sponge Cakes

Table 1. Composition of ester-catechins in instant tea powder (%)^a.

EGCG ^a	GCG ^b	ECG ^c	Total content
23.65	0.37	6.15	30.17

^a (+)-epigallocatechin-3-gallate; ^b (+)-gallocatec-gin-3-gallate, ^c (+)-epicatechin-3-gallate.

The formula of sponge cake in this study was adopted from the work of Lee *et al.* (2008) with a little modification. The 3 different formulations of sponge cakes were presented in Table 2. ITP, flour, sucrose, and soybean oil were whipped to a cream. Then, egg yolks, baking powder (An-qi, Angel Yeast Co., Ltd), and egg white were added into the mixture (JB50-S, Shanghai Cany Precision Instrument Co., Ltd.) and whipped (50 r min⁻¹, 5 minutes). Finally, equal amounts of the batter (100 g in each pan) were poured into nonstick pans (Φ 20 cm, 3.5 cm high) and baked at 180°C for 20 minutes in an oven (NT-GT1, Sanyo Electric Co., Ltd. Japan). Sponge cakes were allowed to cool at room temperature. They were carefully taken out of the pans and placed in plastic boxes, and the boxes were stored in a dry and cool environment at 25±2°C prior to analysis.

To produce experimental sponge cakes with ITP, the samples were prepared with 0, 7.5, 12.5, and 17.5% replacement of cake flour with ITP and the corresponding samples were designated as the control, ITP1, ITP2, and ITP3, respectively. Sixty sponge cakes were prepared from each cake batter. Thirty sponge cakes from the same batter were used for chemical characteristic measurements, and another 30 sponge cakes were used for sensory evaluation.

Microbiological Analysis

The microbiological analysis procedure was conducted as described previously (Siripatrawan and Noipha, 2012) with a little modification. Twenty-five grams of cakes were homogenized in 225 ml of 0.1% peptone buffer for 2 minutes. The homogenized samples were serially diluted (1:10) in sterile 0.1% peptone water. Diluted samples (1 ml) of serial dilutions were spread-plated on plate count agar and incubated at 37°C for 24 hours for total counts. For coliforms, 1 ml diluted sample was plated on violet red bile agar (VRBA) and incubated at 37°C for 24 hours, counted

Table 2. Formulation of sponge cakes ^a.

Ingredient (g)	Control	ITP1	ITP2	ITP3
Cake flour	200 (22.0%)	185 (20.4%)	175 (19.3%)	165 (18.2%)
ITP	0	15 (1.7%)	25 (2.8%)	35 (3.9%)
Sucrose	100	100	100	100
Whole egg	425	425	425	425
Cream of Tartar	4	4	4	4
Baking powder	5	5	5	5
Soybean oil	50	50	50	50
Water	125	125	125	125

^a Control, ITP1, ITP2, and ITP3: prepared with 0, 7.5, 12.5, and 17.5% replacement of cake flour with instant tea powder, respectively.

purple-red colonies and picked at least 10 representative colonies and transferred each to a tube of brilliant green lactose bile (BGLB) broth. Incubate tubes at 37°C for 24 hours. For molds and yeasts, 1ml diluted sample was spread-plated on potato dextrose agar and incubated at 28°C for 120 hours, then counted.

Preparation of Lipid Extract

The preparation of lipid was according to the modified Baiano *et al.* (2005) procedure. The lipid was extracted from sponge cake sample (100 g), mixed with 200ml petroleum ether in a flask with a stopper, and kept at room temperature overnight, then filtered through Whatman No. 1 filter paper. The extracted lipid was stored for subsequent determination.

Peroxide Value

Peroxide value (PV) of extracted lipid was determined according to the GB/T of the Chinese standard (GB/T 5009.37-2003). Three grams lipid samples were mixed with a mixture of chloroform and acetic acid (2:3) solution. Then, 1 ml saturated potassium iodide was added and the solution was kept in the dark for 3 minutes. After stabilization, 100 ml distilled water and 1ml starch solution (1 g 100 mL⁻¹) was added into the solution and titrated with Na₂S₂O₃ until

reaching the end point (colorless). Peroxide values were calculated as follows:

$$PV (meq\ kg^{-1}) = \frac{(V_1 - V_2) \times c \times 1000}{m}$$

(1)

Where, V_1 is the titration amount of standard volumetric Na₂S₂O₃ for the sample (ml); V_2 is the titration amount of standard volumetric Na₂S₂O₃ for the blank (ml); c is the concentration of standard volumetric Na₂S₂O₃ (mol L⁻¹), and m is the weight of the sample (g).

Acid Value

Acid value (AV) of the extracted lipid was determined according to the GB/T of the Chinese standard (GB/T 5009.37-2003). Three grams lipid sample was weighed and 50ml mixture of diethyl ether and ethanol (2:1) was added. Then, 0.1ml phenolphthalein indicator was poured into the solution. The solution was titrated with 0.05 mol L⁻¹ KOH until reaching the end point (reddish). Acid values were calculated as follows:

$$AV (mg\ g^{-1}) = \frac{V \times c \times 56.11}{m} \quad (2)$$

Where, V is the titration amount of standard volumetric KOH solution used (ml); c is the concentration of the standard volumetric KOH solution (mol L⁻¹), and m is the weight of the sample (g).



Sensory Evaluation

A panel of 11 subjects (6 males, 5 females) in the Department of Tea Science (Fujian Agriculture and Forestry University) was selected to participate in sensory evaluation of sponge cakes. Sensory attributes, namely, color, odor, flavor, chewiness, and overall acceptability were evaluated based on a hedonic scale test (1= Dislike extremely and 7= Like extremely). The panel consisted of graduate students who had experience in sensory evaluation. During the panel session, panelists were instructed to rinse their mouths with water. Quantitative descriptive analysis was used to obtain the five attributes to describe the samples.

Statistical Analysis

All experiments were repeated three times

with duplicate samples. Data were processed with the Statistical Analysis System (SAS Institute, Cary, NC) for a one-way analysis of variance and Duncan's multiple range test was used to determine whether significant difference ($P < 0.05$) existed between mean values.

RESULTS AND DISCUSSION

Microbiological Analysis

Table 3 shows the results of total counts, coliforms, molds and yeasts of sponge cakes during storage at room temperature. The presence of these microorganisms is considered to be the factor affecting food safety and organoleptic properties (Lv *et al.*, 2011). Comparing with the samples treated with ITP, the control samples had higher population of total counts, coliforms, molds, and yeasts indicating that the microbial

Table 3. Total count, coliforms, molds and yeasts (Log CFU g⁻¹) of sponge cakes^a.

Storage time(day)	Sample	Total count	Coliforms	Molds and yeasts
0	Control	1.64±0.11 c	ND	ND
	ITP1	1.22±0.06 e	ND	ND
	ITP2	< 1	ND	ND
	ITP3	< 1	ND	ND
1	Control	3.16±0.16 b	2.37±0.08 c	< 1
	ITP1	1.51±0.08 cd	2.30±0.06 c	< 1
	ITP2	1.46±0.12 cde	2.32±0.16 c	< 1
	ITP3	1.35±0.07 de	1.89±0.11 d	< 1
2	Control	UC	2.75±0.17 ab	< 1
	ITP1	3.62±0.16 a	2.40±0.13 c	< 1
	ITP2	3.35±0.14 b	2.48±0.16 bc	< 1
	ITP3	3.32±0.10 b	2.23±0.14 c	< 1
3	Control	UC	2.88±0.23 a	1.87±0.12 a
	ITP1	UC	2.51±0.16 bc	< 1
	ITP2	UC	2.57±0.17 abc	1.26±0.08 b
	ITP3	UC	2.49±0.12 bc	< 1

^a ND= Not detected, UC= Uncountable. Each value is expressed as Mean±SD. Mean values with different letters are significantly different ($P < 0.05$) within columns. Storage temperature: 25±2°C.

As for table3 the first columns (from the left) mean the storage day; the second columns mean different treatment in the same day respectively; another 3 columns mean the enumeration of Total count, coliforms, molds and yeasts respectively; a-e means within columns the same lowercase do not differ significantly ($P > 0.05$).

growth was more rapid in the control samples. At day 2, the total counts of control samples were uncountable, while the samples prepared with ITP had moderate numbers. Although the enumerations of total counts in day 3 were uncountable in the control and the treated samples, it was clear that sponge cakes prepared with ITP could prolong the shelf life of sponge cake by approximately 1 day compared with control.

As for coliforms, the result indicated that ITP1 and ITP3 treatments had a lower enumeration compared with control samples throughout storage. This result might be attributed to the damage caused by biochemical components from tea to the membrane permeability of *E. coli*. (Yoda *et al.*, 2004). However, no significant difference for molds and yeasts was observed on days 1 and 2, while the antimicrobial effect was evident on day 3, the ITP-treated samples had fewer enumerations of molds and yeasts compared with that of the control samples. It was suggested that ITP could enhance the

antimicrobial ability as well as extend the shelf life of the sponge cakes. This result is supported by Siripatrawan and Noipha (2012), who found that green tea extract was able to extend the shelf life of pork sausages. The effect of enhanced antimicrobial activity was thought to be related to the antibacterial activity of tea, which could alter the integrity of the outer membrane of microorganisms and disrupt cell walls, increasing the permeability and leakage of intracellular components (Yi *et al.*, 2010).

Peroxide Value

The peroxide value (PV) was employed for determining the formation of lipid oxidation products during storage of the cakes. The effects of ITP on changes in PV of lipids are shown in Figure 1. During the storage period, the PV was evidently higher in control samples than those of ITP-treated samples, which showed an ITP dose-dependent effect. This result indicated that

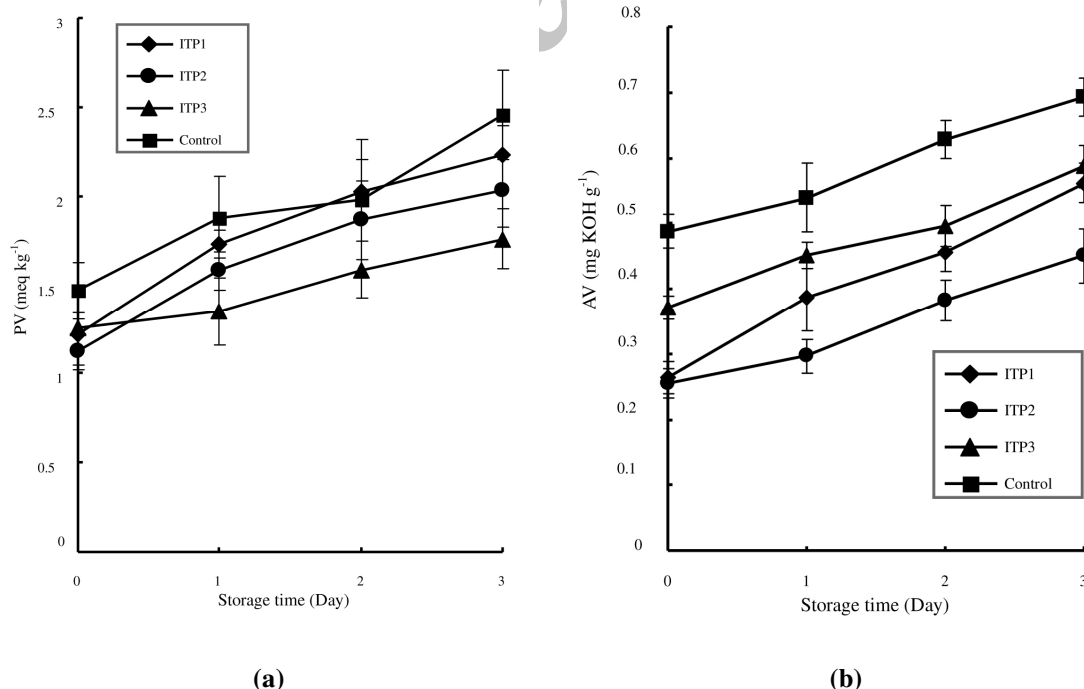


Figure 1. Changes in Peroxide value (PV) (a) and Acid value (AV)(b) of sponge cakes during storage at room temperature.



lipid oxidation in sponge cakes could be inhibited by the use of ITP, probably due to its antioxidant activity from tea (Juśkiewicz *et al.*, 2008). Similar findings have been reported by Lu *et al.* (2010); however, they did not study the changes of *PV* during a long period. The result of our experiment revealed that ITP could suppress the lipid oxidation during 4 days, consequently, retarding the deterioration of sponge cakes at room temperature in the short run. This result is consistent with green tea having high antioxidative and radical-scavenging activity (Almajano *et al.*, 2008; Huvaere *et al.*, 2011).

Acid Value

The acid value (AV) measures free fatty acids and is usually considered to be one of the main parameters reflecting the quality of food during the storage period (Rao *et al.*, 2009). The effect of ITP on changes in AV of lipids is shown in Figure 2.

The AV of the control samples was higher than that of ITP-treated samples during the storage. And there was no significant difference between ITP1 and ITP3 samples on day 2 and day 3. The ITP2 samples had the lowest AV among all treatment groups, reflecting that the production of free fatty acids was restrained. It was suggested that overuse of ITP could inhibit the hydrolysis of lipid during the storage period. The results showed that ITP of moderate concentration (12.5%) had a better effect on inhibiting the emergence of free fatty acid so as to preserve the sponge cakes in good quality in a short run, which might be attributed to the inhibitory effect of ITP on

bacterial growth.

Sensory Evaluation

Means of sensory attribute scores including odor, color, flavor, chewiness and overall acceptability of sponge cake samples are shown in Table 4. In this study, subjects participating in the panel agreed that egg smell was strong in the control, while ITP could mask the egg smell in part when the content of ITP was low (7.5 and 12.5%). However, overuse of ITP (17.5%) might bring some unpleasant odor. The ITP2 samples had the highest flavor score in all treatment samples, while scores of the control and ITP1 had no significant differences and were higher than that of ITP3 samples. Therefore, a spot of ITP could improve the flavor of sponge cake, and excessive ITP could destroy the original flavor of sponge cake. We found statistically significant difference in the color scores among the control, ITP2, and ITP3 samples. It was concluded that ITP can be an additive in changing the color of sponge cake. According to the sensory scores, it was found that ITP3 received significantly lower chewiness values than the other treatments. It was speculated that overuse of ITP led to the increase of particles in sponge cake, thereby reducing the satisfaction. Overall acceptability could reflect the consumers' potential willingness to purchase. As shown in Table 4, ITP2 had the highest score in overall acceptability; whereas ITP3 scored lower than the other samples. It was clear that moderate utilization of ITP would improve physical features of sponge cake; but excessive ITP could result in the

Table 4. Results of the sensory evaluation values for sponge cake ^a.

Cake sample	Odor	Flavor	Color	Chewiness	Acceptability
Control	5.61±0.71 ab	5.43±1.07b	5.54±0.81 b	5.24±1.24 a	5.63±1.04 b
ITP1	5.17±0.84 b	4.77±0.60b	5.08±1.09 bc	4.67±1.19 ab	5.32±1.21 b
ITP2	6.35±0.95 a	6.58±0.99a	6.46±0.71 a	5.68±1.06 a	6.82±0.96 a
ITP3	4.06±1.20 c	3.32±1.34c	4.33±1.28 c	3.61±1.67 b	3.83±1.50 c

^a Each value is expressed as Mean±SD. Mean values with different letters are significantly different (P<0.05) within columns.

lowering of organoleptic quality of sponge cakes, reducing the consumers' purchasing intention as well.

CONCLUSIONS

In summary, a successful and novel formulation of ITP-added sponge cake production was developed. As ITP is a good source of antimicrobial and antioxidant activity, modest utilization of ITP could improve the organoleptic qualities of sponge cakes. Moreover, ITP can extend the shelf life of sponge cakes by retarding the lipid oxidation and microbial growth at room temperature, which has vast market potential to meet consumers' demand for food with tea flavor or without chemical preservatives.

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اثر پودر چای فوری حاوی مقادیر زیاد استر-کاتچین روی افزایش ماندگاری کیک

اسفنجی

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چکیده

در این تحقیق، ترکیب بندی (فرمولاسیون) جدیدی برای کیک اسفنجی بررسی شد. برای درست کردن کیک اسفنجی، پودر چای فوری حاوی مقدار زیادی استر-کاتچین به اندازه های مختلف شامل ۰ = شاهد، $ITP_1 = 7/5\%$ ، $ITP_2 = 12/5\%$ و $ITP_3 = 17/5\%$ به جای آرد به کار رفت. همراه با تجزیه های میکروبیولوژیکی و آزمون های اکسیداسیون چربی، ارزیابی بو، طعم، جوندگی، و پسند پذیری کلی نمونه های مختلف با روش حسی انجام شدند. نتایج به دست آمده بر اساس معیارهای کیفی حسی، تفاوتی معنی دار بین ITP_2 و شاهد نشان داد و ITP_3 در این روش امتیاز دهی کمترین امتیاز را گرفت. نیز نتایج نشان داد که در مقایسه با کیک شاهد، کیک اسفنجی با پودر چای فوری خاصیت ضد میکروبی و آنتی اکسیدان خوبی داشت و کیک هایی که به آنها پودر چای فوری افزوده شده بود از ماندگاری بیشتری برخوردار بودند.