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ORIGINAL ARTICLE

Use of Green Tea in Production of Functional Cookie and Assessment of Its Quality Characteristics

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ABSTRACT

The use of tea in baking industry with addition of antioxidant activity, increase the health benefits of this product. For this purpose, several different formulas were used for making the cookie containing green tea. Cookies quality characteristics were evaluated based on a completely randomized design with 8 treatments including adding green tea powder (GTP) at four levels (5, 10, 15 and 20%), adding green tea extracts (GTE) at three levels (10, 20 and 30%) to the cookie ingredients and control (without adding green tea). Physicochemical parameters of samples such as moisture, firmness, antioxidant activity, crude fiber, protein, pH and ash were determined. Five points hedonic test was used for sensory attributes. The results showed that antioxidant activity, crude fiber, protein and ash of the GTP treatments were at the highest level. In these treatments, crude fiber, protein and total ash significantly increased with increase of GTP percent. PH in GTP treatments were less than other treatments. The antioxidant activity of GTE treatments was increased with increasing concentrations of the extract. Protein was ascending and pH descending through the applying GTE. Samples treated with GTE received the most points overall acceptability of the panelist group and this difference was not significant compared with the control.

Key words - functional cookie, green tea, physicochemical properties

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INTRODUCTION

Green tea is one of several herbs, vitamins, and minerals associated with cancer prevention and treatment. The efficacy of green tea consumption in preventing and slowing the progression of cancers is reviewed and suggested associations between green tea consumption and a decreased risk for some cancers. In selected cases, green tea was effective in slowing the progression of the early stages of cancer [1].

Green tea, *Camellia sinensis*, and its polyphenols have been the subject of many interests. A particular polyphenol, epigallocatechin gallate (EGCG), possesses antimutagenic and anticarcinogenic properties. Epigallocatechin gallate also has been shown to inhibit DNA replication, induce apoptosis in leukemia cells in vitro, as well as suppress infected lymphocytes in vivo [1].

Several studies have reported that green tea extract has antioxidant, antibacterial, antiviral, anticarcinogenic, and antimutagenic functions [2]. Green tea contains considerable amounts of catechins, which contribute most to its antioxidant properties. Besides, green tea is also reported to reduce serum cholesterol levels and inhibit hypertension in several experiments. Antioxidants are used as food

additives in order to prevent the oxidative deterioration of fats and oils in processed food. Natural antioxidants can inhibit lipid peroxidation in bakery foods and improve these qualities and safety [3].

In the United States, green tea extract may be used as a flavor agent with antioxidative properties in various fats, oils and foods containing fats and oils. Green tea has a history of safe use as a food flavouring and is known for its antioxidative functionality as a secondary effect. Green tea extract is well known in Asian food. In the United States, green tea extract may be labeled as natural flavouring Certain green tea extracts are also regarded as traditional foods in the EU, however, market clearance of green tea extracts depends on the intended use as well as the product profile. There is growing consumer interest in the green tea extract supplemented products in recent years [4]. Green tea extract has been used in a variety of food products including bread [5], biscuits, dehydrated apple [6] and various meat products [7,8].

Green tea extract (GTE) as an excellent source of tea polyphenols, especially tea catechins, was added to bread dough in a no-time bread making process in reports [5,9]. It was found that tea catechins were relatively stable in bread making, having 84% of the total tea catechins remained after baking as well as during its shelf life [5]. On the other hand, instrumental results revealed some negative impacts on the quality of bread with GTE, giving smaller bread volume and harder crumb [9].

Below the threshold value, both the product quality and sensory quality of GTE-fortified bread were not significantly compromised. Meanwhile the GTE-fortified bread was found a functional food product with additional health benefits. This provides a good guide for those bread manufacturers who are to pursue the production of GTE-fortified bread [10].

Sponge cake formulated with partial replacement of the cake flour with up to 20% green tea had bioactive components and pleasant tea flavour as compared to cake prepared with 100% cake flour. Green tea sponge cake was good in antioxidant properties [3].

The protective properties of GTE against the formation of primary and secondary oxidation products of fats in biscuits were detected. It is concluded that the GTE is a source of active antioxidants and might be used in food lipids stabilization. GTE gave an excellent antioxidant effect on the biscuits lipid stability, inhibiting hydroperoxides formation by about 47% to 73%, while formation of secondary oxidation products by about 3.5%. In comparison with synthetic antioxidant, plant extracts are safe and have many positive effects on human health, including their anti-inflammatory activity and anticarcinogenic properties [11].

During the past few decades, the use of natural antioxidants and plant-derived extracts have received increased interest due to concerns over possible adverse health effects caused by the use of synthetic antioxidants. Green tea, a natural source of antioxidant, has been successfully used not only to enhance flavor, but also to extend the shelf-life of various food products. Baked food products are enjoyed by consumers all over the world. Because of their high consumption, they are potential carriers of bioactive compounds and dietary fiber. Thus, it would be beneficial to develop a novel formulation of cookie production with green tea. The objectives of this research were to make a cookie with green tea (powder and extract) to evaluate the influence of green tea on cookie quality and contents of the functional component as a result of supplementation. The antioxidant properties of cookie were also determined.

MATERIALS AND METHODS

The experiment was carried in tea research center laboratory in 2015. In this study different methods were used to prepare green tea cookies, the quality characteristics of the product were examined. Quality characteristics conducted in a completely randomized design with three replications. The treatments consist of 8 recipes to prepare cookies, green tea powder (GTP) with the ratio of 5, 10, 15 and 20% of flour quantity and green tea extract (GTE) with concentration of 10, 20 and 30% were added to dough and marrow to prepare cookies. Control was prepared without adding tea. Sensory characteristics, moisture, firmness, antioxidant activity, crude fiber, protein, pH and ash were determined after cookie preparation.

A. Preparing green tea

Green tea was provided from local market. The dried tea leaves were ground in a mill and screened through a 0.5 mm sieve.

B. Extraction preparation

A specified amount of green tea was extracted using a multiple steps with 100 ml of water at 80°C for 30 min on a shaker and cooled to 24–26 °C [12]. The required amount was added to cookies dough and marrow.

C. Cookies preparation

The traditional cookie formula in this study was, according to International Standard Islamic Republic of Iran (ISIRI), 2554 [13]. Ingredients for baking cookies, weighed, prepared and processed manually according to the formulation presented in Table 1. For each cookie, 55 g of dough and 18 g marrow was prepared and baked at 180 °C for 15 min in a preheated oven. The cookies were allowed to cool, and then were packed in polypropylene bags at room temperature before physico-chemical and sensory evaluation analyses.

D. Evaluation of the physicochemical characteristics of cookies

Moisture content, pH, ash and proteins conducted according to the ISIRI, 2554 [13]. Crude fiber was measured according to ISO 5498, [14]. The firmness of texture was measured using, Lutron dynamometer model FG-5020 with probe speed 14 mm/min. 2.45 cm cubic from top of cookies was measured [15]. The antioxidant activity of the samples was measured by using the DPPH (2, 2-diphenyl-l-picryhydrazyl) assay [16].

Statistical analysis of data based on a completely randomized design using SAS and SPSS software and mean comparison using LSD test and graphs were drawn using EXCEL software.

E. Cookies sensory characteristics evaluation

The hedonic test was used to determine the degree of overall liking for the cookies. For this study, untrained consumers were recruited from the staff of the Iran tea research center. All consumers were interested volunteers and informed that they would be evaluating cookies. For the cookies manufacturing study, 50 consumers (males and females) received eight samples and were asked to rate them based on the degree of liking on a 5-point hedonic scale (1 = dislike extremely, 3 = neither like nor dislike, 5 = like extremely) and also colour, texture and taste of cookies were investigated. Samples were given to a random two-digit numbers [3]. The data were analyzed by using the Kruskal- wallis test.

RESULTS AND DISCUSSION

Chemical and physical properties of cookies

The significant difference ($p < 0.05$) was observed between types of cookies in all characters. Moisture content of control and 10% GTP cookies was less than the others (Table 2). The use of different types of green tea, GTP and GTE had no significant difference in cookies moisture content. Changes in different doses of GTE had no impact on the amount of cookies moisture ($p < 0.05$).

Table 1. Formulation of cookies in different treatments

Treatments	Cake Flour [g]	Green Tea Powder [g]	Green Tea Extract [g]	Water [g]	Other Ingredient
Control	100	-	-	25	Equal in all of treatments
GTP 5%	95	5	-	25	
GTP 10%	90	10	-	25	
GTP 15%	85	15	-	25	
GTP 20%	80	20	-	25	
GTE 10%	100	-	5	20	
GTE 20%	100	-	5	20	
GTE 30%	100	-	5	20	

GTP: green tea powder and GTE: green tea extract were added to formulation of cookies, control: cookie without GTP and GTE

Table 2. Effect of different formulation of cookies on moisture content and firmness

Treatments	Moisture Content [%]	Firmness [N]
Control	15.5±0.87B[a]	0.44±0.17AB
GTP 5%	16.7±0.65A	0.28±0.07B
GTP 10%	15.5±0.74B	0.43±0.12AB
GTP 15%	16.5±0.33AB	0.41±0.11AB
GTP 20%	17.2±0.68A	0.54±0.03A
GTE 10%	17.1±0.45A	0.39±0.13AB
GTE 20%	17.3±0.45A	0.46±0.12AB
GTE 30%	16.7±0.53A	0.44±0.14AB

[a] Each value is expressed as mean ± SD (n = 3). Means with different capital letter within a row are significantly different ($P < 0.05$).

GTP: green tea powder and GTE: green tea extract were added to formulation of cookies, control: cookie without GTP and GTE

Table 3. Effect of different formulation of cookies on sensory characteristics

Treatments	Colour	Texture	Taste	Overall Acceptance
Control	3.5±0.14AB[a]	3.3±0.12AB	3.6±0.14 A	3.4±0.12AB
GTP 5%	3.1±0.15ABC	3.0±0.14AB	3.2±0.15ABC	3.1±0.15ABC
GTP 10%	3.0±0.15BC	3.0±0.15AB	2.8±0.16BCD	2.7±0.15ABC
GTP 15%	3.0±0.15BC	3.1±0.11AB	2.6±0.16CD	2.6±0.16BCD
GTP 20%	2.4±0.17C	2.7±0.13B	2.2±0.15D	2.2±0.16CD
GTE 10%	3.6±0.11AB	3.6±0.12A	3.5±0.15A	3.6±0.14D
GTE 20%	3.6±0.12AB	3.4±0.11A	3.5±0.13A	3.6±0.12A
GTE 30%	3.7±0.13A	3.6±0.13A	3.4±0.12AB	3.5±0.13A

[a] Each value is expressed as mean ± SD (n = 50). Means with different capital letter within a row are significantly different (P < 0.05).

GTP: green tea powder and GTE: green tea extract were added to formulation of cookies, control: cookie without GTP and GTE

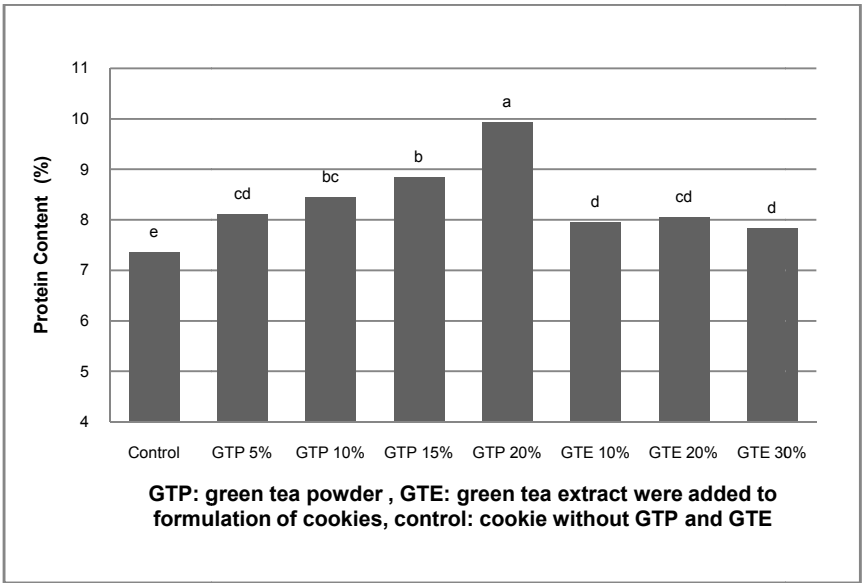

Fig. 1. Effect of different formulation of cookies on crud fiber

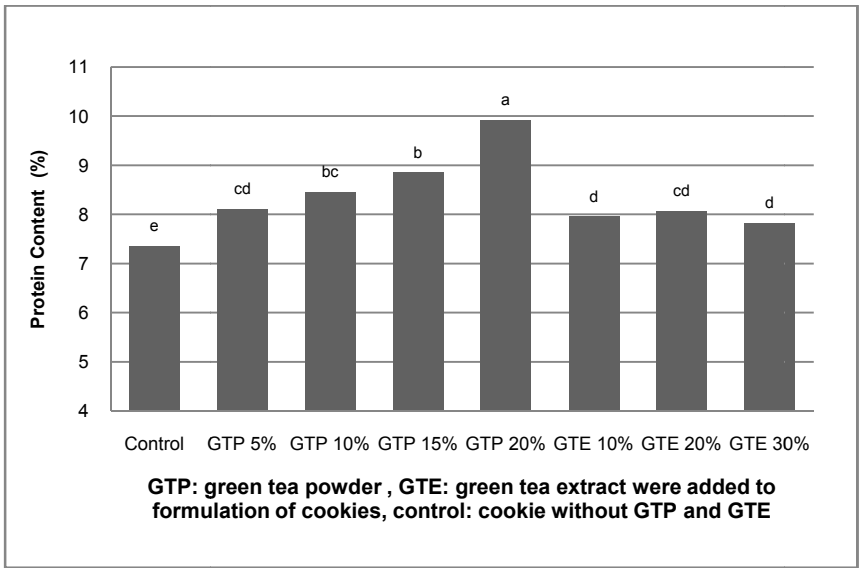

Fig. 2. Effect of different formulation of cookies on protein content

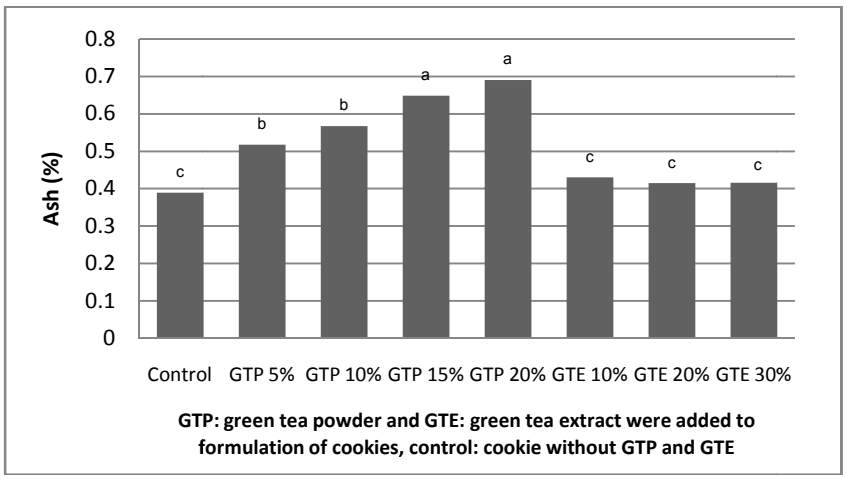

Fig. 3. Effect of different formulation of cookies on ash

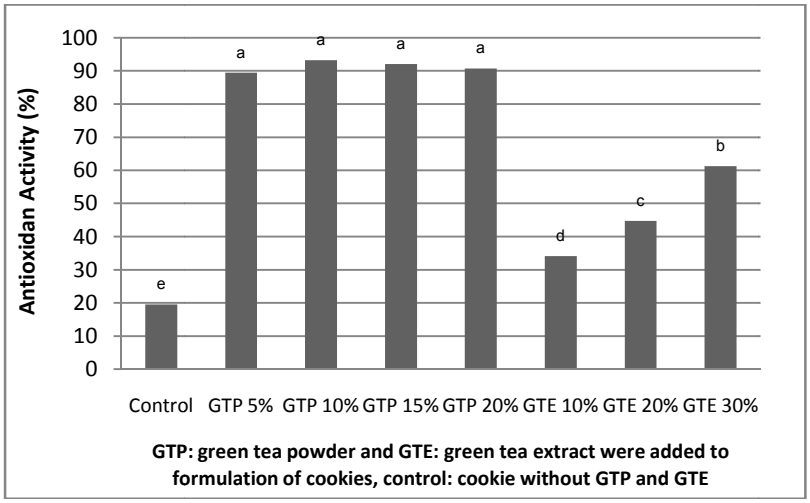

Fig. 4. Effect of different formulation of cookies on Antioxidant Activity

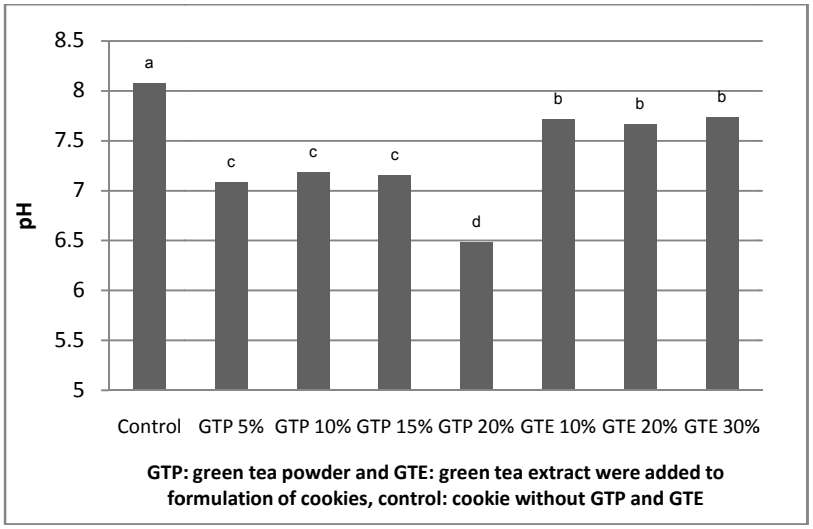

Fig. 5. Effect of different formulation of cookies on pH

Cookies containing 5 and 20 percent GTP showed softest and hardest tissue respectively (Table 2). Replacing 20 percent of the flour with GTP causing less porous texture, can reduce the soft tissues and softness of the cookie. It may be due to increased replacement of flour with cellulose of GTP, which has been reported to weaken the gluten matrix, responsible for retaining gases in baked goods [3].

The amount of antioxidant activity, crude fiber, protein and ash was more in cookies with GTP compared to GTE and control ($p < 0.05$). As shown in Figures 1, 2 and 3 with the increase in the percentage of GTP percent in cookies, crude fiber, protein and ash were increased. Treatment containing 20% GTP rises the crude fiber content, protein and ash by 2.5, 9.9 and 0.69% respectively. According to Iranian national standard definition the minimum amount of protein in cookies is 6.5% [13]. Antioxidant activity changes were not significant in all four treatments using GTP in cookies (Figure 4). Similar studies on sponge cake, enriched with green tea have shown that, replacing the flour with powdered green tea increased crude fiber, protein and ash that had a direct correlation with the percentage of green tea powder. In this research increase the antioxidant effects of green tea in the cake has been proven [3].

Increasing of protein and fiber in addition to the creation of antioxidant compounds enhance the nutritional properties. The recommended Daily Value (DV) of dietary fiber is 25 g for a 2,000 calorie diet. To make a "good source", "contains", or "provides" claim, the food should contain 2.5 g or more of fiber (10% of the DV) [17]. So by taking two cookies containing GTP in addition to the antioxidant properties benefit, ten percent of daily fiber needs will be met. Ash and crude fiber in variety of cookies with GTE, showed no significant differences with the control. But the amount of protein and antioxidant activity was greater than control and less than those containing GTP. Increasing antioxidant activity was quite significant in samples with more concentration of the extract. Antioxidant activity in cookies with GTE was in the descending order: 30% GTE > 20% GTE > 10% GTE > control. The results showed that adding green tea greatly enhanced antioxidant properties of the cookies. The improved antioxidant properties of green tea cookie might be due to the incorporation of phenolic compounds, mainly various catechins, which had been shown to possess antioxidant activity. The assay of DPPH radical scavenging activity showed that GTE is a very good source of active antioxidant compounds [11].

Adding GTP with 5.6 pH, especially 20% GTP, significantly decreased the pH value even less than the control. The average pH was 6.5, 7.5 and 8.1 in GTP, GTE and control cookies respectively (Figure 5). The stability of tea catechins is closely associated with pH. In alkaline solution, they are very unstable and decompose in a few minutes, whereas, in acidic solution, they are relatively stable. The stability of EGCG increased when the biscuit dough was prepared without adding any alkalinity-inducing material [18]. Su et al. (2003) studied the stability of green tea catechins in sodium phosphate buffer solution over a pH range from 5 to 7.4. They found that catechins were stable for over a period of time (18 h) only at pH 5, and they began degrading from pH 6 onwards [19]. In this study the low pH in treatment with GTP might lead to higher antioxidant properties in GTP cookies than in GTE cookies.

Sensory characteristics

Using the Kruskal-Wallis test sensory scores obtained sample panelist group were compared. The statistically significant difference evaluated by untrained consumers in the colour, texture, taste and overall acceptance of cookies. Flavor and overall acceptability of all GTP cookies showed significant differences ($p<0.05$) in compared with GTE cookies and control (Table 3). Sensory characteristics liking colure and tissue in cookies containing 20% of GTP were significantly lower than the control and GTE cookies. However Sensory characteristics liking score of 20% GTP cookies were the worst. It could be because of slightly bitter of this cookie that be attributed to the caffeine of green tea [3]. This treatment also had a dark green colour that was undesirable for consumers. GTE cookies received the most points overall acceptance from the panelist group that was not significant compared with the control. The sensory characteristics liking the results pointed out that samples containing GTE had the highest utility.

Conclusion

Comparing and physicochemical properties of cookies in different treatments indicate that, sample containing 20% of GTP with more protein, crude fiber and minerals has better nutrient properties compared to other samples. But the sensory evaluation showed that this treatment in terms of colour, texture, taste and overall utility acceptability could not reach the marketplace. The firmness of the sample in the test device confirmed this deficit. In addition dark green colour and bitter taste were unfavorable for the consumers.

The desirable sensory was less in treatments containing GTP comparing with control and treatments containing GTE, but in the midst, the treatment with 5% GTP showed better acceptance of the consumer. In addition to the antioxidant properties of this treatment, the percentage of protein, crude fiber and total ash was higher than the control. The treatment containing 30% of GTE with 61.2% antioxidant activity was well accepted by the consumer.

In general, the best choice for production of functional cookie from tea with respect to functional sensory and physicochemical properties is the treatment with 30% GTE and 5% GTP.

COMPETING INTERESTS

The authors have declared that no competing interest exists.

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