Chemical characteristics and glycemic index of processed products from corn starch modified with green tea polyphenols

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Abstract. This study aimed to estimate chemical composition, glycemic index (GI) and glycemic load (GL) of cake and cookies from native and corn starch modified with 4% green tea extract 58-62 °Brix. Chemical composition analysis includes proximate, starch, dietary fiber and resistant starch. GI test was conducted in vivo on 12 healthy people. The results show no significant differences in chemical composition between native and modified corn starch cake and cookies (p>0.05), except starch total of cake and dietary fiber total, insoluble dietary fiber and soluble dietary fiber content of cookies. GI and GL decreased only in cakes from 85.02 to 74.96 and 15.35 to 12.41 respectively. The decrease was not significant (p>0.05). Cake of modified corn starch still had high GI, but intermediate GL. Cookies of native and modified corn starch had low GI (52.23) and intermediate GI (58.25) respectively. The GI of both products were not significantly different (p>0.05). GL of modified corn starch cookies significantly higher than native. Cookies of modified corn starch and native had high GL, 23.38 and 20.66 respectively. The study concluded that corn starch modified with green tea extract had not been effective yet in reduction GI and GL of the processed products.

1. Introduction
Starch is the major carbohydrate in the daily diet and 60% of its availability was used for food [1]. A healthy diet requires 50-65% of energy from carbohydrates [2]. Selection of the type of carbohydrates for patients with degenerative diseases (diabetes mellitus, coronary heart disease, obesity, cancer) is important. World Health Organization (WHO) reported that 68% of global deaths due to these diseases [3]. WHO and the consensus of international scientists recommend the consumption of low glycemic index (GI) and glycemic load (GL) products [3,4]. It shows the important role in the prevention and management of these diseases.
GI is a property of carbohydrates in different foods that refers to the blood glucose-raising ability of the digestible carbohydrates [5]. Carbohydrate foods that digested, absorbed and metabolized quickly are considered high GI foods (≥70), whereas those digested, absorbed and metabolized slowly are considered low GI foods (≤55) [4].

Corn starch and other starches generally have in vitro starch digestibility and high GI. Corn, arenga, sago and tapioca starch have in vitro starch digestibility 89.64%, 90.55%, 90.48% and 99.36% respectively [6,7]. Corn starch and tapioca have a high GI, 74.9 and 115 respectively [8,9]. The corn starch has broad and potential application to substitute 20-100% tapioca starch needs [10].

Green tea (Camellia sinensis O. Kuntze) is one source of polyphenols [11,12] which is a decrease in vitro starch digestibility and GI [6,13,14,15]. Polyphenol content of green tea (10-15%) is higher than black tea (5%) [11]. Corn, tapioca, arenga and sago starches that modified with 4% (w/v) green tea extract 58-62 °Brix contain 232.78 mg GAE/100 mg extract of poliphenol significantly reduce in vitro starch digestibility from 89.64–99.36% to 83.42-87.22% [6]. Modified tapioca starch with the same extract significantly reduce blood glucose and increase the population of pancreatic beta cells, 48.81 per 10 mm² Langerhans islets on diabetes rat [16]. The addition of 7% and 4% green tea extract on processing parboiled and instant rice reduce in vitro digestibility starch 72.73% and 53.97% respectively. It produces intermediate and low GI of rice, 56 and 49 respectively. The rice also inhibits decreasing of islets Langerhans number (parboiled rice) and rate of destruction of Langerhans beta cells (instant rice) on diabetic rats [13,14]. Soaking rice process with green tea, black tea and 0.1% tannic acid affect in vitro starch digestibility of rice with the lowest digestibility produced by green tea extract [15].

Polyphenol affects carbohydrates metabolism through inhibition of carbohydrate digestion and absorption of glucose in the small intestine [17]. The inhibition related to the ability of the compounds to inhibit α-amylase activity [18]. Green tea polyphenols (0.05 mg/ml) inhibit 61% of α-amylase activity [19]. The compounds form starch complex such as amylose-fat complex that caused the changes of molecular structure of starch. It is unrecognized by digestive enzymes [20,21].

This study aimed to determine changes on chemical composition, GI and GL of cake and cookies from corn starch modified with green tea leaf extract compare to native starch.

2. Materials and methods
Corn starch (Zea mays) was obtained from PT Subafood Pangan Jaya, Tangerang-Banten, Indonesia. Dry green tea (Camellia sinensis O. Kuntze) type peko super were harvested from Experimental Green Tea Garden in Pasir Sarongge Cianjur, Indonesia. The cake and cookies ingredients were purchased from local market (Bogor, Indonesia). In addition, the chemicals were analytical grade and obtained from Merck, SIGMA and HUMAN Company.

2.1. Processing of green tea extract
The extraction of green tea used Widowati modified method [13]. Dry green tea powder (32 mesh) were extracted with boiled water 1:10 (w/v) using water bath (Gallenkamp, United States) at 85°C for 8 minutes. The filtrate filtered by 200 mesh, centrifuged at 2000 rpm (MSE K1213A, United Kingdom) and evaporated at 80°C until 58-62 °Brix (Rotavapor Buchi RII, Germany).

2.2. Processing of modified corn starch
Corn starch soaked at 4% green tea extract 58-62 °Brix contain 232.78 mg GAE/100 mg extract of poliphenol 1:1 (w/v) for 6 hours using shaker (Gallenkamp Orbital, United Kingdom) at 200 rpm. The starch dried using cabinet drier at 80°C until 13% of moisture (maximum).

2.3. Processing of cake and cookies
The cake processed according to Marahimin and Rusdzalil method [22]. These ingredients consist of 250 g native and modified corn starch, 225 g palm sugar, 5 g pandan leaves, 1 g salt, 750 mL water, and 8% (w/w) grinded coconut.
Starch solution was processed by mixing of starch, salt, and water. In different places palm sugar solution processed by boiling (15 minutes) of palm sugar, pandan leaves and water. Starch and palm sugar solution was then mixed, and boiled, to form a cake. The cake was sliced to 3 x 4 cm size and sprinkled with salt and grinded coconut.

The cookies was processed using Gustiar’s formula [23]. These ingredients consist of 250 g native and modified corn starch, 87.5 g sugar, 137.5 g margarine, 18.75 g low fat milk, 31.25 g yolk, and 0.5 g baking soda.

Sugar, margarine, low fat milk, and yolk were mixed by hand mixer for 10 minutes. Baking soda was added and the dough was mixed. The starch added slowly until the mixture well combined. The mixture baked for 30 minutes (160-170°C) (Memmert, Germany).

2.4. Chemical properties
Moisture, ash, fat, protein, and carbohydrates total were measured according to AOAC [24]. Starch total content followed Luff Schoorl method [25], soluble dietary fiber, insoluble dietary fiber and dietary fiber total [24] and resistant starch was used enzymatic methode [26]. All the measurements were conducted in tri replicate.

2.5. Determination of gi and gl
GI were measured according to International Organization for Standardization methode 26642:2010 [5] and Joint FAO/WHO Expert Consultation, Carbohydrates in human nutrition [8]. The test was conducted on each 6 healthy man and woman aged between 20-38 years, with 18.5-24.99 kg/m² body mass index (BMI) [27], unpregnant and unbreastfeeding and unsmoker. Ethical approval was obtained from National Institute of Health Research and Development, Ministry of Health, Indonesia (document number: LB.03.04/KE/6122/2010) and all subjects signed informed consent.

All subjects had fasting for 12 hours at night, except for drinking water. After fasting 50 μl finger-prick capillary blood of subject was taken. Subjects were requested to consume sample (cake or cookies) or glucose solution (reference food) equal to 50 g glycemic available carbohydrate (200 calorie) and 150 ml water within 15 minutes. They had further blood (50 μl) taken at 30, 60, 90 and 120 min after the initial meal intake.

Later blood was added to 500 μl uracil acetate (Human 09006) test-tube, then blood glucose was analyzed. The analysis used GOD-PAP (Glucose Oxidase Phenol Amino Phenazine) methode using spectrophotometer (spectrophotometer chem 7). Blood glucose content was ploted into 2 axis, time (x) and blood glucose content (y), as result is incremental area under the blood glucose response curve (IAUC) of sample and reference food. The GI was calculated using equation (1) [5]:

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GI = \frac{IAUC_{sample}}{IAUC_{reference}} \times 100
\]

A food is classified being low, intermediate and high GI if it has GI value > 70; 56-69 and <55, respectively [4,28]. GI test for each sample determined at different day with 1 day minimum interval. The GL is the GI of product and the total available carbohydrate content in a given amount of food (100 g) [4]. A food classified to low, intermediate, and high GL if it has GL value ≥ 20, 10-19, < 9, respectively [28].

2.6. Statistical analysis
The chemical composition, GI and GL of modified corn starch cake and cookies was compared by t-test.
3. Results and discussion

3.1. Chemical composition of modified corn starch cake and cookies

The chemical composition of native and modified corn starch cake and cookies are shown in table 1 & 2 respectively. The addition of 4% (w/v) green tea extract 52-62 °Brix was not significantly affect to all of the chemical composition of the cake and cookies. Starch total of the cake and dietary fiber total, insoluble and soluble dietary fiber content of the cookies were significantly changed (p<0.05) (table 1 & 2). Research on the other source of polyphenols reported that the addition of 4% (w/v) red guava leaf extract 52-62 °Brix was not significantly affect to all of the chemical composition of the cake, except on fat, carbohydrates total and starch total content of the cookies (p<0.05) [29].

Modified corn starch cake has significantly low starch total (34.25%) than the native (37.43%) (table 1). The low starch total content related to decreasing content of amylopectin of green tea modified corn starch as the raw material products. As the result, starch total content of modified corn starch and its products were decreased. It caused by heat moisture treatment (HMT) processing in the starch. HMT is the heating of starch above the gelatinization temperature (70-130 °C) at least one hour, with a limited moisture (15-35%) [30]. Modified corn starch obtained by HMT processing techniques. The HMT process in rice starch caused the degradation of amylopectin. It reduces the number of large molecules (amylopectin) and increases the number of small molecules (amylose) [31].

Table 1. Chemical composition (% dry basis) cake of native and modified corn starches.

| Chemical composition                  | Native starch | Modified corn starch |
|--------------------------------------|--------------|----------------------|
| Moisture                             | 51.74±3.79   | 51.64±0.05           |
| Fat                                  | 5.27±0.64    | 5.39±0.30            |
| Protein                              | 0.68±0.07    | 0.62±0.03            |
| Ash                                  | 1.11±0.09    | 1.07±0.00            |
| Carbohydrate total (by difference)   | 92.94±0.79   | 92.91±0.27           |
| Starch total                         | 37.43±0.27   | 34.25±0.11           |
| Resistant starch                     | 8.64±1.56    | 9.35±0.19            |
| Insoluble dietary fiber              | 4.02±0.17    | 4.67±0.30            |
| Soluble dietary fiber                | 1.08±0.22    | 1.15±0.05            |
| Dietary fiber total                  | 5.10±0.39    | 5.82±0.35            |

Note: The values within the same row followed by different superscript letters are significantly different (p<0.05)
Table 2. Chemical composition (% dry basis) of native and modified corn starches.

| Chemical composition                  | Native starch | Modified corn starch |
|---------------------------------------|---------------|----------------------|
| Moisture                              | 0.73±0.05<sup>a</sup> | 0.63±0.28<sup>a</sup> |
| Fat                                   | 26.96±0.43<sup>a</sup> | 26.36±0.43<sup>a</sup> |
| Protein                               | 1.90±0.04<sup>a</sup>  | 1.89±0.02<sup>a</sup>  |
| Ash                                   | 1.14±0.01<sup>a</sup>  | 1.14±0.08<sup>a</sup>  |
| Carbohydrate total (by difference)    | 70.00±0.38<sup>a</sup> | 70.61±0.50<sup>a</sup> |
| Starch total                          | 39.85±0.78<sup>a</sup> | 40.39±0.24<sup>a</sup> |
| Resistant starch                      | 5.17±0.56<sup>a</sup>  | 4.67±0.33<sup>a</sup>  |
| Insoluble dietary fiber               | 2.70±0.10<sup>a</sup>  | 3.18±0.05<sup>b</sup>  |
| Soluble dietary fiber                 | 0.92±0.05<sup>a</sup>  | 0.67±0.00<sup>b</sup>  |
| Dietary fiber total                   | 3.63±0.05<sup>a</sup>  | 3.85±0.05<sup>b</sup>  |

The values within the same row followed by different superscript letters are significantly different (<i>p</i>&lt;0.05)

Cake from wheat flour had lower moisture and carbohydrate, higher protein and fat content than cake from corn starch, 29%, 12.2%, 13% and 42.8% respectively. Whereas it is not remarkably different on ash content (1%) [32]. The cake from arenga starch modified with guava leaf extract had slightly higher protein (0.48%), ash (1.09%), total carbohydrate (93.56%), total starch (39.91%), soluble dietary fiber (1.46%), dietary fiber total (6.10%) and lower moisture (48.99%), fat (4.88%), resistant starch (6.99%) and insoluble dietary fiber (4.64%) than modified corn starch [29]. The ingredients are main factor that cause the differences.

Modified corn starch cookies had significantly higher total dietary fiber and insoluble dietary fiber than native starch (table 2). High contents of insoluble dietary fiber increase contents of total dietary fiber of product. The soluble dietary fiber content of modified corn starch cookies significantly lower than native starch (<i>p</i>&lt;0.05) (table 2).

The water and ash content of cookies both native and modified corn starch are accomplished the standard [33]. The cookies moisture content was less than 1% (w/w). It is lower than water content of cookies in the market (2.69%). The low water content was generated by ideal baking of the dough. It will prevent microbial growth that can damage the product. The ash content of cookies is not significantly different with generally cookies in the market, 0.92-1.72% [34]. However, the protein content of the both of products are not accomplished the standard, because the cookies were made from poor protein starch (less than 1%). Water and protein content of standarized cookies are maximum 5% w/w [33]. Protein content of the both of products are also lower than generally cookies in the market, 5.86-12%. Both of cookies have a higher fat content compared to generally cookies in the market, 20.32% [34].

The cookies from arenga starch modified with red guava leaf extract had high moisture (1.95%), ash (1.30%), resistant starch (6.52%), dietary fiber total (4.35%) and soluble dietary fiber (1.18%). It is not remarkably different in fat (26.34%), protein (1.82%), carbohydrate total (70.54%), starch total (40.74%), and insoluble dietary fiber (3.17%) respectively than corn starch modified with green tea extract [29].

3.2. Gi and gl of cake and cookies

GI and GL of native and modified corn starches of cake and cookies are shown in table 3 & 4 respectively. The addition of 4% (w/v) green tea extract 52-62 °Brix only significantly affect GL of the cookies (<i>p</i>&lt;0.05) (table 3 and 4).
Table 3. GI and GL of native and modified corn starches cakes.

| Parameter                   | Native starch                        | Modified corn starch                           |
|-----------------------------|--------------------------------------|-----------------------------------------------|
| Glycemic index (GI)         | 85.02±11.21a                         | 74.96±10.48a                                  |
| GI category                 | High                                 | High                                          |
| Glycemic load (GL)          | 15.35±1.10a                         | 12.41±0.05a                                  |
| GL category                 | Intermediate                         | Intermediate                                |

Note: The values within the same row followed by different superscript letters are significantly different (p<0.05).

Table 4. GI and GL of native and modified corn starches cookies.

| Parameter                   | Native starch                        | Cookies                                       |
|-----------------------------|--------------------------------------|-----------------------------------------------|
| Glycemic index (GI)         | 52.23±6.78a                         | 58.25±8.33a                                  |
| GI category                 | Low                                  | Intermediate                                 |
| Glycemic load (GL)          | 20.66±0.39a                         | 23.38±0.21b                                  |
| GL category                 | High                                 | High                                         |

The values within the same row followed by different superscript letters are significantly different (p<0.05).

GI and GL cakes decreased from 85.02 to 74.96 and 15.35 to 12.41 respectively (table 1). The decreasing of GI cakes was not significant (p>0.05). Cake of native and modified corn starch still had high GI, but intermediate GL. It shows that consumption of modified corn starch cakes can increase blood glucose contents slowly than native starch.

Consumption of food containing polyphenols affect the metabolism of carbohydrates. One of the mechanism is inhibition of carbohydrate digestion and glucose absorption in the intestine through inhibition the enzyme activity of α-amylase [17]. Polyphenol (flavonoids) inhibit α-amylase activity of humans through two mechanisms: (1) Formation of a hydrogen bond between hydroxyl groups of polyphenols ligands and catalytic residues of the enzyme binding site; (2) Formation of a conjugated π-system that stabilizes the interaction of poliphenol (AC ring of polyphenols ligan) and the enzyme active site (indole ring of Trpα-amilase). Two hydrogen bond are formed between hydroxyl groups (OH) in R3' and R4' of ring B polyphenols and carboxylate groups of Asp197 and Glu233 α-amylase. R7 OH of polyphenol and carboxylic group of His305 α-amylase is formed [18].

The addition of 0.05 mg/mL green tea polyphenols inhibit the activity of α-amylase, pepsin, trypsin, and lipase 61%, 32%, 38% and 54% respectively [19]. Polyphenols have inhibited the other enzymes such as tyrosinase, peroxidase [35], decarboxylase [36], squalene epoxidase [37], ribonuclease [38] and α-glucosidase [39]. As the result, starch digestibility and GI of food are decreased.

The inhibition related to the ability of the compounds form starch complex such as amylose-fat complex that caused the changes of molecular structure of starch. It is unrecognize by digestive enzymes to inhibit α-amylase activity [18,20,21]. Starch and polyphenol compounds form a covalent bond through ether bridge on C4 of carbohydrates and the bridge of H+ and hydrophobic interactions [40]. Polyphenols-carbohydrates complex lead to changes of the starch molecular structure that cause decreasing starch digestibility [20,41].

Insignificant difference of GI of the cakes caused the GL is insignificant too. GL was calculated by multiplying GI value with available carbohydrate [28]. While GI of modified corn starch cakes and its native cakes are high, GL of both products are medium. It generated by low total starch content in both products. The average of starch total of native and modified corn starch cake are 18.06 and 16.56% wet base respectively.
The addition of 7% and 4% green tea extract on processing parboiled and instant rice reduce in vitro digestibility starch 72.73 and 53.97%. It produces intermediate and low GI of rice, 56 and 49 respectively. The rice also inhibits decreasing of islets Langerhans number (parboiled rice) and rate of destruction of Langerhans beta cells (instant rice) on diabetic rats [13,14]. Modified arenga starch cake with red guava leaf extract had lower GI (77.72) than its native (51.84). Its products had intermediate GL, 10.55, 15.05 respectively (p<0.05) [29].

Cookies of modified corn starch had intermediate GI (58.25), however cookies of native had low GI (52.23). The GI both of products were not significantly different (p>0.05) (table 4). The addition of 4% green tea extract 58–62 °Brix was not significantly affect the decreasing GI of corn starch cookies, but increased GI category from low to intermediate. Researchers reported similar result that the cookies were made from different type of starch has a low GI, such as hotong starch cookies [37] [42]; rice bran cookies [31] [43] and modified arrowroot starch cookies [31] [23]. In the other hand cookies that were made from wheat flour has low to high GI, 20-79 [28], 44-67 [23,43]. Research on the other source of polyphenols was reported that native and modified arenga starch cookies had low GI, 47.31; 46.20 respectively and intermediate GI, 18.34; 18.45 respectively. GI and GL of the both of the products had not significantly different (p>0.5) [29].

The main factor caused the insignificant differences of GI of the products are: (1) There are no significant differences in the average of fat, protein, resistant starch, insoluble fiber, soluble fiber and total fiber (cake); fat, protein and resisten starch (cookies) (table 1 and 2). The chemical composition has important role in reducing GI of food [28,44,45,46]; (2) The low content of polyphenols and the formation of amylose-lipid complexes in products of modified corn starch. Amylose-lipid complex increases digestive enzymes resistance [47] which is cause reduction of GI. The ability of amylose-lipid complexes formation by catechins as the main green tea polyphenol compound [12] in corn starch and sorghum is lower than ferulic acid [21]. It cause GI of the products are not significantly decreased. Polyphenol content of modified corn starch cookies has suppose to decrease during processing. As the results concentration of polyphenol is low and GI of the products are stable.

Mainly content of catechin polyphenol compounds in green tea were epigallocatechin 3-O-gallate (EGCG) and epicatechin 3-O-gallate (ECG). It was stable and maximum in dough condition, but decrease during baking process. ECG and EGCG in biscuits that made from flour containing 300 mg/100 g powdered green tea extract was decreased, 62.51% and 64.92% respectively. The reduction of catechin content in biscuits occurs due to combination of alkaline pH effect from the dough (the addition of baking soda), interaction between catechins with several components in the dough, epimerization or oxidation of catechins during baking and catechin degradation during the biscuit-making process (stirring and baking) [48].

Green tea catechins are less stable at high pH (alkaline) and high temperatures. The catechins are stable for 18 hours only at pH 5, and begin to degrade at pH> 6 [49]. Radical EGCG can be oxidized by O2 molecules to form O2- and EGCG quinone. Quinone reacts with other EGCG molecules to form dimers. Dimers are transformed into other components, polymers [50]. Epimerization involve converting epi structures into non-epi structures. As the results catechins content (EGCG and ECG) in biscuit are low. This epimerization occurs at 120°C and pH 5-6 [50]. High temperatures during baking (160°C) are required to triggers the epimerization of green tea catechins [48].

Similar results reported by Widowati shows that GI were influenced by the chemical composition of materials and the types of processing. The high chemical composition of polyphenols/free phenols decrease GI in parboiled and functional instant rice. Functional instant rice has 41.39% in vitro starch digestibility with high contents of free polyphenols (1.68%). It causes by the effect of 4% green tea extract addition. As the result GI of instant rice decrease from 60 (intermediate) to 49 (low). Functional parboiled rice has lowest in vitro starch digestibility (11.25%) with free polyphenol contents lower than functional instant rice (0.73%). It causes by the effect of adding 7% green tea extract. As the result GI of instant rice decrease from 60 (intermediate) to 56 (intermediate) [13,14].

While GI of native and modified corn starch cookies are low and intermediate, the both of products had high GL (table 4). The products should be consumed wisely, considering that the GL per serving size...
(100 g) is high. Consumption the both of the products should be reduced, maximum 92 g, 81 g for native and modified corn starch cookies respectively.

3.3. Blood glucose responses in subjects

Blood glucose responses in normal subjects elicited by consumption of cakes and cookies of native and modified corn starches are shown in figure 1. All of the product increased blood glucose after 30 minutes consumed, and gradually decreasing up to 120 minutes after the consumption. Slower reduce in blood glucose content was shown only by the treatment groups compare to control group which has similar pattern in rapid change, except cookies. Native corn starch cake tends to be more rapid changes of blood glucose. It caused higher GI than modified corn starch cake. However rising and falling blood glucose curve of both not significant. In the other hand, native corn starch cookies that have low GI show a slow changes of blood glucose. It is confirmed by slightly rising and falling of the curve (figure 1).

![Blood glucose curve](image)

**Figure 1.** The changes of blood glucose subject for 2 hours GI test.

The cake had high GI, while cookies had a low to intermediate GI. This caused by differences processing, maillard reaction and chemical composition of both the products. The cake was made by boiling starch in sugar solution which involves the addition of high amount of water (± 61% of the total ingredients). This process resulted complete starch gelatinization. It make cake easily digested, because it provides larger surface area for the digestive enzymes to interact [45,52].

Cookies processing involves HMT that modify the crystalline structure of the starch to more resistant on gelatinization process, increasing gelatinization temperature and reduce amount of dissolve amylose [30].

Fat and protein content of cookies were higher than cake (table 1 and 2). High fat and protein food decrease rate of gastric emptying that lead the food digestion rate decreased. Fried sago and potato had lower GI (33 and 44-58) than roasted sago and potato (71.5 and 73-97). Full fat Italy milk and Canadian low fat milk had low GI, 11 and 27-37 respectively [28,46].

Maillard reaction was occured during processing of cookies [53]. It produces melanoidin and premelanoidin that undigested and unabsorbed. Melanoidin and premelanoidin were excreted by feces 87% and 64% respectively and by urine 4% and 27% respectively of total consumed [54,55].
4. Conclusion

The chemical composition of modified corn starch cake and cookies was not significantly different than native starch (p>0.05), except starch total of cake and dietary fibre total, insoluble dietary fibre and soluble dietary fibre content of the cookies. Modified corn starch cake had significantly lower starch total than native. However, modified corn starch cookies has significantly higher dietary fiber total and insoluble dietary fiber and low soluble dietary fiber than native (p<0.05). The GI and GL of the cakes are decreased from 85.02 to 74.96 and 15.35 to 12.41 respectively, but the decrease was not significant (p>0.05). Cake of modified corn starch still had high GI, but intermediate GL. GI of native and modified corn starch cookies were not significantly different, 52.23 (low) and 58.25 (intermediate) respectively. However the both of products had high GI, 20.66, 23.38 respectively. GL of modified corn starch cookies significantly higer than native (p<0.05). Corn starch modified with 4% green tea extract 58-62 °Brix had not been effective yet in reduction GI and GL of the processed products.

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