







mixtures of vanillic acid and caffeic acid were prepared at different ratios: (a) VA: Caff (1:1, v/v) and (b) (3:1, v/v). Both standards had concentrations of 0.01 mg/mL, and the injection volume was 20  $\mu$ L. With the VA: Caff (1:1) mixture, 0.1  $\mu$ g vanillic acid and 0.1  $\mu$ g caffeic acid was injected; with VA: Caff (3:1) mixture, 0.15  $\mu$ g vanillic acid and 0.05  $\mu$ g caffeic acid was injected. VA: Caff (1:1) mixture was first injected, followed by VA: Caff (3:1) mixture. The area of peak 1 increased from 32% (Appendix 1, peak 1a) to 64% (peak 1b); area of peak 2 reduced from 68% (peak 2a) to 36% (peak 2b). Thus, it was deduced that peak 1 represented vanillic acid and peak 2 represented caffeic acid, and that vanillic acid eluted before caffeic acid.

### Statistical analysis

Statistical analyses of all the results were carried out using one-way analysis of variance (ANOVA) to assess for any differences between the samples. The means obtained were separated by Tukey pairwise comparison test at 95% confidence level using MINITAB 17 statistical software (Minitab® Statistical Software, 2010). All data were presented as means  $\pm$  SD (n=6). Pearson's coefficient ( $R^2$ ) was also identified for all calibration curves. Pearson's correlation (r) was calculated at  $P < 0.05$  and 0.01 using the same software.

## RESULTS AND DISCUSSION

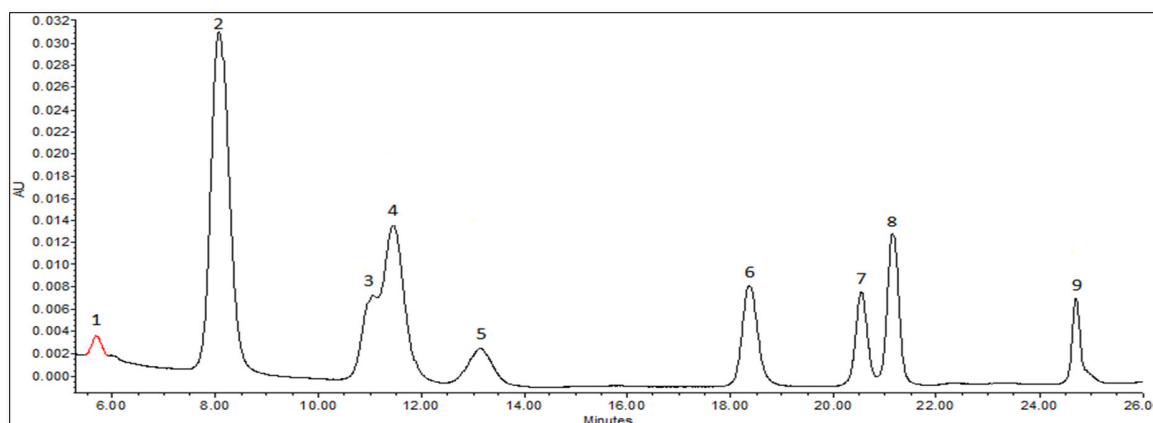
### Total polyphenol content

The free polyphenols (FPP) and bound polyphenols (BPP) fractions were analysed separately, and the calculated sum was reported as total polyphenol content (TPC). Both chocolate (Ch) and chocolate-coated popcorn (CCP) had significantly ( $P < 0.05$ ) greater amounts of FPP than plain popcorn (PP) alone. However, FPP content in Ch ( $802.89 \pm 23.98$  mg GAE/100g DW) was significantly ( $P < 0.05$ ) higher than those in CCP ( $639.74 \pm 15.05$  mg GAE/100g DW) and PP ( $87.01 \pm 1.35$  mg GAE/100g DW) (Table 1). The same trend was observed for BPP and TPC fractions. Total polyphenol content (TPC) in all three samples varied significantly ( $P < 0.05$ ) from  $1560.49 \pm 21.84$  mg GAE/100g DW to  $1103.32 \pm 13.58$  mg GAE/100g DW and  $505.25 \pm 10.05$  mg GAE/100g DW in Ch, CCP and PP, respectively (Table 1). It was clear that TPC in plain popcorn was attributed mainly to BPP ( $418.24 \pm 10.87$  mg GAE/100g DW) in comparison with FPP ( $87.01 \pm 1.35$  mg GAE/100g DW). On the contrary, both CCP and Ch had significantly ( $P < 0.05$ ) higher FPP than BPP content. The FPP content detected in CCP and Ch were  $639.74 \pm 15.05$  mg GAE/100g DW and  $802.89 \pm 23.98$  mg GAE/100g DW, respectively (Table 1 and Figure 1).

**Table 1.** Polyphenol content (mg GAE/100g DW. sample) and Trolox equivalent antioxidant capacity (TEAC) (mg TE/100g DW. sample) of different polyphenol fractions of popcorn (PP), chocolate-coated popcorn (CCP) and chocolate (C).

	PP	CCP	C
<b>Free Polyphenols</b>	$87.01 \pm 1.35^c$	$639.74 \pm 15.05^b$	$802.89 \pm 23.98^a$
<b>TEAC</b>			
<b>DPPH</b>	$65.70 \pm 3.17^c$	$1102.00 \pm 31.10^b$	$1155.35 \pm 8.12^a$
<b>ABTS</b>	$77.29 \pm 2.24^c$	$931.00 \pm 53.2^b$	$1094.40 \pm 55.0^a$
<b>Bound Polyphenols</b>	$418.24 \pm 10.87^c$	$463.58 \pm 8.49^b$	$757.60 \pm 27.70^a$
<b>TEAC</b>			
<b>DPPH</b>	$321.23 \pm 10.45^c$	$930.00 \pm 43.40^b$	$1404.20 \pm 69.60^a$
<b>ABTS</b>	$319.08 \pm 14.46^c$	$872.40 \pm 52.50^b$	$1284.10 \pm 70.4^a$
<b>Total Polyphenols Contents</b>	$505.25 \pm 10.05^c$	$1103.32 \pm 13.58^b$	$1560.49 \pm 21.84^a$
<b>TEAC</b>			
<b>DPPH</b>	$386.93 \pm 11.45^c$	$2032.00 \pm 40.0^b$	$2559.50 \pm 69.1^a$
<b>ABTS</b>	$396.37 \pm 15.4^c$	$1803.40 \pm 65.3^b$	$2378.50 \pm 108.0^a$

Results expressed as means ( $n = 6$ )  $\pm$  SD. Means within each row followed by different superscript letters are significantly different ( $P < 0.05$ )



**Figure 1.** Chromatogram of polyphenol standards recorded at 290nm: 1 = gallic acid, 2 = ( $\pm$ )-catechin hydrate, 3 = vanillic acid, 4 = caffeic acid, 5 = (-)-epicatechin, 6 = *p*-Coumaric acid, 7 = *trans*-ferulic acid, 8 = sinapic acid and 9 = quercetin hydrate.

The amounts of FPP ( $87.01 \pm 1.35$  mg GAE/100g DW) and TPC ( $505 \pm 10.05$  mg GAE/100g DW) in PP were greater than those values reported in the literature for yellow popcorn popped without oil. A FPP content of 7 mg GAE/100g DW while TPC of 131 mg GAE/100g DW. Furthermore, the detected FPP content in PP was higher than in popcorn kernel (37 mg GAE/100g DW). On the other hand, TPC in PP reported in this study was lower than those in popcorn kernels of 539 mg GAE/100g DW and 797 mg GAE /100g DW, respectively. Such variations could be attributed to many factors, including, popcorn variety and method of preparation, extraction and analysis.

The BPP represent the main polyphenols in whole grains, and the calculated value from results in **Table 1** showed that BPP represented approximately 83% of TPC in plain popcorn. This percentage BPP content was within the range obtained for corn kernels (62-85%) [27,7], but lower than the 95% for popcorn kernels. Unfortunately, the literature on BPP in popped popcorn is lacking, and most studies only focused on FPP.

The FPP content measured in baking chocolate (803 mg GAE/100g DW equivalent to 800 mg GAE/100g FW) was within the values in dark chocolate (800 - 840 mg GAE/100g FW) [28], but smaller than those, 1816 mg GAE/100g FW [29]. The TPC (1560 mg GAE/100g DW equivalent to 1555 mg GAE/100g FW) (**Table 1**) was within the range (1176 to 2970 mg GAE/100g FW) [30], but smaller than the 5146 mg GAE/100g FW [31].

It has been estimated that in baking chocolate, about half of the polyphenols existed as BPP, mostly as condensed tannins [32,34]. Similarly, polyphenol content in dark chocolate consisted of 38% FPPs and 62% BPP; while in milk chocolate, FPP made up 53% and BPP made up 47% of total polyphenols [35]. It should be noted that polyphenol composition (FPP and BPP) detected in this current investigation did not agree with the findings of dark

chocolate, but was similar to that of milk chocolate. This could possibly due to the fact that measured BPP content using a different method and expressed the results as condensed tannin equivalents. Additionally, the presence of milk influenced polyphenol content. Milk solids are one of the raw materials used in the production of our baking chocolate sample, which could possibly cause the composition to be similar to that of milk chocolate. Another contributing factor to variations in reported result could be the methods of polyphenols extraction. Previous studies investigated the phenolic content in yellow popcorn and baking chocolate using aqueous organic solutions of methanol, ethanol and/or acetone [28,22]. These extraction conditions can only liberate the FPP, while the BPP remains in the residue [36,37]. consequently, the values reported by these authors underestimated TPC and were smaller than the amount reported in the current study.

#### Antioxidant Capacity

Trolox equivalent antioxidant capacity (TEAC) for free polyphenols (FPP) and bound polyphenols (BPP) were performed separately, using DPPH and ABTS assays. The TEAC in total polyphenols (TPP) were then calculated from the individual data of FPP and BPP fractions. Both DPPH and ABTS assays showed similar results, in which the FPP fraction in Ch and CCP had significantly ( $P < 0.05$ ) higher antioxidant capacity than in PP. Additionally, TEAC of FPP in Ch was significantly higher ( $P < 0.05$ ) than those in CCP. The same trend was observed for BPP. Similar to the previous findings of polyphenol contents, the TEAC in Ch was significantly ( $P < 0.05$ ) the highest, followed by those in CCP, and in PP in descending order for both FPP and BPP fractions (**Table 1**).

The TEAC detected in the TPP fraction of PP [ $386.93 \pm 11.45$  (DPPH method) and  $396.37 \pm 15.4$  mg TE/100g DW (ABTS)] (**Table 1**) were within the range (128 – 96825 mg TE/100g DW) in popcorn kernels, and slightly smaller than

those (400 - 501 mg TE/100g DW). The high TEAC in PP can be attributed to the significantly ( $P < 0.05$ ) large quantities of BPP (83%) compared with FPP (17%).

The TEACs of FPP measured in chocolate and on fresh weight bases for easy comparison with the literature values (1091 and 1151 mg TE/100g FW, using ABTS and DPPH, respectively) were higher than the range in dark chocolate (881-961 mg TE/100g FW), and lower than (1972 to 3751 mg TE/100g FW). Additionally, the TEAC in the TPC fraction of chocolate (2370-2551 mg TE/100g FW) varied from literature values reported in dark and baking chocolates. The TEAC in Ch was greater than the amounts reported (3.78 - 621.22 and 2000 mg TE/100g FW, respectively), and smaller than those observed (3475-7357 TE/100g FW) [38,39].

The antioxidant capacities of FPPs and BPPs in Ch were not in accordance with their respective polyphenol contents. The FPP content (802.89 mg GAE/100 g DW) was larger than that in BPP (757.60 mg GAE/100 g DW). While, the TEAC in the BPP fraction (1404.2 mg TE/100g DW) was greater than in FPP (1155.35 mg TE/100 g DW) of chocolate. This inconsistency could be attributed to the presence of glycoside-bound polyphenols in BPP extracts, which have highly reactive scavenging compounds, causing BPP to have a higher antioxidant capacity than FPP [40-43].

On the contrary to the results of TEAC in Ch, data in **Table 1** revealed good correlation between the reported amounts of free and bound polyphenols and the TEAC in CCP. The larger content of FPP (639.74 mg GAE/ 100 g DW) yielded greater amount of TEAC (1102.00 mg TE/ 100 g DW). These results are in agreement with the previous suggestion that glycoside-bound polyphenols in BPP extracts contributed more to the antioxidant capacity. Consequently,

the significantly the smaller amount of BPP (463.58 mg GAE/ 100 g DW) in comparison with FPP (639.74 mg GAE/ 100 g DW) generated less TEAC in CCP.

The differences in measured antioxidant capacity using DPPH and ABTS methods could be due to the differences in reactivity of antioxidants in the analysed samples with the radicals in ABTS and DPPH [44].

### Phenolic compounds in free polyphenol fractions

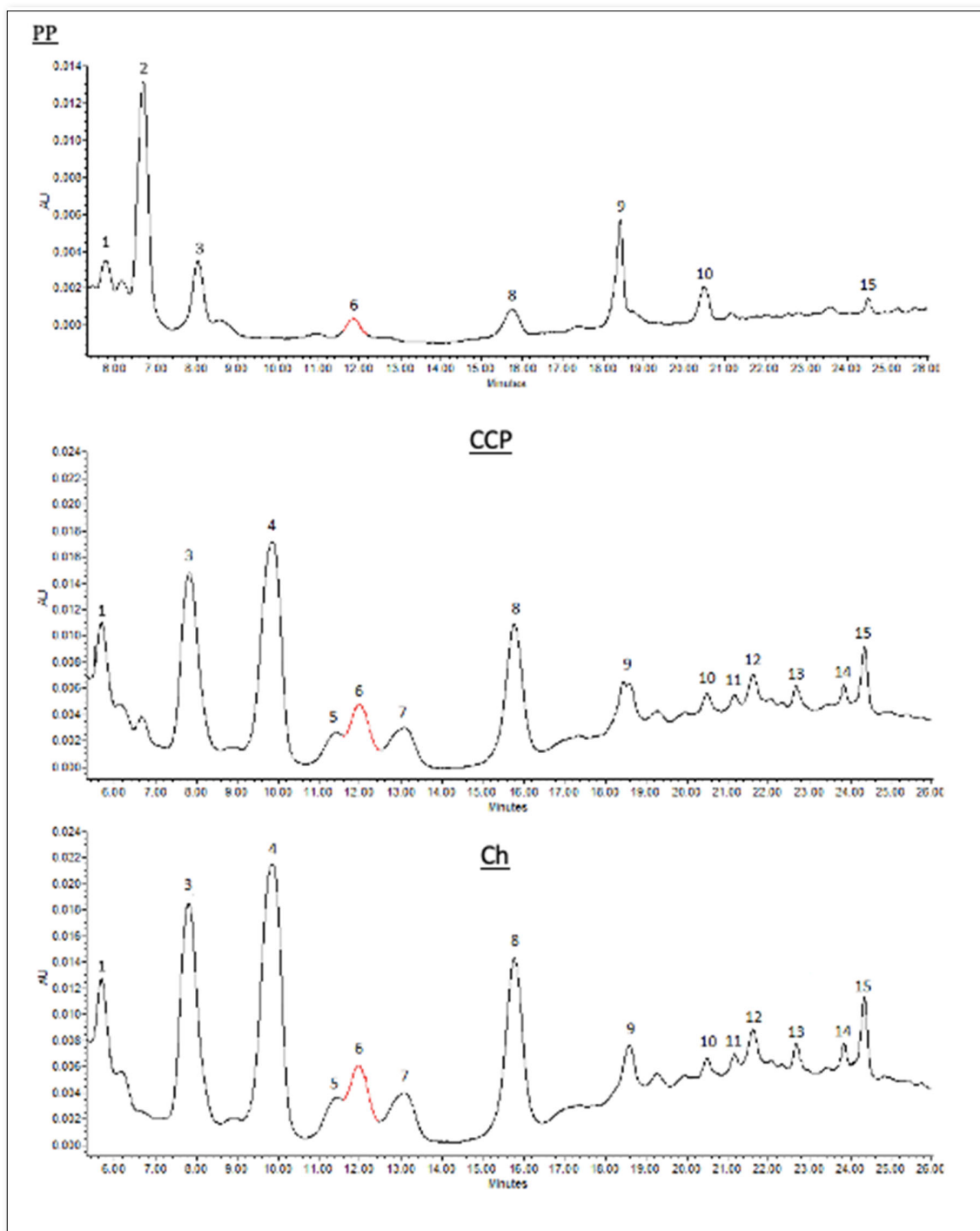
Using a mobile phase of methanol and acetic acid, two flavanol compounds (catechin, epicatechin), one flavonol (quercetin) and six phenolic acids (gallic acid, *p*-coumaric acid, ferulic acid, sinapic acid, vanillic acid, caffeic acid) were identified in the three samples (PP, Ch, & CCP). A total of nine polyphenol standards were applied (**Figure 1**). The wavelength used to detect ( $\pm$ )-catechin hydrate, (-)-epicatechin and sinapic acid was 280 nm, while 290 nm was applied with gallic acid, vanillic acid, caffeic acid, *p*-coumaric acid, *trans*-ferulic acid and quercetin hydrate. The chromatograms obtained for free polyphenol fractions (FPP) in PP, CCP and Ch are shown in **Figure 2**. Epicatechin, vanillic acid and sinapic acid were not detected in PP (**Figure 2**). However, Ch had significantly ( $P < 0.05$ ) greater amounts of epicatechin, vanillic acid, sinapic acid, gallic acid, catechin, caffeic acid and quercetin than CCP. Similarly, CCP showed the similar pattern with significantly ( $P < 0.05$ ) greater amounts of gallic acid, catechin, caffeic acid and quercetin than PP. *p*-coumaric acid concentrations in CCP (13.37  $\mu$ g/g DW) and Ch (12.93  $\mu$ g/g DW) were similar ( $P > 0.05$ ), and at the same time significantly ( $P < 0.05$ ) greater than that in PP (8.22  $\mu$ g/g DW). Ferulic acid was the only polyphenol in PP with significantly ( $P < 0.05$ ) greater concentration compared with CCP and Ch (**Table 2**).

**Table 2.** Concentrations of polyphenols ( $\mu$ g/g sample dry weight) \* in plain popcorn (PP), chocolate-coated popcorn (CCP) and chocolate (Ch).

	PP	CCP	Ch
<b>Gallic Acid</b>	90.33 $\pm$ 1.81 <sup>c</sup>	131.88 $\pm$ 3.70 <sup>b</sup>	147.32 $\pm$ 7.79 <sup>a</sup>
<b>Catechin hydrate</b>	56.78 $\pm$ 3.20 <sup>c</sup>	500.17 $\pm$ 10.36 <sup>b</sup>	636.52 $\pm$ 10.98 <sup>a</sup>
<b>Vanillic Acid</b>	Not detected	30.04 $\pm$ 1.20 <sup>b</sup>	36.87 $\pm$ 1.39 <sup>a</sup>
<b>Caffeic Acid</b>	7.19 $\pm$ 0.42 <sup>c</sup>	34.37 $\pm$ 1.33 <sup>b</sup>	42.81 $\pm$ 1.76 <sup>a</sup>
<b>Epicatechin</b>	Not detected	356.38 $\pm$ 5.47 <sup>b</sup>	452.63 $\pm$ 5.00 <sup>a</sup>
<b><i>p</i>-Coumaric acid</b>	8.22 $\pm$ 0.088 <sup>b</sup>	13.37 $\pm$ 0.24 <sup>a</sup>	12.93 $\pm$ 0.49 <sup>a</sup>
<b>Ferulic Acid</b>	6.63 $\pm$ 0.37 <sup>a</sup>	4.80 $\pm$ 0.30 <sup>b</sup>	4.33 $\pm$ 0.24 <sup>c</sup>
<b>Sinapic Acid</b>	Not detected	9.51 $\pm$ 0.50 <sup>b</sup>	17.25 $\pm$ 1.00 <sup>a</sup>
<b>Quercetin Hydrate</b>	13.58 $\pm$ 0.78 <sup>c</sup>	75.39 $\pm$ 3.93 <sup>b</sup>	93.27 $\pm$ 2.11 <sup>a</sup>

Results are means ( $n=6$ )  $\pm$  SD. Means within each row followed by different superscript letters are significantly different ( $P < 0.05$ )

\*Concentration of gallic acid was expressed in mg/g sample dry weight



**Figure 2.** Chromatograms of various phenolic compounds detected at 290 nm in the FPP fractions of PP, CCP and Ch: 1 = gallic acid, 3 = ( $\pm$ )-catechin hydrate, 5 = vanillic acid, 6 = caffeic acid, 7 = (-)-epicatechin, 9 = *p*-coumaric acid, 10 = *trans*-ferulic acid, 11 = sinapic acid, 15 = quercetin hydrate

Gallic acid was the predominant polyphenol in all three samples (PP, CCP and Ch). More than 99% of FPP comprised of gallic acid. Consequently, gallic acid was expressed in mg/g sample DW, instead of  $\mu$ g/g sample DW,

which was used with all other eight polyphenols. Following gallic acid, catechin was the second highest polyphenol in all three samples (**Table 2**). Gallic acid concentration in Ch (147.32 mg/g DW) was much higher than the concentration

reported by Tokusoglu and Ünal (2002) in dark chocolate (0.57-0.72 mg/g FW).

Catechin concentration measured in chocolate (0.64 mg/g FW, equivalent to 636.52 µg/g DW) was within the values for baking chocolate (0.112-0.727 mg/g FW for chocolate (0.11-1.17 mg/g FW); and for sweetened chocolate (0.63-0.66 mg/g FW) [45]. On the other hand, catechin concentration was higher than in baking chocolate (0.24 mg/g FW), and lower than (1.848 mg/g FW) [33].

The detected amounts of vanillic acid in CCP and Ch in this current study (30.04 and 36.87 µg/g DW, respectively) were significantly greater ( $P < 0.05$ ) than in chocolate milk (0.019 mg/g FW). However, both vanillic and sinapic acids were not detected in PP in this study.

Caffeic acid concentration in PP (7.19 µg/g DW) was much higher than those reported (0.013 µg/g DW). However, caffeic acid concentration was within the values reported in popcorn kernels 0.014 -9.83 µg/g DW. Caffeic acid concentration (0.0428 mg/g DW, equivalent to (7.19 µg/g DW) was much lower than the concentration reported in baking chocolate (0.32 mg/g FW). These discrepancies could be due to differences in the methods of analysis and extraction solvents, as different solvents will affect the recovery of polyphenols [46].

Epicatechin concentration in Ch (0.451 mg/g FW, equivalent to 0.453 mg/g DW) was within the range for baking chocolate (0.412-1.223 mg/g FW), but lower than the range (0.52 mg/g FW). Epicatechin is widely acknowledged as the main flavanol compound in chocolate. However, catechin concentration in Ch was higher than epicatechin [38,47] (Table 2).

*P*-coumaric acid concentration in PP (8.22 µg/g DW) was greater than the value reported in popcorn (0.005 µg/g DW), and smaller than the value in popcorn kernels (16.31 µg/g DW). Likewise, ferulic acid concentration in PP (6.63 µg/g DW) was greater than the amount (0.006 µg/g DW) in popcorn, and close to that in popcorn kernel (5.94 µg/g DW) [48].

Quercetin was detected in all tested samples (PP, CCP and Ch) with concentrations ranging from 93.27 µg/g DW in Ch to 13.58 µg/g DW in PP. The detected amount of quercetin in PP was much greater than the concentration in popcorn kernels (7.6 µg/g DW). It should mention also that neither detected quercetin in popcorn [49-52].

Due to limited standards availability at the time of this investigation, peaks 2 and 8 in PP and peaks 4 and 8 in CCP and Ch (Figure 2) were not identified.

## CONCLUSION

The present study showed that covering popcorn with chocolate produced a snack with more polyphenol content and antioxidant capacity from chocolate and more fiber from

popcorn. Consequently, the CCP can be considered a healthier snack than the individual PP and Ch [53-56].

Further investigation into other antioxidants such as carotenoids from popcorn, which is known to be rich in carotenoids, is suggested. Additionally, bioaccessibility / bioavailability tests are recommended to determine the nutritional value of CCP compared with PP and Ch.

## REFERENCES

1. Bilman EM, van Trijp JCM, Renes RJ (2010) Consumer perceptions of satiety-related snack food decision making. *Appetite* 55(3): 639-347.
2. Watson WL, Kury A, Wellard L, Hughes C, Dunford E, et al. (2016) Variations in serving sizes of Australian snack foods and confectionery. *Appetite* 96: 32-37.
3. Fayet F, Mortensen A, Baghurst K (2012) Energy distribution patterns in Australia and its relationship to age, gender and body mass index among children and adults. *Nutr Diet* 69(2): 102-110.
4. Hooper L, Kay C, Abdelhamid A, Kroon PA, Cohn JS, et al. (2012) Effects of chocolate, cocoa, and flavan-3-ols on cardiovascular health: a systematic review and meta-analysis of randomized trials. *Am J Clin Nutr* 95: 740-51.
5. Katz DL, Doughty K, Ali A (2011) Cocoa and chocolate in human health and disease. *Antioxid Redox Signal* 15: 2779-2811.
6. Nguyen V, Cooper L, Lowndes J, Melanson K, Angelopoulos TJ, et al. (2012) Popcorn is more satiating than potato chips in normal-weight adults. *Nutr J* 11: 71.
7. Min B, Gu L, McClung AM, Bergman CJ, Chen MH (2012) Free and bound total phenolic concentrations, antioxidant capacities, and profiles of proanthocyanidins and anthocyanins in whole grain rice (*Oryza sativa* L.) of different bran colours. *Food Chem* 133: 715-722.
8. Payne MJ, Hurst WJ, Miller KB, Rank C, Stuart DA (2010) Impact of fermentation, drying, roasting, and Dutch processing on epicatechin and catechin content of cacao beans and cocoa ingredients. *J Agr Food Chem* 58: 10518-10527.
9. Halvorsen BL, Carlsen MH, Phillips KM, Bohn SK, Holte K, et al. (2006) Content of redox-active compounds (i.e., antioxidants) in foods consumed in the United States. *Am J Clin Nutr* 84: 95-135.
10. Kaliora AC, Dedoussis GVZ, Schmidt H (2006) Dietary antioxidants in preventing atherogenesis. *Atherosclerosis* 187: 1-17.



11. Di Mattia CD, Sacchetti G, Mastrocola D, Serafini M (2017) From cocoa to chocolate: The impact of processing on in vitro antioxidant activity and the effects of chocolate on antioxidant markers in vivo. *Front Immunol* 8: 1207.
12. Özgüven MG, Berktaş I, Özçelik B (2016) Change in stability of procyanidins, antioxidant capacity and in-vitro bio accessibility during processing of cocoa powder from cocoa beans. *LWT* 72: 559-565.
13. Kofink M, Papagiannopoulos M, Galensa R (2007) Enantioseparation of catechin and epicatechin in plant food by chiral capillary electrophoresis. *Eur Food Res Technol* 225: 569-577.
14. Bernard R (2016) *Snack Foods in the United States*, Report, Agriculture and Agri-Food Canada (AAFC), Canada, viewed 1 March 2018.
15. Donkeun P, Allen KGD, Stermitz FR, Maga JA (2000) Chemical composition and physical characteristics of unpopped popcorn hybrids. *J Food Compos Anal* 13: 921-934.
16. Paraginski RT, de Souza NL, Alves GH, Ziegler V, de Oliveira M, et al. (2016) Sensory and nutritional evaluation of popcorn kernels with yellow, white and red pericarps expanded in different ways. *J Cereal Sci* 69: 383-91.
17. Sweley JC, Rose DJ, Jackson DS (2013) Quality traits and popping performance considerations for popcorn (*Zea mays* Everta). *Food Rev Int* 29: 157-177.
18. Karababa E (2006) Physical properties of popcorn kernels. *J Food Eng* 72: 100-107.
19. Quinn PV, Hong DC, Both JA (2005) Increasing the size of a piece of popcorn. *Physica A* 353: 637-48.
20. Food Standards Australia New Zealand (2014) *Food Nutrient Database. AUSNUT – Australian Food, Supplement and Nutrient Database (AUSNUT) 2011-13 food nutrient database*. Retrieved 16<sup>th</sup> April 2018, from FSANZ
21. Kljak K, Grbeša D (2015) Carotenoid content and antioxidant activity of hexane extracts from selected Croatian corn hybrids. *Food Chem* 167: 402-8.
22. Prasanthi PS, Naveena N, Rao MV, Bhaskarachary K (2017) Compositional variability of nutrients and photochemical in corn after processing. *J Nutr Biochem* 18: 567-579.
23. Sirisena S, Ng K, Jalousie S (2016) Antioxidant activities and inhibitory effects of free and bound polyphenols from date (*Phoenix dactylifera* L.) seeds on starch/Bilman digestive enzymes. *Int J Food Stud* 5: 212-223.
24. Garcia GB, Pardo GD, Arroqui C, Virseda P, Arroyo MRM, et al. (2015) Intra-laboratory validation of micro plate methods for total phenolic content and antioxidant activity on polyphenolic extracts, and comparison with conventional spectrophotometric methods. *J Sci Food Agr* 95: 204-209.
25. Tow WW, Premier R, Jing H, Ajlouni S (2011) Antioxidant and anti proliferation effects of extractable and non extractable polyphenols isolated from apple waste using different extraction methods. *J Food Sci* 76: T163-T172.
26. Gu L, House SE, Wu X, Ou B, Prior RL (2006) Procyanidin and catechin contents and antioxidant capacity of cocoa and chocolate products. *J Agr Food Chem* 54: 4057-4061.
27. Adam KK, Liu RH (2002) Antioxidant activity of grains. *J Agr Food Chem* 50: 21.
28. Petronijević JL, Komes D, Gorjanović S, Cvitanović AB, Pezo L, et al. (2016) Content of total phenolics, flavan-3-ols and proanthocyanidins, oxidative stability and antioxidant capacity of chocolate during storage. *Food Technol Biotech* 54: 13-20.
29. Vertuani S, Scalambra E, Vittorio T, Bino A, Malisardi G, et al. (2014) Evaluation of antiradical activity of different cocoa and chocolate products: relation with lipid and protein composition. *J Med Food* 17: 512-516.
30. Miller KB, Stuart DA, Smith NL, Lee CY, McHale NL, et al. (2006) Antioxidant activity and polyphenol and procyanidin contents of selected commercially available cocoa-containing and chocolate products in the United States. *J Agr Food Chem* 54: 4062-4068.
31. Wu X, Beecher GR, Holden JM, Haytowitz DB, Gebhardt SE, et al. (2004) Lipophilic and hydrophilic antioxidant capacities of common foods in the United States. *J Agr Food Chem* 52: 4026-4037.
32. Çelik EE, Gökmen V (2018) A study on interactions between the insoluble fractions of different coffee infusions and major cocoa free antioxidants and different coffee infusions and dark chocolate. *Food chem* 255: 8-14.
33. Meng CC, Jalil AMM, Ismail A (2009) Phenolic and theobromine contents of commercial dark, milk and white chocolates on the Malaysian market. *Mol* 14: 200-209.

34. Schwan RF, Wheals AE (2004) The microbiology of cocoa fermentation and its role in chocolate quality. *Crit Rev Food Sci Nutr* 44: 205-221.
35. Tabernero M, Serrano J, Calixto FS (2006) The antioxidant capacity of cocoa products: Contribution to the Spanish diet. *Int J Food Sci Technol* 4: 28-32.
36. Arranz S, Calixto FS (2010) Analysis of polyphenols in cereals may be improved performing acidic hydrolysis: A study in wheat flour and wheat bran and cereals of the diet. *J Cereal Sci* 51: 313-318.
37. Hellström JK, Torronen AR, Mattila PH (2009) Proanthocyanidins in common food products of plant origin. *J Agr Food Chem* 57: 7899-7906.
38. Brcanovic JM, Pavlovic AN, Mitic SS, Stojanovic GS, Manojlovic DD, et al. (2013) Cyclic voltametric determination of antioxidant capacity of cocoa powder, dark chocolate and milk chocolate samples: correlation with spectrophotometric assays and individual phenolic compounds. *Food Tech Biotechnol* 51: 460.
39. Cervellati R, Greco E, Costa S, Guerra MC, Speroni E (2008) A comparison of antioxidant properties between artisan-made and factory-produced chocolate. *Int J Food Sci Tech* 43: 1866-1870.
40. Das AK, Sreerama YN, Singh V (2014) Diversity in photochemical composition and antioxidant capacity of dent, flint, and specialty corns. *Cereal Chem* 91: 639-645.
41. Mellor DD, Amund D, Georgousopoulou E, Naumovski N (2018) Sugar and cocoa: Sweet synergy or bitter antagonisms. Formulating cocoa and chocolate products for health: A narrative review. *Int J Food Sci Tech* 53: 33-42.
42. Wollgast J, Anklam E (2000) Review on polyphenols in Theobroma cacao: Changes in composition during the manufacture of chocolate and methodology for identification and quantification. *Food Res Int* 33: 423-447.
43. Xu JG, Hu QP, Wang XD, Luo JY, Liu Y, et al. (2010) Changes in the main nutrients, phytochemicals, and antioxidant activity in yellow corn grain during maturation. *J Agr Food Chem* 58: 5751-5756.
44. Alfieri M, Hidalgo A, Berardo N, Redaelli R (2014) Carotenoid composition and heterotic effect in selected Italian maize germplasm. *J Cereal Sci* 59: 2.
45. Tokusoglu Ö, Ünal KM (2002) Optimized method for simultaneous determination of catechin, gallic acid, and methylxanthine compounds in chocolate using RP-HPLC. *Eur Food Res Technol* 215: 340-346.
46. Alothman M, Bhat R, Karim AA (2009) Antioxidant capacity and phenolic content of selected tropical fruits from Malaysia, extracted with different solvents. *Food Chem* 115.
47. Jolić SM, Redovniković IR, Marković K, Šipušić ĐI, Delonga K (2011) Changes of phenolic compounds and antioxidant capacity in cocoa beans processing. *Int J Food Sci Technol* 46: 1793-1800.
48. Zilić S, Serpen A, Akilhoğlu G, Gökmen V, Vančetočić J (2012) Phenolic compounds, carotenoids, anthocyanins, and antioxidant capacity of colored maize (*Zea mays* L) kernels. *J Agr food chem* 60.
49. Pandey R, Singh A, Maurya S, Singh U, Singh M (2013) Phenolic acids in different preparations of Maize (*Zea Mays*) and their role in human health. *Int J Curr Microbiol App Sci* 2: 84-92.
50. Re R, Pellegrini N, Proteggente A, Pannala A, Yang M, et al. (1999) Original Contributions: Antioxidant activity applying an improved ABTS radical cation decolorization assay. *Free Radic Biol Med* 26: 1231-1237.
51. Risner CH, Kiser MJ (2008) High-performance liquid chromatography procedure for the determination of flavour enhancers in consumer chocolate products and artificial flavours. *J Sci Food Agr* 88: 1423-1430.
52. Miller KB, Hurst WJ, Flannigan N, Ou B, Lee CY, et al. (2009) Survey of commercially available chocolate-and cocoa-containing products in the United States. 2. Comparison of flavan-3-ol content with nonfat cocoa solids, total polyphenols, and percent cacao. *J Agr Food Chem* 57: 9169-9180.
53. Hurst WJ, Krake SH, Bergmeier SC, Payne MJ, Miller KB, et al. (2011) Impact of fermentation, drying, roasting and Dutch processing on flavan-3-ol stereochemistry in cacao beans and cocoa ingredients. *Chem Cent J* 5: 53.
54. Cooper KA, Donovan JL, Waterhouse AL, Williamson G (2008) Cocoa and health: A decade of research. *Br J Nutr* 99: 1-11.
55. Australian Bureau of Statistics (ABS) (2014) Australian Health Survey: Nutrition First Results - Food and Nutrients. 2011-12.
56. Bayomy HM (2017) Sensory, Nutritional and Popping Qualities of Yellow and Purple Popcorn. *J Food Dairy Sci* 8(8): 361-367.