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Original Article

Comparative HPLC Analysis of Flavonoid Content and Antioxidant Activity of *Ginkgo biloba* Products Available in the Bangladeshi Market

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Abstract: Different brands of *Ginkgo biloba* standardized extract available in the Bangladeshi market are widely used for the symptomatic treatment of cognitive dysfunction, dementia, Alzheimer's disease, etc. This study was conducted to evaluate the quality of two *Ginkgo biloba* capsule dosage forms; one is from a mainstream pharmaceutical company (sample 2) and another is from a recognized herbal drug manufacturing company (sample 1). To assess their quality, the qualitative and quantitative analysis of the flavonoid content of the selected products were performed by HPLC followed by antioxidant activity determination using different antioxidant activity study methods. HPLC analysis of them identified the presence of two principal flavonoids; quercetin and kaempferol in the quantity of 6.01 and 0.29 mg in sample 2; and 1.34 and 0.28 mg in sample 1. Thus, the HPLC analysis revealed that the quantity of quercetin and kaempferol present in sample 2 was higher than in sample 1. In the DPPH assay, sample 2 showed higher DPPH free radical scavenging power with an IC_{50} of 0.34 mg/mL than sample 1 with an IC_{50} of 0.57 mg/mL Moreover, sample 2 showed higher TPC, TFC, and TAC than sample 1.

Keywords*: Ginkgo biloba*; Phytochemical screening; HPLC; Flavonoids; Antioxidant activity

1. Introduction

According to the World Health Organization (WHO), a total of 55 brands of herbal products are registered which are mentioned in the database of the Directorate General of Drug Administration (DGDA), Bangladesh as of 2012 [1,2]. A total of 25 Pharmaceutical companies (herbal division) and Herbal drug manufacturing companies in Bangladesh are producing herbal medicines [3]. Several brands of *Ginkgo biloba* extracts are manufactured by Bangladeshi Pharmaceutical companies and herbal drug manufacturing companies. The quality of products is of utmost priority for the drugs to be effective and safe [3,4]. Drugs may be collected from multiple sources, and the quality of the drugs can be varied accordingly. Thus, there might be a possibility of the presence of some substandard drugs along with standard

drugs [5]. This raises a concern regarding the safety, efficacy, and price of the medicines available in the market, and therefore physicians and patients must be extremely conscious while selecting medicines [4]. Post-market monitoring performs as a confidential mechanism to assess the quality, therapeutic efficacy, and safety of commercially available drug products [6]. Findings of such monitoring help accelerate product development and improve existing regulations to ensure the desired quality of the drug products [7].

Ginkgo biloba belongs to the Ginkgoaceae family and has a long history of use in traditional Chinese medicines. Extracts of *Ginkgo biloba* are well-documented with therapeutic effects to improve cognitive function and increase blood circulation in the brain and the entire body. It has been reported to be effective in mild to moderate cerebrovascular insufficiency, in the reduction of depression and thrombosis, and inhibition of platelet aggregation. Most importantly, *Ginkgo biloba* extract can improve concentration, and thinking problems, combat short-term memory loss, and thus, improve symptoms of Alzheimer's disease and dementia. It has also been found effective in treating Raynaud's disease, peripheral vascular disease, arterial occlusive disease, blood disorders, COPD symptoms, vision problems, vertigo, and tinnitus [8,9,10]. High-quality standardized *Ginkgo biloba* extract contains 24 % flavones glycosides namely, kaempferol, quercetin, and isorhamnetin along with 6 % terpene lactones such as bilobalide and Ginkgolides A, B, and C. Between these two main constituents of *Ginkgo biloba*, flavone glycosides are responsible for antioxidant activity while Ginkgolide is responsible for neuroprotection, improves choline uptake in the brain synapses, and reduces blood clotting [8,11]. Quercetin, a flavonol is abundantly present in the standardized *Ginkgo biloba* extract and exerts potent antioxidant effects by free radical scavenging activity which is attributed to the right molecular structure of quercetin [12].

After going through an in-depth literature review on *Ginkgo biloba*, it was found that post-market HPLC analysis of flavonoid content and *in-vitro* antioxidant potential of marketed samples containing standardized *Ginkgo biloba* extract had never been performed before in Bangladesh. This fact led us to assess the quality of commercially available *Ginkgo biloba* capsules in the Bangladeshi market where one of them (sample 1) was from a nationally recognized herbal drug manufacturing company and the other one (sample 2) was from a top-ranked mainstream pharmaceutical company. This study was devised to perform phytochemical screening and qualitative and quantitative HPLC analysis of flavonoids (quercetin and kaempferol) of the selected commercial products followed by determination of their antioxidant activity to compare their quality. These two products are commercially available in capsule dosage forms of 60 and 120 mg and are therapeutically used to treat cerebral insufficiency, and dementia syndromes:

memory deficit, poor concentration, Alzheimer's disease, depression, cognitive dysfunction, etc. **(Table 1)**.

2. Materials and Methods

2.1 Sample Collection

Selected two *Ginkgo biloba* brands were bought from a local authorized pharmacy shop in Mohakhali, Dhaka, Bangladesh. A general description of these two marketed samples is listed in **Table 1** and this information on the selected products was extracted from the websites of the selected companies.

Table 1. Description of the selected *Ginkgo biloba* products available in Bangladesh market

Sample no.	Dosage form (Dose)	Dosage and administration	Indications
Sample 1	Capsule (60 mg)	1 capsule twice daily	Cognitive dysfunction, Dementia, Alzheimer's disease, loss of memory and concentration, tinnitus, vertigo and cochlear deafness, senile macular degeneration and diabetic retinopathy, Raynaud's disease and acrocyanosis, intermittent claudication, varicose vein and bronchial asthma
Sample 2	Capsule (60 mg)	For adults: 120-240 mg/day. 1 or 2 capsules 2 to 3 times daily or as advised by the physician.	Cerebral insufficiency: memory deficit, depression, attention, and memory loss that occur with Alzheimer's disease and multi-infarct dementia. Vertigo and tinnitus, Peripheral vascular disease: improvement of pain-free walking distance in, Peripheral Arterial Occlusive Disease in Stage II according to Fontaine (intermittent claudication) in a regimen of physical therapeutic measures, walking exercise, acute cochlear deafness, and sexual dysfunction associated with SSRI use.

2.2 Preliminary phytochemical screening

A preliminary phytochemical screening was performed on the methanolic leaf extract of *Ginkgo biloba* from two commercial products according to the methods described by [13,14] to determine its qualitative chemical compositions, namely, the presence/absence of flavonoids, terpenoids, glycosides, alkaloids, sterols, coumarin, resins, phenolic compounds, tannin, saponins, etc.

2.3 High-performance liquid chromatography (HPLC) employed metabolite profiling of two Ginkgo biloba commercial products

HPLC analysis of *Ginkgo biloba* capsules containing standardized extract was performed to quantitatively identify two flavonoids; kaempferol and quercetin using the method explained in the United States Pharmacopoeia [15]. Alcohol, hydrochloric acid (HCl), and distilled water (H_2O) were added to a 100 mL volumetric flask at the ratio of 25:4:10 to prepare the extraction solvent. On the other hand, methanol, water, and phosphoric acid were mixed in a 100 mL volumetric flask at the ratio of 100:100:1 to prepare the mobile phase. Standard solution A (Quercetin standard solution) was prepared by measuring and dissolving 0.02 mg of USP Quercetin RS (Reference standard) in 1 mL methanol. Standard solution B (Kaempferol standard solution) was prepared by measuring and dissolving 0.02 mg of USP Kaempferol RS in 1 mL methanol. Approximately 1g of *Ginkgo biloba* fine powder from both *Ginkgo biloba* capsules (Marketed samples) was transferred to a 250 mL reflux condenser and round bottom flask fitted and 78 mL of the extraction solvent was added to the reflux condenser. The reflux condenser was placed in a hot water bath for a duration of 35 minutes until the solution turned into a deep red color and then the solution was allowed to cool at room temperature and decanted to a 100 mL volumetric flask. 20 mL of methanol was added again to the 250 mL flask and sonication was performed for 30 minutes. The solution was then filtered, and the filtrate was collected in a 100 mL volumetric flask. The residue on the filter was washed with methanol and collected in the same 100 mL volumetric flask which was later diluted with methanol to volume up to 100 mL and mixed. The extraction of flavonoids from the commercial *Ginkgo biloba* capsule powder was performed separately. Then, 20 µL of the solution was taken and injected into the HPLC column to obtain the HPLC chromatogram and detect the desired flavonoids at UV 370 nm at a flow rate of 1.5 mL/min on LC mode through 4.6 mm×25 cm (packing L1) column (Luna, Phenomenex) and the total run time was 50 minutes. It is important to note that the relative retention times (RTs) for Quercetin in standard solution A, and Kaempferol in standard solution B, are approximately 25.627 and 45.560 minutes, respectively. Finally, the percentage of Quercetin and Kaempferol present in the portion of *Ginkgo biloba* powder taken from the two samples was calculated

using the equation, quantity of flavonoid (mg) = (r_u/r_s) ×(Cs/W) ×F×10 Where r_u = Peak area of the relevant analyte of the Sample solution; r_s = Peak area of the relevant analyte of the Standard solution A/ Standard solution B; Cs = Concentration of the relevant analyte in Standard solution A/ Standard solution B; W = Weight of sample powder taken to prepare the Sample solution and F = Mean molecular mass factor used to convert each analyte into flavone glycoside with a mean molecular mass of 756.7: 2.504 for Quercetin and 2.588 for Kaempferol.

2.4 In-vitro antioxidant activity screening of two commercial Ginkgo biloba products

In-vitro antioxidant activity of the aqueous extracts of the two *Ginkgo biloba* commercial products was estimated using four methods were such as: DPPH free radical scavenging assay, total phenolic content (TPC), total flavonoid content (TFC), and total antioxidant capacity (TAC).

2.5 DPPH (1, 1-diphenyl-2-picryl hydrazyl) free radical scavenging assay

The DPPH free radical scavenging assay of aqueous extract of *Ginkgo biloba* from two marketed samples was determined using the method described by [16] and L-ascorbic acid was used as the standard. Different concentrations of sample solutions: 50-1200 µg/mL were prepared by serial dilution. The absorbance of the sample solutions and control (DPPH and methanol) were measured at 517 nm using U-2910 UV-Vis spectrophotometer (U-1800 SHIMADZU, Japan). The percentage inhibition of DPPH free radicals and the IC_{50} values were calculated.

2.6 Determination of total phenolic content (TPC)

The TPC of aqueous extracts of samples 1 and 2 was determined by the modified Folin Ciocalteu method [17]. Different concentrations of solutions of two samples ranging from 200 to 1200 µg/mL were prepared by serial dilution of stock solution with a concentration of 12 mg/mL. Gallic acid was used as a standard. The absorbance of standard and sample solutions was measured against a blank at 765 nm using a spectrophotometer (U-1800 SHIMADZU, Japan). TPC was expressed as gallic acid equivalent (GAE in mg) per gram of crude extracts.

2.7 Determination of total flavonoid content (TFC)

The total flavonoid content of the aqueous extract of two *Ginkgo biloba* products was determined according to the method described by [18]. TFC was also determined using the same concentration range as used for the TPC estimation of both samples. Quercetin was used as the standard and the stock solution was prepared in the same manner as the extract resulting in four serially diluted concentrations,

ranging from 1200, 800, 400, and 200 µg/mL. The absorbance of each of the sample and standard solutions was measured at 415nm against a blank using UV-Vis spectrophotometer (U-1800 SHIMADZU, Japan). The TFC of each of the samples was expressed as quercetin equivalents (QE) per gram of extracts.

2.8 Determination of total antioxidant capacity (TAC)

The total antioxidant capacity of two commercial products containing *Ginkgo biloba* standardized extracts was determined by using the method described by [19]. The sample and the standard ascorbic acid solutions ranging from 1200 to 200 µg/mL were prepared by serial dilution. Finally, the absorbance of the sample and standard solutions was measured against a blank at 695 nm using a UV-Vis spectrophotometer (U-1800 SHIMADZU, Japan). The total antioxidant capacity, A, for each of the fractions were expressed as ascorbic acid equivalents (AAE) in mg per gram of extracts.

3. Results

3.1 Preliminary phytochemical screening

Preliminary phytochemical screening of two commercial samples was conducted using methods described by [13,14] to detect the presence of different classes of phytoconstituents such alkaloids, flavonoids, coumarins, glycosides, terpenoids, tannins, saponins, phenolics, etc. The result is evident that both the samples contain flavonoids, coumarins, terpenoids, tannins, and phenolics **(Table 2)**. However, alkaloids, glycosides, sterols, saponins and resins were absent in both products.

Table 2. Results of preliminary phytochemical screening of sample 1 and sample 2

	Class of compound	**Result**	
		Sample 1	**Sample 2**
1.	Alkaloids	-	-
2.	Flavonoids	++++	++++
3.	Terpenoids	+	+
4.	Phenols/Phenolic compounds	++	++
5.	Glycosides	-	-
6.	Tannins	+++	+++
7.	Coumarins	++	++
8.	Resins	-	-
9.	Phytosterols	-	-
10.	Saponins	-	-

(+) means presence in a single method test, (++) means presence experimented in two methods, (+++) means presence experimented in three methods, (++++) means presence experimented in four methods and (-) means absence.

3.2 Identification and quantification of quercetin and kaempferol in sample 1 and sample 2 using the HPLC method

HPLC analysis of the selected samples was performed at 370 nm following standard protocol [15]. The standard Quercetin and Kaempferol produced peaks at 25.627 and 45.560 minutes in the HPLC chromatograms, respectively **(Figure 1 and 2)**. From the chromatogram of two samples, the presence of two flavonoids; quercetin and kaempferol in both samples were identified and quantified with comparison to retention time and peak area of two standards, respectively. In the case of the samples, sample 1 contained 1.34 mg of quercetin per capsule with a retention time of 25.500 minutes and 0.28 mg of kaempferol per capsule with a retention time of 45.727 minutes **(Figure 3 and 5).** On the other hand, sample 2 contained 6.01 mg of quercetin per capsule with a retention time of 25.793 minutes and 0.29 mg of kaempferol per capsule with a retention time of 45.847 minutes **(Figure 4 and 5).**

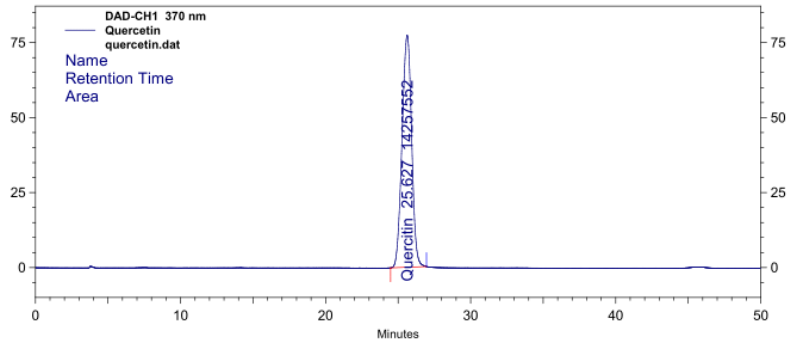

Figure 1. Identification of standard Quercetin by HPLC analysis

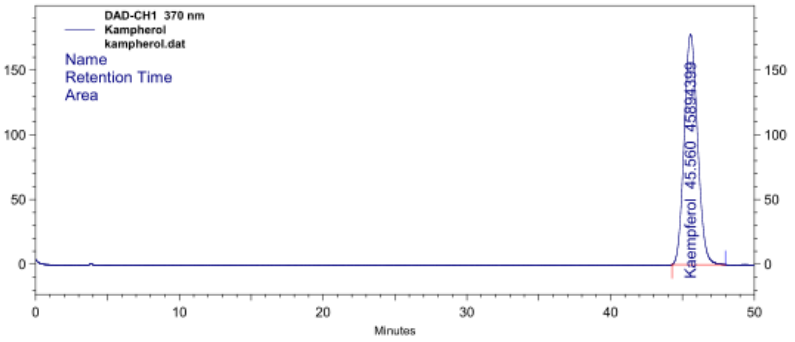

Figure 2. Identification of standard Kaempferol by HPLC analysis

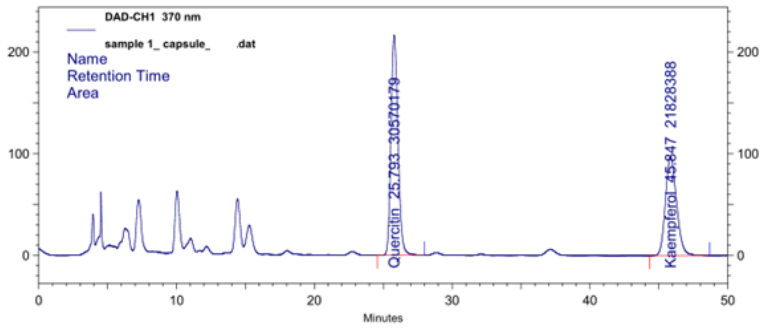

Figure 3. Identification of Quercetin and Kaempferol present in sample 1 by HPLC analysis

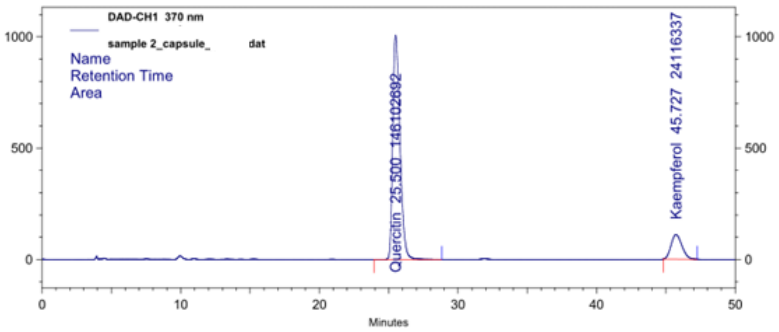

Figure 4. Identification of quercetin and kaempferol present in Sample 2 by HPLC analysis

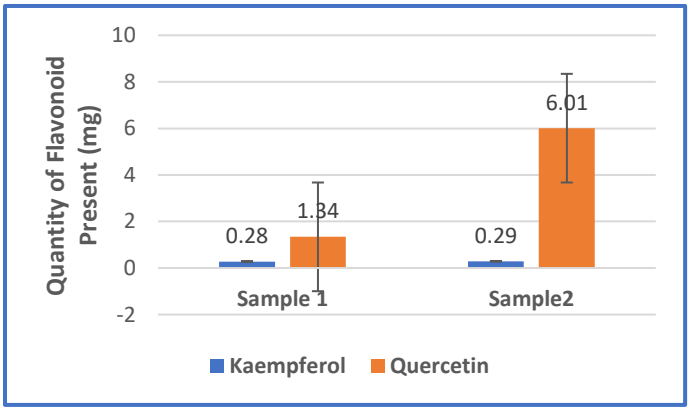

Figure 5. Quantity of two flavonoids; quercetin and kaempferol present in samples 1 and 2

3.3 Evaluation of antioxidant activity

3.3.1 DPPH ((1, 1-diphenyl-2-picryl hydroxyl) free radical scavenging potential of sample 1 and sample 2

DPPH free radical scavenging potential of both samples was found to increase with increased concentrations and at the highest concentration of 1200 µg/mL, both products exhibited the highest % of DPPH free radical inhibition which was 88.022±0.36 and 96.892±0.45 % for sample 1 and sample 2, respectively. IC_{50} values were found to be 566.00 and 333.99 µg/mL for sample 1 and sample, respectively. IC_{50} value of the standard ascorbic acid was found to be 300.50 µg/mL which was comparable to that of sample 2 **(Table 3)**.

Table 3. DPPH free radical scavenging activity of sample 1, sample 2, and the standard (Ascorbic acid).

Concentration (µg/mL)	**DPPH free radical scavenging assay (% of inhibition)**		
	Sample 1	**Sample 2**	**Standard (Ascorbic acid)**
50	15.706±0.25	15.367±0.22	27.797
100	32.005±0.41	25.124±0.41	39.661
200	35.706±0.21	55.367±0.30	52.542
400	47.005± 0.57	74.124± 0.23	60.790
800	58.757± 0.44	80.451± 0.25	76.723
1200	88.022± 0.36	96.892± 0.45	85.650
IC_{50} (µg/mL)	566.00	333.99	300.50

The values are the average of triplicates of experiments and are represented as mean ± % of relative standard deviation.

3.4 Total phenolic content (TPC) of sample 1 and sample 2

TPC of the samples was calculated using the standard curve of gallic acid ($y = 0.0002x + 0.0393$; R^2=0.988) and expressed as gallic acid equivalent (mg) per gram of standard extracts of sample 1 and sample 2. Sample 1 was found to have 837.88± 2.62 mg/g phenolic content whereas sample 2 was found to have 970.76 ± 1.66 mg/g phenolic content. It was evident from the result that sample 2 contained higher TPC than of sample 1 **(Table 4)**.

3.5 Total flavonoid content (TFC) of sample 1 and sample 2

TFC of both samples was calculated using the standard curve of quercetin ($y = 0.0002x + 0.0853$; $R^2 = 0.959$) and expressed as quercetin equivalent (mg) per gram of standard extracts of sample 1 and sample 2. Sample 1 and sample 2 were

found to have 778.39±2.10 and 896.83± 1.78 mg/g flavonoid content, respectively. It was evident from the result that sample 2 contained higher TFC than that of sample 1 **(Table 4)**.

3.6 Total antioxidant capacity (TAC) of sample 1 and sample 2

TAC of both samples was calculated using the standard curve of ascorbic acid ($y = 0.0002x + 0.0846$; $R^2 = 0.989$) and expressed as ascorbic acid equivalent (mg) per gram of standard extracts of sample 1 and sample 2. Sample 1 and sample 2 were found to have 822.24±1.08 mg/g and 960.42±0.57 total antioxidant capacity, respectively. It was evident from the result that sample 2 contained higher TAC than that of sample 1 **(Table 4)**.

Table 4. TPC, TFC, and TAC of *Ginkgo biloba* commercial products: sample 1 and sample 2 were expressed in mg gallic acid equivalent (GAE), quercetin equivalent (QE), and ascorbic acid equivalent (AAE) per g of dry extracts, respectively.

Antioxidant assay methods	**Sample 1**	**Sample 2**
TPC	837.88± 2.62	970.76 ± 1.66
TFC	778.39±2.10	896.83± 1.78
TAC	822.24±1.08	960.42±0.57

The values are the average of triplicates of experiments and are represented as mean ± % of relative standard deviation.

4. Discussion

The study was performed to evaluate the phytochemical screening, HPLC analysis of flavonoid content, and antioxidant activity of the aqueous standard extracts of *Ginkgo biloba* from two commercially available marketed products manufactured by Bangladeshi companies.

Post-market qualitative and quantitative HPLC analysis of flavonoid content of commercial *Ginkgo biloba* products manufactured by Bangladeshi companies has not been performed before. Qualitative analysis of two products by HPLC identified the presence of two main flavonoids; quercetin and kaempferol, and the quantitative analysis of the selected products by HPLC exhibited that product 1 contained 1.34 mg of quercetin and 0.28 mg kaempferol whereas product 2 contained 6.01 mg of quercetin and 0.29 mg of kaempferol per capsule containing 60 mg of standardized extracts. It is noted that in the total 25 % of ginkgo flavone glycosides present in the plant, the percentage of quercetin is 64.8-81.5 % (16.2-20.38 mg) of the total content (dominant), the percentage of kaempferol is 13.3-28.9 % (3.33-7.23 mg) of the total content and 2-8.4 % for isorhamnetin which is very low compared to the other two constituents [20]. Our study findings showed that sample 1 contained 2.23 %

quercetin and 0.47 % kaempferol and sample 2 contained 10.01 % quercetin and 0.48 % kaempferol. This means the content of the constituents present in these two samples is much lower than that found in the natural plant sources. However, the result shows that the contents of flavonoids present in sample 2 were higher than in sample 1 **(Figure 5).** Previously *Ginkgo biloba* five solid dosage forms available in the local market of South Africa were analyzed by HPLC-UV to determine flavonoid contents such as rutin, quercitrin, quercetin, kaempferol and isorhamnetin [21]. Quantitative analysis of flavonoid glycosides and terpene trilactones from the extracts of 11 commercial samples (tablet dosage forms) available in the local market of China by UPLC-UV has been reported previously [22].

As aqueous extract of *Ginkgo biloba* products available in the Bangladeshi local market was never used before to estimate the antioxidant activity, *in-vitro* antioxidant tests were carried out to examine the antioxidant potential of aqueous standard extracts of the selected *Ginkgo biloba* products. DPPH free radical scavenging assay, TFC, and TAC tests were used to evaluate the antioxidant capacity of aqueous extract of the two marketed products where data provided the evidence that they possess strong antioxidant capacity.

A wide number of diseases such as neurodegenerative diseases, Alzheimer's disease, aging, cancer, and cardiovascular diseases are induced by reactive oxygen species [23]. Free radicals-induced lipids or protein damage cause cell death. Endogenous neurotoxins are produced by the reaction between free radicals with neurotransmitters and these neurotoxins are responsible for dementia of Alzheimer's disease [24]. Plants' secondary metabolites particularly flavonoids are well-documented for their ability to neutralize free radicals and to possess a wide array of therapeutic activities such as antioxidative, antihypertensive, antimicrobial, anticancer, anti-inflammatory, diuretic, and antimicrobial [23,25]. These two commercial products manufactured by Bangladeshi companies contain standardized extracts of *Ginkgo biloba* leaf and are used for the treatment of Alzheimer's disease, loss of memory, cognitive dysfunction, memory loss, dementia, etc. which belong to neurodegenerative diseases primarily induced by free radicals generated in the biological system. Standardized extracts of *Ginkgo biloba* contain 24 % flavones glycosides; quercetin, kaempferol, and isorhamnetin and 6 % terpene lactones; Ginkgolides A, B, C and bilobalide [8,11]. Preliminary phytochemical screening of two products revealed the presence of flavonoids, phenolic compounds, terpenoids, coumarins, and tannins **(Table 2)**.

The DPPH free radical scavenging assay of two commercial products exhibited a concentration-dependent % of DPPH free radical scavenging **(Table 3)**. Product 2 showed much higher DPPH free radical scavenging potential (IC_{50}: 333.99 µg/mL) than that of product 1 (IC_{50}: 566.00 µg/mL) **(Table 3)**. This high quantity of

quercetin in product 2 found in HPLC analysis could be responsible for the higher DPPH free radical scavenging activity compared to product 1. Between these two main constituents of *Ginkgo biloba*, flavone glycosides (quercetin, kaempferol, and isorhamnetin) are responsible for antioxidant activity [11]. Previous studies reported good DPPH free radical scavenging activity of *Ginkgo biloba* leaf extract [26, 27]. The highest inhibition of DPPH free radical scavenging was produced by both *Ginkgo biloba* methanolic and ethanol extracts compared to stevia and parthenium [23]. Strong DPPH activity could be attributed to the electron transfer ability or hydrogen donating capacity of identified flavonoids; quercetin and kaempferol in the selected samples which is also reported by a previous study [25]. In addition to that, the antioxidant activity of the flavonoids also depends greatly on their chemical structure and the relative orientation of different groups present in the molecule, particularly the number and position of hydroxyl groups within the molecule.

The presence of a hydroxyl group in position three (3-OH) of the C ring is crucial for the antioxidant activity exerted by flavonoids [28]. For example, the flavonoid aglycones, such as quercetin, fisetin, (+)-catechin, myricetin, and morin, are more potent inhibitors of LPO than those lacking a 3-OH substitution such as diosmetin, apigenin (flavones), hesperetin, and naringenin (flavanones) [29].

TPC, TFC, and TAC determination of two samples exhibited antioxidant activity in a concentration-dependent manner. In total phenolic content determination, sample 2 had a higher TPC (970.76 ± 1.66 mg GAE/g of dry extract) than that of sample 1 (837.88± 2.62 mg GAE/g of dry extract). Antioxidant activity screening of crude methanol extract found TPC was 76.0±5.2 mg GAE/g dry weight [30]. Since our marketed samples were manufactured using standardized extract, they showed much higher TPC compared to this crude extract. Another study by found the phenolic content of aqueous ethanolic extracts was 75.74 mg g^{-1} GAE for the *Ginkgo biloba* leaf, and TPC ranged from 85.51 to 147.14 mg g^{-1} GAE for the commercial tea drugs they used [31].

Similarly, in total phenolic content determination, sample 2 contained more TFC (896.83± 1.78 mg QE/g of dry extract than that of sample 1 (778.39±2.10 mg QE/g of dry extract). This result is supported by the quantitative HPLC analysis of both samples where sample 2 was found to have 6.01 mg quercetin, a flavonoid whereas sample 1 had only 1.34 mg quercetin. It is noteworthy to mention that the sources of the two samples were different; sample 2 was from a mainstream top-ranked pharmaceutical company and sample 1 was from an herbal product manufacturing company. This high antioxidant activity in terms of TFC may be contributed partly by another flavanone glycoside, isorhamnetin found in the GB extract which was not identified and quantified in our study.

In the case of total antioxidant capacity determination, sample 2 exhibited

higher TAC (960.42±0.57 mg AAE/g of dry extract) than that of sample 1 (822.24±1.08 mg AAE/g of dry extract). Finally, it is noteworthy to mention that the total antioxidant capacity of both samples was found to be much higher than the standard Ascorbic acid. A previous study showed that the aqueous ethanolic extract of *Ginkgo biloba* leaf had 69.12 mmol/g AAE [31].

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5. Conclusions

The phytochemical screening of two commercial *Ginkgo biloba* products indicated the presence of phytochemical constituents namely, flavonoids, terpenoids, phenolic compounds, coumarin, and tannins. Qualitative HPLC analysis of both samples detected the presence of two main flavonoids; quercetin and kaempferol, however quantitative HPLC analysis of them evident that sample 2 was found to have more quercetin and kaempferol content than sample 1. In all assay methods, the antioxidant potential determination of both samples revealed that sample 2 had stronger antioxidant properties than sample 1.

Author Contributions:

Conceptualization, DRA.; methodology, DRA, and SA.; data curation, SA.; writing—original draft preparation, DRA, SA, and MTK.; writing—review and editing, DRA and MTK.; Supervision, DRA. All authors have read and agreed to the published version of the manuscript."

Conflict of interest statement

Authors declare no conflict of interest

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Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

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