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COMPARATIVE ANALYSIS OF PHARMACEUTICALS AND DIETARY SUPPLEMENTS CONTAINING EXTRACTS FROM THE LEAVES OF *GINKGO BILOBA* L.

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Abstract: Chromatography (TLC and HPLC) tests were performed of 11 preparations containing dry extract of *Ginkgo biloba* leaves: three pharmaceuticals (preparations **1**, **3** and **5**) and eight dietary supplements (preparations **2**, **4**, **6**–**11**), and dry extract of *Ginkgo biloba* leaves (preparation **12**) as a standard certified for compliance with Eur. Ph. 6.1. and FP VIII (1, 2). Preparations registered in Poland as pharmaceuticals contained the major active ingredients (flavonoids and terpene lactones) in amount declared by their producers (and consistent with pharmacopoeial requirements) and acceptable level of potentially toxic ginkgolic acids (below 5 ppm). The concentration of active compounds in dietary supplements was varied. Some of them satisfied applicable quality criteria (mainly preparation **8**), however, the majority had reduced levels of therapeutic compounds (**4**, **6**, **7**, **11**) and increased concentration of ginkgolic acids (**4**, **9**, **10**, **11**).

Keywords: *Ginkgo biloba*, herbal products, pharmaceuticals, dietary supplements, flavonoids, terpene lactones, ginkgolic acids

Ginkgo biloba (Ginkgoaceae) is one of the most popular medicinal plants, it is the third best-selling and the fifth or sixth most frequently used herbal product in the United States and in Europe. Ginkgo leaf extracts are used in medical practice to improve cognitive functions (memory and concentration), particularly in elderly patients. They are most commonly used in the treatment of various forms of dementia, including Alzheimer disease (3–6). They increase blood flow through peripheral and cerebral blood vessels and reduce vascular permeability. The activity is connected with their neuroprotective, antioxidant and membrane stabilizing properties. Significant for the therapeutical application are also inhibition of platelet aggregation and stimulation the secretion of endothelial vasodilating factor (7–10).

The therapeutic effect of Ginkgo leaf extracts is mainly linked with the synergistic action of two distinctly separate classes of chemical compounds, flavonoids and terpene lactones, although the other chemical compounds may also contribute to medical efficacy. Flavonoids are mainly mono-, di- and triglycosides of quercetin, kaempferol and isorhamnetin, some esterified with *p*-coumaric acid in their sugar moiety, whereas biflavones are represented by amentoflavone. Flavan-3-ol derivatives include (+)-catechin, (–)-epicatechin and (+)-gallocatechin, as well as their dimeric compounds, proanthocyanidins. In contrast to flavonids, the terpene trilactones (ginkgolides and bilobalide) are unique chemical compounds, which are only present in *Ginkgo biloba* leaves. Ginkgolides (A, B, C, and J) are diterpenes having cage like structure consisting of six 5-membered carbocyclic rings, three lactones and tetrahydrofuran. Bilobalide is closely related to the ginkgolides, it is a sesquiterpene trilactone and differs by the absence of tetrahydrofuran ring. *Ginkgo biloba* leaves also contain carboxylic acids (phenolic and non-phenolic acids), polyprenols, carbohydrates and long-chain alkylphenols (ginkgolic = anacardic acids), which may be toxic (4, 8–11).

Ginkgo dry extract, refined and quantified (*Ginkgonis extractum siccum raffinatum et quantificatum*), as specified in pharmacopoeias, should contain 22.0 to 27.0% of flavonoids, expressed as

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flavone glycosides; 2.6 to 3.2% of bilobalide, 2.8 to 3.4% of total ginkgolides A, B and C, and less than 5 ppm (5 µg/g) of ginkgolic acids (1, 2).

A number of pharmaceuticals and dietary supplements containing extracts from *Ginkgonis folium* are available on the Polish market. In most of them, the content of flavonoids and terpene lactones is declared by the producer. Therefore, it seemed necessary to compare their pharmaceutical quality. Such comparative studies have been already performed for *Ginkgo biloba* preparations available in the USA (12, 13), Egypt (14) and others countries (15).

The aim of our investigations was to assay the concentration of active substances (flavonoids, terpene lactones) and potentially toxic ginkgolic acids in selected pharmaceuticals and dietary supplements containing extracts of *Ginkgo biloba* leaves.

The qualitative and quantitative analyses were performed following the methods described in the official pharmacopoeias for extract of *Ginkgo biloba* leaves (1, 2) and modified method of Ji et al. (16), in which experimental data from the chemical analysis of different extracts are compared without accurate quantification or identification of individual compounds (16–18).

EXPERIMENTAL

Materials and methods

Eleven herbal products (**1–11**) containing extracts of *Ginkgo biloba* leaves and dry extract of *Ginkgo biloba* leaves (**12**), having a certificate for compliance with pharmacopoeia requirements (1, 2), have been tested (Tab. 1.). Three herbal products (**1**, **3** and **5**) are registered in Poland as pharmaceuticals and eight (**2**, **4** and **6-11**) as dietary supplements, all of them (in the form of tablets or capsules) were purchased in one of the pharmacies in Poznań (Tab. 1).

Preparation of extracts

Tablets (**2-6**, **9** and **10**) or the contents of the capsules (**1**, **7**, **8** and **11**) were rubbed in a mortar. Taking into account producer's declarations and depending on the type of analysis, specified quantities of the preparations were weighed to obtain the following quantities of dry extract: 0.020 g (TLC of flavonoids), 0.100 g (HPLC fingerprinting), 0.200 g (HPLC flavonoid content), 0.120 g (HPLC terpene lactones content), 0.100 g (HPLC ginkgolic acids content).

Extraction and quantitative analyses of the obtained extracts were performed according to pharmacopoeias requirements (1, 2). For fingerprint analysis, weighed quantities of preparations were extracted with 5 mL of ethanol 80% for 20 min in an ultrasound bath. The extracts after filtration through a filter membrane RC 0.2 µm were analyzed by HPLC (16).

Chemicals and Samples

Chemicals: (Merck, Germany): ethanol, isopropanol, tetrahydrofuran, water, methanol;

Table. 1. Herbal products containing extracts of *Ginkgo biloba* leaves under analysis.

Preparation [a]	Batch	Galenical formulation	Dose [mg extract]	Average weight of tablets/capsules [mg]
1	B49605	Pharmaceutical capsule	40	190.16
2	081432C	Dietary supplement tablet	40	257.60
3	100508	Pharmaceutical tablet	40	219.42
4	C8D1669	Dietary supplement tablet	40[b]	954.93
5	R422	Pharmaceutical tablet	40	260.32
6	1437 241	Dietary supplement tablet	60	512.50
7	022177	Dietary supplement capsule	60[b]	563.54
8	011008	Dietary supplement capsule	70[b]	622.90
9	01880407	Dietary supplement capsule	80	569.14
10	063493	Dietary supplement capsule	80	373.36
11	921008/2	Dietary supplement capsule	80	293.87
12 – *Ginkgo biloba* extract	41441	Dry powdered extract	-	-

[a] names of preparations are available from authors; [b] preparation **4** (in addition to 150 mg magnesium); preparation **7** (in addition to 100 mg soybean lecithin, 120 mg magnesium and 2 mg vitamin B_6); preparation **8** (in addition to 50 mg ginseng extract and 330 mg magnesium lactate)

hydrochloric acid, phosphoric acid, phosphate buffer solution pH 5.8, trifluoacetic acid, acetonitrile, TLC silica gel plates (5–40 μm), anhydrous formic acid, glacial acetic acid, ethyl acetate, diphenylboric acid aminoethyl ester, macrogol 400, kieselguhr for chromatography.

Standards: (PhytoLab, Poland; Roth, Germany): rutin, quercetin, chlorogenic acid, ginkgo dry extract for peak identification CRS, ginkgolid acids CRS, benzyl alcohol CRS, ginkgolic acids CRS.

Chromatographic conditions

Determination of flavonoids

TLC analysis – according to the methods described in pharmacopoeias (1, 2).

HPLC analysis – Acquity UPLC system (Waters, USA) with K06UPD883M detector (PDA).

- fingerprint analysis: according to a modified method of Ji et al. (16). LiChroCART Nucleosil RP18 (250 mm × 4.0 mm, 5 μm) column, mobile phase A: water acidified with H_3PO_4 to pH 2.5/isopropanol/tetrahydrofuran (85:4:11, v/v/v); mobile phase B: water acidified with H_3PO_4 to pH 2.5/acetonitrile (22:78, v/v); flow rate of 1 mL×min^{-1}, with detection at λ = 350 nm. Non-linear concentration gradient was used; the gradient programme: 0–15 min. 100% A; 15–25 min. 100→98% A and 0→2% B; 25–55 min. 98→90% A and 2→10% B; 55–75 min. 90→0% A and 10→100% B. Each sample was injected 3 times (n = 3) at 3 μL (due to high sensitivity of the detector).
- quantity analysis**:** according to the methods described in pharmacopoeias (1, 2). LiChroCART LiChrospher100 RP18 (125 mm × 4.0 mm, 5 μm) column.

Determination of terpene lactones

HPLC analysis according to the methods described in pharmacopoeias (1, 2). Acquity HPLC system (Waters, USA) with Differential Refractometer 410. LiChroCART LiChrospher RP8 (250 mm × 4.0 mm, 5 μm) column.

Determination of ginkgolid acids

HPLC analysis according to the methods described in pharmacopoeias (1, 2). Acquity HPLC system (Waters, USA) with 996 detector (PDA). Symmetry C8 (250 mm × 4.6 mm, 5 μm) column.
Determination of each group of compounds was performed in triplicate.

RESULTS AND DISCUSSION

Eleven herbal products containing dry extract of *Ginkgo biloba* leaves, including three pharmaceuticals (**1**, **3** and **5**), eight dietary supplements (**2**, **4**, **6-11**), and dry extract of *Ginkgo biloba* leaves (**12**) certified for compliance with pharmacopoeia requirements (1, 2) were analyzed. A description is given in Table 1. Three herbal products contained ginkgo extract together with: magnesium (preparation **4**), magnesium and ginseng extract (preparation **8**), and magnesium with soybean lecithin and vitamin B_6 (preparation **7**).

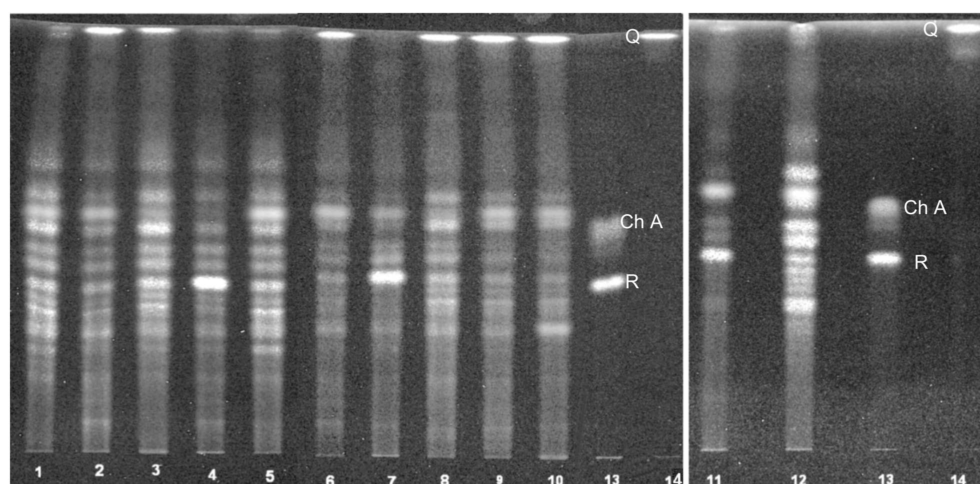

Figure 1. TLC chromatograms of unhydrolyzed extracts from preparations (**1-11**), *Ginkgo biloba* extract (**12**) and standards: rutin and chlorogenic acid (**13**), quercetin (**14**) in $UV_{366\,nm}$. Plate: TLC silica gel plate (Merck); Mobile phase: anhydrous formic acid : glacial acetic acid : water : ethyl acetate (75:75:175:675, v/v/v/v); Detection: diphenylboric acid aminoethyl ester + Macrogol 400, **1–11** studied preparations (numbered as listed in Table 1); **12** – *Ginkgo biloba* extract; **13** – chlorogenic acid (ChA) and rutin (R); **14** – quercetin (Q)

Table 2. Content of flavone glycosides, total terpene lactones and ginkgolic acids in *Ginko biloba*-containing preparations.

Preparation	Percentage of flavonoids in extracts before hydrolysis [%]			Amount of flavonoids after hydrolysis [%]				Amount of terpene lactones [%]			Amount of ginkgolic acids[c] [ppm]
				Percentage of flavonoids in extracts after hydrolysis			Sum of flavonoids[a]	Total ginkgolides A, B and C	Bilobalide	Total terpene lactones[a]	
	Rutin	Quercetin	Remaining compounds	Quercetin	Kaempferol	Remaining compounds					
1	7.00	1.48	91.52	**39.19**	**43.04**	17.77	**26.60**	2.78	3.28	**6.06**	**3.18**
2	3.80	**52.94**	43.26	72.80	16.32	10.88	**20.95**	3.54	2.83	**6.37**	**3.22**
3	6.85	4.11	89.04	**43.09**	**42.73**	14.18	**23.33**	3.52	2.58	**6.10**	**2.43**
4	**58.04**	0.38	41.58	0.00[b]	0.00[b]	100.00[b]	**0.53**	0.17	0.00	**0.17**	**391.83**
5	10.09	0.56	89.35	**45.66**	**37.14**	17.20	**23.68**	2.87	2.80	**5.67**	**4.75**
6	3.86	**58.93**	37.21	76.06	13.69	10.25	**21.65**	3.40	3.16	**6.56**	**5.34**
7	**66.29**	0.50	33.21	86.69	6.72	6.59	**21.03**	0.65	0.08	**0.73**	**2.62**
8	3.59	28.18	68.23	**57.05**	**29.20**	13.75	**25.09**	4.76	2.49	**7.25**	**4.85**
9	1.64	**55.68**	42.68	77.12	14.07	8.81	**24.76**	4.13	3.13	**7.26**	**1005.03**
10	1.01	**62.24**	36.75	80.97	10.91	8.12	**27.98**	3.97	2.10	**6.07**	**8053.48**
11	1.47	0.50	97.03	85.45	8.68	5.87	**26.75**	2.78	1.80	**4.58**	**572.72**
12– Ginkgo biloba extract	6.88	1.06	92.04	**35.86**	**43.77**	20.37	**26.72**	2.80[d]	2.80[d]	**5.60**[d]	**1.0**[d]

[a] according to producers' declarations, preparations should contain 24% flavonoids (no declaration available for preparations **8** and **9**) and 6% total terpene lactones (no declaration available for preparations **1**, **7**, **8** and **9**). [b] for preparation **4**, low aglycone concentration after hydrolysis is connected with too mild hydrolysis conditions. Increasing the amount of 2M HCl (from 15 to 20 mL – at the expense of water) produced an increase in the hydrolysate share of quercetin 26.27%, kaempferol 4.25% and other peaks 81.66% (incl. 51.14% unhydrolyzed rutin) after 25 min of hydrolysis. Complete hydrolysis occurred after 60 min. [c] according Eur. Ph. 6.1., preparations should not contain more than 5 ppm of ginkgolic acids. [d] according to Indena S.A.S. certificate.

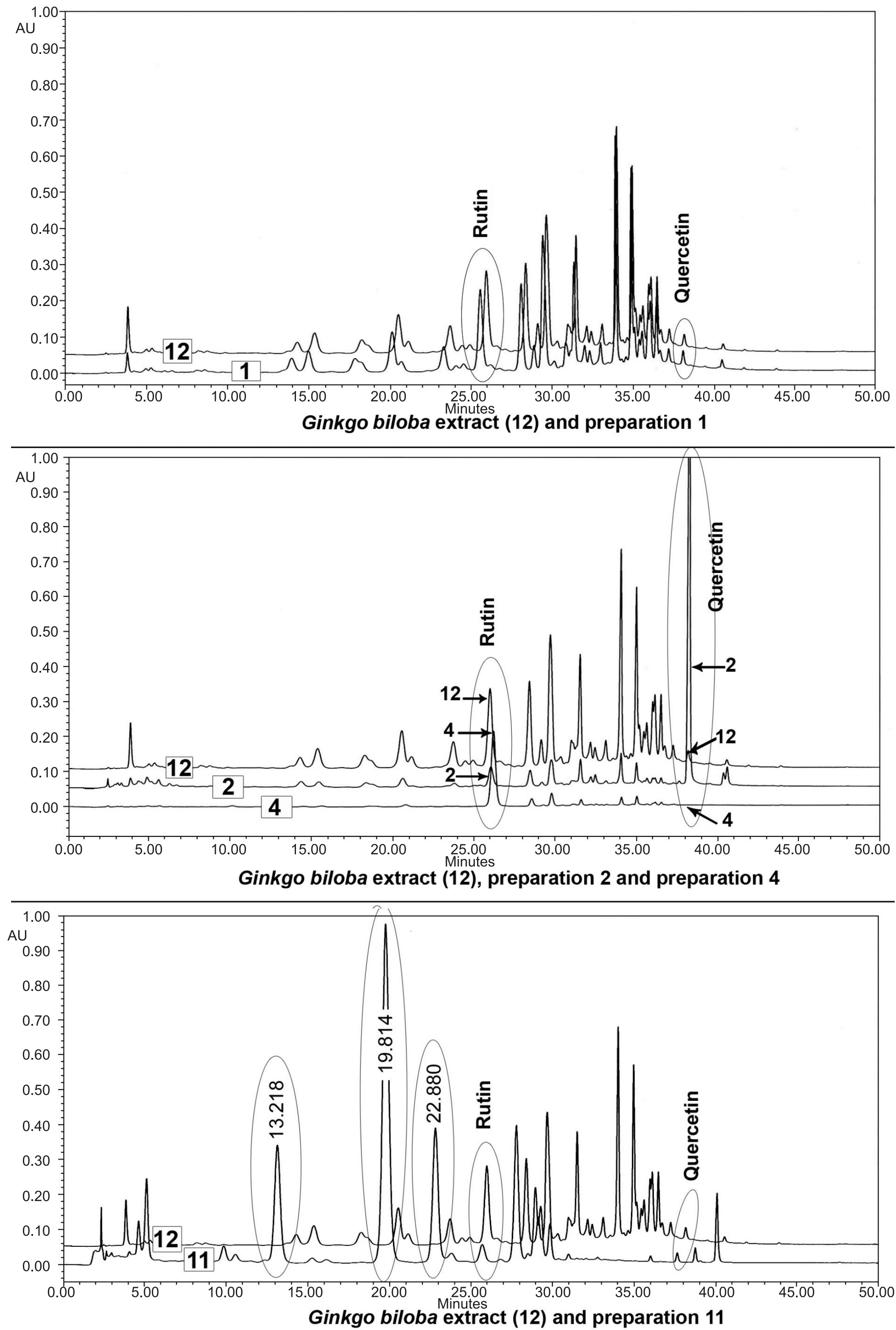

Figure 2. HPLC fingerprints chromatograms of unhydrolyzed extracts from selected preparations (**1**, **2**, **4**, **11**) and *Ginkgo biloba* extract (**12**)

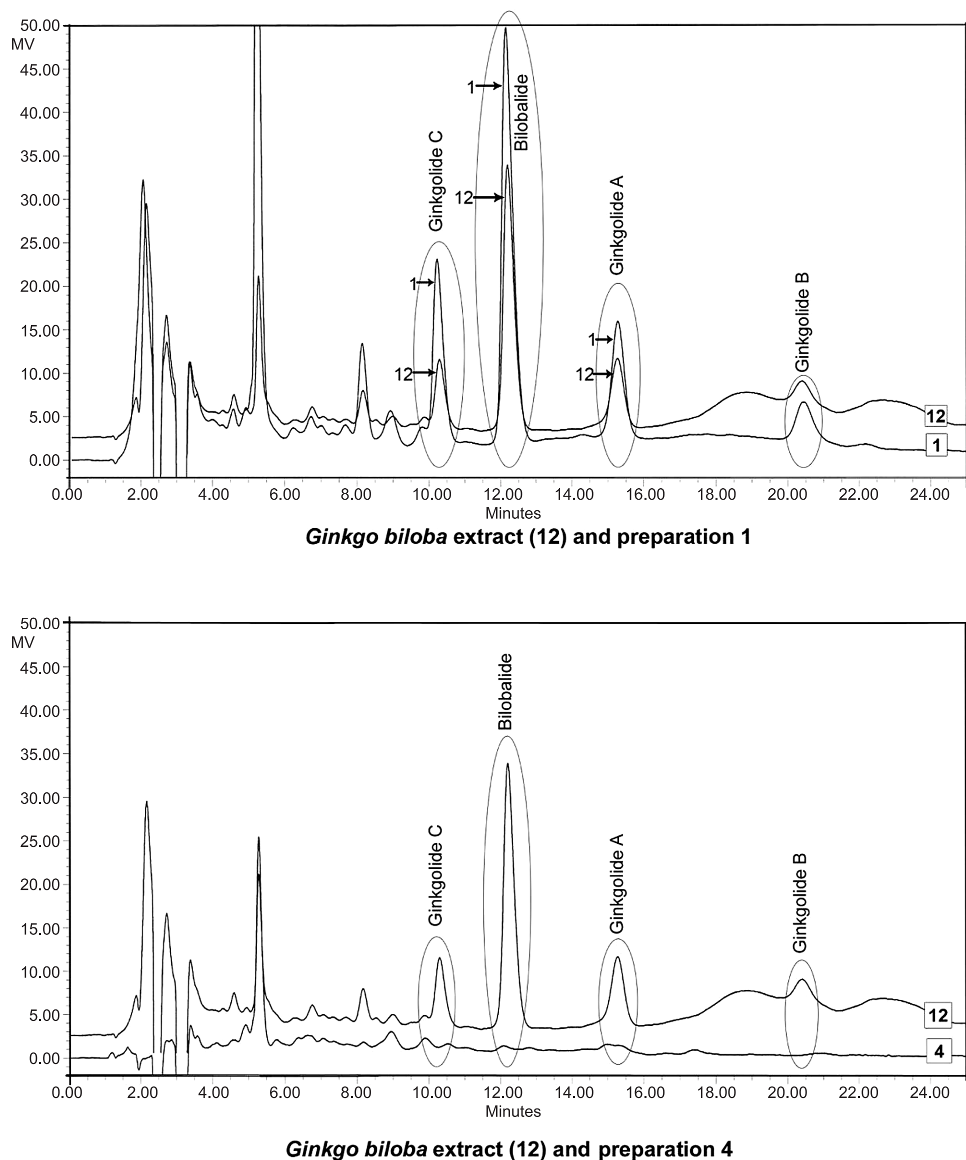

Figure 3. HPLC chromatograms of terpene lactones in *Ginkgo biloba* extract (**12**) and preparations **1** and **4**

Preparations containing extracts of *Ginkgo biloba* leaves which were analyzed by HPLC were found to contain diverse amounts of flavonoid compounds, terpene lactones and ginkgolic acids.

Identification

TLC analysis (Fig. 1)

TLC chromatograms of extracts of the preparations (**1-11**) and extract of *Ginkgo biloba* leaves (**12**) and standard solutions: chlorogenic acid and rutin (**13**) and quercetin (**14**) are presented in Figure 1.

On the TLC plates, the extracts of analyzed preparations demonstrated all zones typical for the extract of *Ginkgo biloba* leaves, including zones of distinct light blue and greenish-brown fluorescence above and two zones of green fluorescence below the chlorogenic acid, as well as several zones of green and yellow-brown fluorescence below the rutin zone (1, 2).

In the extracts of preparations **1**, **3** and **5** (pharmaceuticals) and in the standard extract (**12**), the fluorescence of the characteristic zones was markedly

stronger, relative to the zones of dietary supplements extracts (**2**, **4**, **6–11**). Furthermore, extracts of dietary supplements (**4**, **7** and **11**) showed a much stronger fluorescence in the rutin zone than extracts of pharmaceuticals. Moreover, chromatograms of preparations **2**, **6**, **8–10** revealed an intense zone at a height, corresponding to reference quercetin, which should not be visible in the TLC plates of extract from *Ginkgo biloba* leaves.

HPLC fingerprint analysis (Tab. 2, Fig. 2)

The HPLC fingerprint analysis of pharmaceuticals (**1**, **3** and **5**) showed a high intensity of peaks corresponding to ingredients of the *Ginkgo biloba* extract. In dietary supplements (**2**, **4** and **6–11**), on the other hand, the intensity of these peaks was low, while peaks corresponding to rutin, quercetin or other flavonoids were more prominent, to a varying extent (preparation **11**). An analysis of peak areas visible on the HPLC chromatogram shows that the *Ginkgo biloba* extract (**12**) contains 7.0% rutin and 1.48% quercetin (rutin's aglycone). The total area of other peaks, i.e., peaks corresponding to flavonoids in the extract of *Ginkgo biloba* leaves is 91.52%, including only trace amounts of the aglycones kaempferol and isorhamnetin (ca. 0.5% and 0.2%, respectively). For preparations **1**, **3** and **5** (pharmaceuticals), the percentage total area of individual peaks was close to corresponding peaks obtained for the *Ginkgo biloba* extract (**12**). Dietary supplements were found to have different component proportions. For example, in preparations **4** and **7** the rutin content (58.04% and 66.29%, respectively) was approximately 9 times higher; whereas in preparations **2**, **6**, **9** and **10** the quercetin content was ca. 50 times higher than in the standard *Ginkgo biloba* extract. The total area of other peaks was ca. 2–3 times lower in preparations **2**, **4**, **6**, **7**, **9** and **10**, compared to the extract of *Ginkgo biloba* leaves. In preparation **8**, the total area of other peaks and rutin was only slightly smaller, however, the quercetin content was many times higher (28.18%).

The HPLC chromatogram of preparation **11** failed to demonstrate recognizable peaks characteristic of the extract of *Ginkgo biloba* leaves, accommodated within the 30–38 min range. On the other hand, the preparation was found to contain 1.47% rutin and 0.50% quercetin. Other peaks, totalling 97.03%, consisted mainly of three peaks with retention times: 13.22 min., 19.81 min. and 22.89 min, accounting for 26.02%, 33.26% and 11.74%, respectively. Peaks with such retention times, preceding the rutin peak, are found neither in the chromatogram of the standard extract of *Ginkgo biloba* leaves (**12**), nor in chromatograms obtained for any other studied preparations. The HPLC analysis of the extract of preparation **11** was found to contradict TLC results, where a band of distinctive intense fluorescence, equivalent to rutin, was identified. Additional peaks determined by HPLC are likely to represent flavonoids which, in the TLC chromatographic conditions applied in the test, have similar Rf levels and the same UV fluorescence as rutin.

Quantitative determination

Content of flavonoids after acid hydrolysis (Tab. 2.)

Standardization of preparations with the extracts of *Ginkgo biloba* leaves is based on HPLC determination of the flavonoid content, expressed as quercetin (taking into account the total of peak areas for aglycones from quercetin to isorhamnetin) (1, 2).

The level of flavonoids determined following the hydrolysis of extracts from test preparations varied between 20.95% and 27.98% (quercetin equivalent), with the exception of preparation **4** (0.53%). Pharmaceuticals (**1**, **3**, **5**), dietary supplements (**8–11**) and the certified extract of *Ginkgo biloba* leaves (**12**) contained manufacturer-declared quantities of flavonoids, allowing for ± 10% differences in content. They also complied with pharmacopoeial requirements (not less than 22% and not more than 27%). Flavonoid levels determined in preparations **2**, **4**, **6** and **7** were lower than declared. Preparation **4** only contained trace amounts of aglycones despite considerable quantities of flavonoid glycosides (incl. 58.04% rutin) assayed in the preparation before hydrolysis.

Hydrolyzed extracts of *Ginkgo biloba* leaves should contain specified concentrations of quercetin and kaempferol (12), as demonstrated in the hydrolysate of the certified *Ginkgo biloba* extract tested in this study (**12**), containing 35.86% quercetin, 43.87% kaempferol and 20.37% of other aglycones. The hydrolyzed extracts of pharmaceuticals (**1**, **3**, **5**) and one dietary supplement (**8**) contained similar concentrations as the standard extract (**12**), that is 39.19%, 43.09%, 45.66% and 57% quercetin, and 43.04%, 42.73%, 37.14% and 29% kaempferol, respectively. The hydrolyzed extracts of the other dietary supplements analyzed (**2**, **4**, **6**, **7**, **9–11**) were found to contain more quercetin (72.80–86.69%) and less kaempferol (6.72–16.32%), which is consistent with pre-hydrolysis assays of extracts which demonstrated higher levels of quercetin (preparations **2**, **6**, **9** and **10**), rutin (**4**

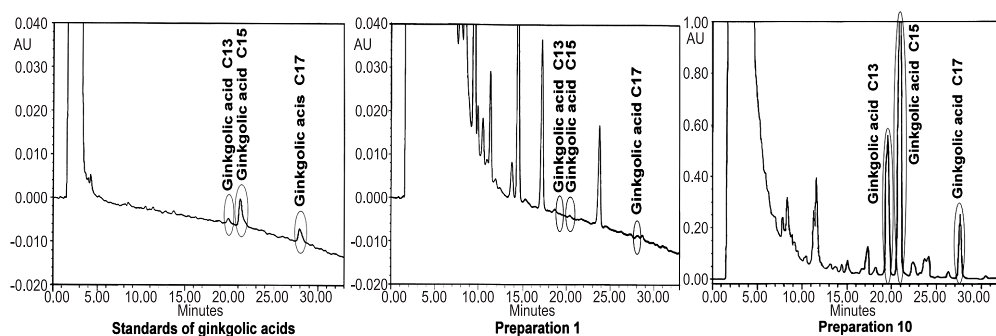

Figure 4. HPLC chromatograms of the standards of ginkgolic acids and ginkgolic acids derived from preparations **1** and **10**

and **7**) or probably the other compounds hydrolyzed to quercetin (**11**).

We can conclude that the analysis of flavonoid compounds after the hydrolysis of extracts (quercetin equivalent) is not a sufficient determinant of quality of preparations containing *Ginkgo biloba* extracts.

In the majority of dietary supplements analyzed in the study, the flavonoid content was close to producers' declarations and pharmacopoeial requirements, even though they contained a small amount of *Ginkgo biloba* extracts and increased concentrations of rutin, quercetin or other flavonoids. The presence of flavonoids other than those normally found in the extracts of *Ginkgo biloba* leaves does not guarantee the efficacy documented for *Ginkgo biloba* extracts in terms of peripheral vascular benefits and cerebral circulation in particular.

Content of terpene lactones

In order to assess the content of terpene lactones, extracts of herbal preparations were subjected to column chromatography on kieselguhr. Eluates were then analyzed by HPLC. The results are listed in Table 2.

It should be noted that pharmacopoeial requirements (1, 2) for the extract of *Ginkgo biloba* leaves concern the content of bilobalide (2.6%–3.2%) and total ginkgolides A, B and C (2.8%–3.4%), not the total concentration of terpene lactones declared by producers of preparations.

The total terpene lactone content, allowing for a 10% deviation from declared levels, was identical or similar to the value declared by producers (6%) in three pharmaceuticals (**1**, **3**, **5**) and five dietary supplements (**2**, **6**, **8**, **9**, **10**). In preparations **8** and **10**, total terpene lactones concentration corresponded to this, specified by the producers, however, bilobalide content was too low (2.49% and 2.10%), with elevated levels of total ginkgolides A, B and C (4.76% and 3.97%). Elevated concentration of total ginkgolides A, B and C was also confirmed for preparation **9** (4.13%). A lower total terpene lactone content together with low bilobalide level (1.8%) was determined in the extract of preparation **11** (4.58%). Preparations **4** and **7** contained only trace amounts of terpene lactones, assayed at 0.17% and 0.73%, respectively.

Analyzing the content of terpene lactones determined in study preparations, it was noted that products having flavonoid concentrations conforming to relevant requirements also had terpene lactone levels consistent with pharmacopoeial requirements and producers' declarations.

Content of ginkgolic acids

Producers of studied preparations do not declare the content of ginkgolic acids, hence the results obtained in tests were compared with pharmacopoeial requirements valid for the extract of *Ginkgo biloba* leaves (1, 2).

The extracts of three herbal pharmaceuticals (**1**, **3**, **5**) and five dietary supplements (**2**, **5–8**) were found to contain below 5 ppm (± 10%) of ginkgolic acids. On the other hand, the ginkgolic acid level in preparations **4**, **9**, **10** and **11** was many times higher, i.e., 391.83, 1005.03, 8053.48, 572.72 ppm (Tab. 2. and Fig. 4).

Ginkgolic acids present in *Ginkgo biloba* leaves and fruit are known to produce sensitising, mutagenic and carcinogenic effect *in vitro* (19, 20). Therefore, standardized *Ginkgonis folium* extracts used in the manufacture of herbal pharmaceuticals must be free from ginkgolic acids, what can be achieved by an appropriate technological process. High ginkgolic acids' concentration in preparations

may be a consequence of producing them from non-standardized extracts, which have not been purified from ginkgolic acids. It is difficult to account for the very high concentration of ginkgolic acids in preparations numbered **4**, **9**, **10** and **11,** which were found to contain very low concentrations of flavonoid compounds typical of *Ginkgo biloba* extracts and reduced levels of terpene lactones (preparations **4** and **11**).

CONCLUSION

It is obvious that herbal preparations must be efficacious and safe. Therefore, it was relevant to compare the pharmaceutical quality of preparations with *Ginkgo biloba* extracts, which are very popular on Polish market. Based on the results, it can be concluded that preparations with *Ginkgo biloba* extracts which are registered in Poland as pharmaceuticals (**1**, **3**, **5**) ensure an appropriate content of active ingredients, flavone glycosides and terpene lactones, so only these preparations are efficacious in the therapy of peripheral circulatory disturbances.

The concentration of active substances in dietary supplements was found to vary. Some of them met relevant quality criteria (mainly preparation **8**), however, the majority had reduced levels of active compounds (**4**, **6**, **7**, **11**) but also the increased content of ginkgolic acids (**4**, **9**, **10**, **11**).

The results were similar to these obtained by other authors for dietary supplements (12–14), which often failed to contain active ingredients in amounts declared by their producers, thus eliminating therapeutic efficacy. Furthermore, even though dietary supplements are generally thought to be completely safe, this claim was not confirmed in this study. The results showed that some dietary supplements contain considerable quantities of potentially toxic chemical compounds.

Patients should not expect dietary supplements to deliver therapeutic effects and should not regard them as equivalent to herbal medicinal products. Dietary supplements are designed to support physiological functions and have a preventative, rather than medicinal, activity, but must be safe.

REFERENCES

1. European Pharmacopoeia 6th Edition, Supplement 6.1, pp. 3461–3463, European Directorate for the Quality of Medicines and HealthCare, Strasbourg 2008.
2. Polish Pharmacopoeia VIII (vol. II), pp. 1841–1845, Polish Pharmaceutical Society, Warszawa 2009.
3. Nahin L.R., Fitzptrick A.L., Williamson J.F., Bruke G.L., DeKosky S.T., Furberg C.: J. Am. Geriatr. Soc. 54, 1725 (2006).
4. Chan P.Ch., Xia Q., Fu P.P.: J. Environ. Sci. Health C 25, 211 (2007).
5. Bidzian L., Bilikiewicz A., Turczyński J.: Psychiatr. Pol. 39, 559 (2005).
6. Gardner Ch.D., Zehnder J.L., Rigby A.J., Nicholus J.R., Farquhar J.W.: Blood Coagul. Fibrinolysis 18, 787 (2007).
7. Blacharz-Klin K., Piechal A., Widy-Tyszkiewicz E.: Przewodnik Lekarza 6, 42 (2003).
8. Bodalski T., Karłowicz-Bodalska K.: Postępy Fitoter. 4, 195 (2006).
9. Singh B., Kaur P., Singh G.-R.-D., Ahuja P.S.: Fitoterapia 79, 401 (2008).
10. Mahadevan S., Park Y.: J. Food Sci. 73, 14 (2008).
11. Ding X.P., Qi J., Chang Y.X., Mu L.L., Zhu D.N., Yu BY.: J. Chromatogr. A. 1216, 2204 (2009).
12. Deng F., Zito S.W.: J. Chromatogr. A 986, 121 (2003).
13. Kressman S., Müller W.E., Blume H.H.: J. Pharm. Pharmacol. 54, 661 (2002).
14. Mesbah M.K., Khalifa S.I., El-Gindy A., Tawfik K.A.: Farmaco 60, 583 (2005).
15. Van Beek T. A., Montoro P.: J. Chromatogr. A 1216, 2002 (2009).
16. Ji Y.B., Xu Q.S., Hu Y.Z., Heyden Y.V.: J. Chromatogr. A 1066, 97 (2005).
17. Ding S., Dudley E., Plummer S., Tang J., Newton R., Brentin A.: Phytochemistry 69, 1555 (2008).
18. Sun G., Liu J.: Anal. Sci. 23, 955 (2007).
19. Fuzzati N., Pace R., Volla F.: Fitoterapia 74, 247 (2003).
20. Ndjoko K., Wolfender J.L., Hostettmann K.: J. Chromatogr. B 744, 249 (2000).

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