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Antioxidant Activity of Extracts from *Bambusa vulgaris* and *Gigantochloa apus* Kurz Bamboo Shoots

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Abstract: Bamboo shoots are easy to find in Indonesia and have been as a food ingredient since antiquity. In addition, bamboo shoots contain compounds that can reduce blood cholesterol. Thus, extracts from bamboo shoots could be used as an alternative treatment for hyperlipidemia. The aim of this study was to determine the amount flavonoids, polyphenols, vitamin E and the antioxidant activity of bamboo shoots. *Bambusa vulgaris* and *Gigantochloa apus* kurz Bamboo shoots aged 1-2 weeks and 3-4 weeks, were used. Bamboo shoots were oven dried (80°C) or freeze-dried; then, compounds were extracted using 90% ethanol. The chemical compounds were analyzed using the SNI 01-2891-1992 method for the proximate test. Quantification of antioxidant compounds and antioxidant activity were analyzed using the DPPH method. The results of the proximate analysis test, the sample of chemical compounds and antioxidant activity in this study showed that, after oven-drying, the greatest shrinkage occurred in bamboo shoots aged 1-2 weeks (69.94%) and the largest shrinkage was with freeze-dried *Gigantochloa apus* kurz bamboo shoots aged 1-2 weeks (77.87%). Extracts of 1-2 week-old *Gigantochloa apus* kurz bamboo shoots (freeze-dried) had the highest protein content (0.41%). The highest fat content was in the extract from 1-2 week-old *Bambusa vulgaris* bamboo shoots (oven-dried; 0.63%). The carbohydrate level from extracts of 1-2 week-old *Gigantochloa apus* kurz bamboo shoots (freeze-dried) was 30.23%. The crude fiber content of the extract from 3-4 week-old *Bambusa vulgaris* bamboo shoots (oven-dried) was 4.12 g. Three to four week-old *Gigantochloa apus* kurz bamboo shoots (freeze-dried) had the lowest water content (3.73%). The largest ash content was in the extract from 3-4 week-old *Bambusa vulgaris* bamboo shoots (freeze dried; 0.98 grams). The highest content of vitamin E was in extracts from 1-2 week-old *Gigantochloa apus* kurz bamboo shoots (freeze-dried; 0.4358%). The total flavonoid content was highest in extracts from 1-2 week-old *Gigantochloa apus* kurz bamboo shoots (freeze dried; 0.03982%). The phenol content was the highest in extracts from 1-2 week-old *Gigantochloa apus* kurz bamboo shoots (freeze-dried; 3.506%). Extracts from 1-2 week-old *Gigantochloa apus* kurz bamboo shoots (freeze-dried) had the highest antioxidant activity (IC_{50}: 22 388 µg/L) compared to other bamboo shoots.

Key words: Proximate analysis, antioxidant activity, bamboo shoots, antiatherosclerosis

INTRODUCTION

Cases of coronary heart disease have become common in Indonesia due to the rapid change in lifestyle. Although there are no definite epidemiological data, morbidity/death looks likely to increase. In 2001, the National Health Survey reported that 3 out of every 1,000 residents of Indonesia suffered from PJK. Furthermore, the Basic Health Research assessment carried out by the Indonesian Health Department in 2007reported that coronary heart disease was one of the leading causes of death, in 9 and 11th. In total, 5.1% of all deaths were caused by ischemic heart disease and 4.6 percent were caused by heart disease. Cumulatively, heart disease is the second highest cause of death, accounting for approximately 9.7% of all deaths in Indonesia.

Coronary heart disease results from decreased oxygen supply (ischemia) to the heart muscle. Coronary arteries become blocked as a result of the atherosclerosis process, which begins with the accumulation of fat and cholesterol in the blood vessels (Ganong, 1983). Excessive cholesterol in the blood vessels can oxidize and interact with macrophages and other biologic substances. This leads to the formation of foam cells, which accumulate in the blood vessel walls and infiltrate arteries, forming an atherosclerotic plaque. The crust or plaque eventually breaks into smaller pieces. These pieces of plaque enter the blood stream and can clog the coronary arteries. Inhibition of blood flow to the heart (caused by blocked coronary arteries) can result in cardiomyocyte death and lead to a myocardial infarct.

An important factor that may increase the probability of developing atherosclerosis is lifestyle. Atherosclerosis can result from an unhealthy diet and lack of exercise. An unhealthy diet can include an increased consumption of foods that are high in fat, carbohydrates and sodium; smoking and drinking alcoholic beverages and a low consumption of foods containing fiber (Soesanto, 2010). Cholesterol levels can be controlled with drugs that treat

hyperlipidemia; however, these drugs are costly and have several side effects [e.g. stomach pain, abdominal pain, urticarial, dysuria, weight loss, ichthyosis, insomnia, depression and dysgeusia (Kamaluddin, 1992)]. Additionally, these drugs have contraindications to other comorbid diseases; thus, they cannot be administered to every patient with atherosclerosis.

Hypolipidemic drugs can be derived from plants. Medicines derived from herbs are easy to find, cost effective and relatively safe compared to synthetic drugs. Plants are a source of chemical compounds and many plants, whether known or undiscovered, are potential sources of medicines. One example of a plant with hypolipidemic compounds is the bamboo shoot,

Bamboo shoots are believed to lower blood cholesterol levels, drug-induced jaundice, liver cirrhosis, drug-induced swelling, sputum cough and fever. Bamboo shoots contain lignin (insoluble fiber), pectin and glucans (soluble fiber), which bind to organic substances such as bile acids and cholesterol. This results in a decrease of fatty acids in the digestive tract (Olwin and Cornelis, 2005). When fiber binds to bile, this removes bile acids out of the enterohepatic cycle because the bile acids that are secreted into the intestine cannot be absorbed. Instead, these bile acids are discharged into the feces. Decreasing the amount of bile acids that enter enterohepatic cycle can cause the cholesterol in the liver to be used as the source of bile acids. Thus, this is one way that fiber can decrease cholesterol levels. Moreover, fiber can inhibit fat emulsification by bile salts and cholesterol, thus binding to cholesterol and getting excreted in the excreta (Hernawati, 2005).

Vitamin E is an antioxidant that protects cell membranes and low density lipoprotein (LDL) cholesterol from free radical damage. This helps slow the aging process in the arteries and protects against cell damage that can cause cancer, heart disease and cataracts. Vitamin E also plays a role in reducing the oxidation of LDL, thus preventing injury to the endothelium, decreasing the production of inflammatory cytokines and decreasing platelet aggregation (Maydani, 2001).

Previous studies indicate that bamboo shoots can decrease blood pressure due to the high content of potassium and pithopenolnya, an antioxidant (Parekh and Chanda, 2007). Bamboo shoots can decrease blood glucose, lipid profiles, hepatic function and symptoms of constipation (Park and John, 2009; Jiao, 2008; Jiao *et al*., 2008). The lignophenol bioactive compounds are antioxidants and also suppress apoptosis in SH-SY5Y neuroblastoma cells (Akao *et al*., 2004; Hu *et al*., 2000). Bamboo leaves are rich in polyphenols, C-glucosides and p-coumaric acid, antioxidant compound (Lu *et al*., 2006; Zhang *et al*., 2007). Bamboo leaves also contain TRICIN (5,7,4'-trihydroxy-3', 5'-dimethoxyflavone), which is an antioxidant compound that reduces cancer cell growth (Jiao, 2008). Bamboo shoots can also have anti-inflammatory effects and inhibit cell proliferation of Ehrlich ascites carcinoma more than Catharanthus roseus, which is a known anti-cancer compound found in plants (Rana *et al*., 2008).

Bamboo shoots are abundant in Indonesia and can grow anywhere. They are also very inexpensive and have been used by many people a food ingredient since antiquity. Bamboo shoots are harvested when their target height has been reached: <20 cm from the ground and a trunk diameter of approximately 7 cm or aged <1 to 2 weeks. if they are harvested late, bamboo shoots are hard and within 1-2 months, they are considered mature bamboo plants (Widiarti, 2013).

Because bamboo shoots contain hypocholesterolemic compounds, they can be used as an alternative treatment to non-pharmacological or traditional medicines (or complementary therapy). Therefore, the aim of this study was to determine the chemical compounds and antioxidant activity in the bamboo shoots, *Gigantochloa apus* kurz and *Bambusa vulgaris*.

MATERIALS AND METHODS

The materials used for the study were fresh bamboo shoots that are commonly used as raw food and medicine, *Bambusa vulgaris* and film that was aged 1-2 weeks and 3-4 weeks. The bamboo shoots were obtained from crops grown in the bamboo gardens of the Banyumeneng people in the village district Mranggen, Demak regency (Widiarti, 2013), in January 2015.

Chemicals that were used to test for the protein content consisted of H_2SO_4, selenium, NaOH 40%, indicators MR, boric acid and HCl. Testing fat content consisted of using the reagents benzene and ether, while testing of raw fiber consisted of using an anti-foaming, H_2SO_4, NaOH, 10%, K_2SO_4. The antioxidant activity was measured using reagents Lar, DPPH and 90%.

The equipment that was used in this study included an oven to dry the bamboo shoots at 80°C, freeze drying and a percolation extraction process. For the proximate analysis, destructive and distillation devices were used for the crude fiber analysis, which used soxhlet as well as tested the antioxidant activity via a UV-VIS spectrophotometer.

The method used to dry bamboo shoots was by an oven set at 80°C, followed by freeze-drying. Deriving extracts from bamboo shoots was done by the percolation method. Proximate analysis performed by the modified method with SNI 01-2891-1992 can do 3 repetitions and employ a method of determination of antioxidant activity using DPPH method with three replications.

Proximate analysis of antioxidant chemical compounds and antioxidant activity was conducted at the Laboratory of Food Technology at the University of Muhammadiyah Semarang and The Laboratory of Integrated Research and Development (LPPT) at Gajah Mada University.

RESULTS AND DISCUSSION

The drying process was done by using a preheated oven at 80°C for 24 h and this allowed for dramatic changes in the heavy bamboo shoots, *Gigantochloa apus* kurz. After 1-2 weeks, *Gigantochloa apus* kurz shrank by 69.94%, while at 3-4 weeks, the *Bambusa vulgaris* bamboo shoot shrank by 67.94%.

The drying process was also done using freeze drying. This method resulted in the largest changes the in heavy bamboo shoot, *Gigantochloa apus* kurz, which after 1-2 weeks, shrank by 77.87%. At 3-4 weeks, the *Bambusa vulgaris* bamboo shoot shrank by 75.28%.

Proximate analysis: Proximate analysis of the bamboo shoots was done to determine the amounts of nutrients such as protein, fat, water, ash and carbohydrates. Results of the proximate analysis extract using oven-dried bamboo shoots are shown in Table 3. The results of the proximate analysis extract using freeze-dried bamboo shoots are also shown.

The results of the analysis of proteins in different extracts of bamboo shoots (Table 3 and 4) included the analysis of *Gigantochloa apus* kurz after 1-2 weeks of freeze drying, which had the highest protein content. The analysis of *Bambusa vulgaris* bamboo after 3-4 weeks of growth and oven-drying, yielded the lowest protein content (0.3%). The highest fat content (0.63%) was observed in the *Bambusa vulgaris* bamboo shoots after 1-2 weeks of growth, followed by oven-drying. The lowest fat content (0.02%) was in *Gigantochloa apus* kurz after 3-4 weeks growth using the freeze-drying method. The carbohydrate levels in bamboo shoots after 1-2 weeks (freeze-dried) were 20.23% and the lowest levels (9.34%) were in the bamboo shoots of *Gigantochloa apus* kurz after 3-4 weeks (oven). Compared with vegetables or other foods, the proteins, fats and carbohydrates in the bamboo shoots are low (TKPI Persagi, 2009). The crude fiber content of the bamboo shoots was high compared with vegetables or other food materials. The fiber content was the highest in 3-4 week-old *Bambusa vulgaris* bamboo shoots (oven-dried; 4.12%) and the lowest fiber content was in 1-2 week-old *Gigantochloa apus* kurz (1.73 g, freeze-dried).

The mean water content was 3.73% in 3-4 week-old *Gigantochloa apus* kurz (freeze-dried), 3.10% in *Bambusa vulgaris* bamboo shoots and 4.47% in 1-2 week-old *Gigantochloa apus* kurz (oven-dried). If the water content is below 10%, bamboo shoot extracts can be stored for long periods of time. This is because high water content in products can result in microbiological, chemical or enzymatic damage.

The ash content in the extracts of some bamboo shoots are shown in Table 3 and 4. Three to four week-old *Bambusa vulgaris* bamboo shoots (freeze-dried) had the highest ash content (0.98 g) and 1-2 week-old *Gigantochloa apus* kurz (oven-dried) had the smallest ash content (0.76 g). The ash content is high in other food materials that are also high in mineral content (Winarno, 1993). The total mineral content in food can be estimated as the ash of an organic residue after the organic materials are burned.

The antioxidant activity in bamboo shoots was evaluated using the DPPH method. The amount of antioxidant activity was determined by IC_{50} values (i.e. the sample concentration required to inhibit 50% of the free radical activity) A small IC50 value indicates higher antioxidant capabilities. One to two week-old *Gigantochloa apus* kurz bamboo shoots (freeze-dried) displayed the highest antioxidant activity (IC_{50}: 22,388 μg/mL) compared to other bamboo shoots because it had an IC50 value of less than 200 mg/L (Hanani *et al*., 2005). Compared with the antioxidant activity of ginger, the antioxidant activity of these shoots was still higher.

Antioxidants: The level of antioxidant compounds in bamboo extracts were also analyzed in the present study. The levels of vitamin E, phenols and flavonoid were determined using the UV-VIS spectrophotometer.

Vitamin E is an antioxidant that protects cell membranes and low density lipoprotein (LDL) cholesterol from free radical damage. This helps slow the aging process in the arteries and protects against cell damage that can cause cancer, heart disease and atherosclerosis, The highest content of Vitamin E was observed in 1 to 2-week-old *Gigantochloa apus* kurz bamboo shoots (freeze dried; 0.4358%), as shown in Table 5 and 6.

Table 1: Weights of bamboo shoots before and after oven drying

Type of bamboo shoots	Before (gr)	After (gr)	Percentage
Bambusa vulgaris bamboo shoots	5000	1540.34	30.81
Bambusa vulgaris bamboo shoots	5000	1603.21	32.06
Bamboo shoots *Gigantochloa apus* Kurz	5000	1502.75	30.06
Bambu apus ahoots	5000	1598.56	31.97

Table 2: Weights of bamboo shoots before and after freeze drying

Type of bamboo shoots	Before (gr)	After (gr)	Percentage
Bambusa vulgaris bamboo shoots	5000	1115.28	22.31
Bambusa vulgaris bamboo shoots	5000	1236.15	24.72
Bamboo shoots *Gigantochloa apus* Kurz	5000	1106.25	22.13
Bambu apus shoots	5000	1221.67	24.43

Table 3: Analysis results of the bamboo shoots proximate test using oven-dried extracts

	Content				
Type of bamboo shoots	Protein (%)	Fat (%)	Water (%)	Ash (gr)	KH (%)
Bambusa vulgaris bamboo shoots 1-2 weeks	0.17	0.63	4.47	0.88	29.78
Bambusa vulgaris bamboo shoots 3-4 weeks	0.15	0.56	4.35	0.77	29.34
Gigantochloa apus kurz bamboo shoots 1-2 weeks	0.41	0.09	4.23	0.76	10.35
Bambu apus ahoots 3-4 weeks	0.38	0.06	4.14	0.85	09.34

Table 4: Analysis results of the bamboo shoots proximate test using freeze-dried extracts

	Content				
Type of bamboo shoots	Protein (%)	Fat (%)	Water (%)	Ash (gr)	KH (%)
Bambusa vulgaris bamboo shoots 1-2 weeks	0.37	0.51	3.27	0.96	30.23
Bambusa vulgaris bamboo shoots 3-4 weeks	0.32	0.48	3.13	0.98	30.11
Gigantochloa apus kurz bamboo shoots 1-2 weeks	0.57	0.05	3.17	0.87	12.47
Bambu apus ahoots 3-4 weeks	0.45	0.02	3.10	0.90	12.26

Table 5: Analysis results of the chemical compounds and antioxidant activity of bamboo shoots using oven-dried extracts

	Content (%)			Antioxidant activity
Type of bamboo shoots	Plavonoid	Phenol	Vitamin E	IC_{50} (µg/mL)
Bambusa vulgaris bamboo shoots 1-2 weeks	0.02479	3.078	0.2935	31.421
Bambusa vulgaris bamboo shoots 3-4 weeks	0.02335	2.875	0.2864	39.425
Gigantochloa apus kurz bamboo shoots 1-2 weeks	0.02778	3.453	0.3284	28.358
Bambu apus shoots 3-4 weeks	0.02468	3.149	0.2956	37.313

Table 6: Analysis results of the chemical compounds and antioxidant activity of bamboo shoots using freeze-dried extracts

	Content (%)			Antioxidant activity
Type of bamboo shoots	Plavonoid	Phenol	Vitamin E	IC_{50} (µg/mL)
Bambusa vulgaris bamboo shoots 1-2 weeks	0.03565	3.100	0.3831	25.373
Bambusa vulgaris bamboo shoots 3-4 weeks	0.03445	2.920	0.3768	32.835
Gigantochloa apus kurz bamboo shoots 1-2 weeks	0.03982	3.506	0.4358	22.388
Bambu apus shoots 3-4 weeks	0.03618	3.205	0.3924	34.328

Flavonoids are a group of phenols that have antioxidant properties and that prevent cell damage by reactive free radicals. Flavonoids also act as drugs by donating a hydrogen atom or through their ability to chelate the metal, in the form of glucosides (containing side chains of glucose) or in aglycone. The results of the flavonoid content analysis are shown in Table 5 and 6. The total flavonoid content was highest in 1-2 week-old extracts of *Gigantochloa apus* kurz bamboo shoots (freeze-dried; 0.03982%).

Polyphenols are found in vegetables, fruit and drinks. They are antioxidants and antiradicals. A phenol compound capable can prevent LDL oxidation better than vitamin E (20 times). The phenol content was largest in the extract of 1-2 week-old *Gigantochloa apus* kurz bamboo shoots (freeze dried; 3.506%).

Conclusion: Based on the aforementioned observations, the results are summarized as follows:

1: After being dried in an oven at 80°C, 1-2 week-old *Gigantochloa apus* kurz bamboo shoots shrank by 69.94% and 3-4 weeks old *Bambusa vulgaris* bamboo shoots shrank by 67.94%
2: After being freeze dried, 1-2 weeks old *Gigantochloa apus* kurz bamboo shoots shrank by 77.87% and 3-4 weeks of old *Bambusa vulgaris* bamboo shrank by 75.28%
3: Extract from 1-2 week-old *Gigantochloa apus* kurz bamboo shoots (freeze dried) has the highest protein content (0.41%) protein content, while 3-4 week-old *Bambusa vulgaris* bamboo shoots (oven-dried) had the lowest (0.15%)
4: The highest fat content was in the extract of the *Bambusa vulgaris* bamboo shoots and the lowest was in bamboo shoots *Gigantochloa apus* kurz
5: The largest carbohydrate content was in the extracts of bamboo shoots *Gigantochloa apus* kurz and the lowest was the extract of *Gigantochloa apus* kurz bamboo shoots 3
6: The largest content of crude fiber content was in the extract of 3-4 week-old *Bambusa vulgaris* bamboo shoots (dried in an oven) and was equal to 4:12 and the lowest was in the extract of 1-2 week-old *Gigantochloa apus* kurz bamboo shoots (1.73 g)
7: The analysis results of the average moisture content of the obtained yield was 3.73% and the lowest water content was 3.10% in extracts from *Gigantochloa apus* kurz bamboo shoots (3-4 weeks old; freeze-dried). The extract of 2-month old *Gigantochloa apus* kurz bamboo shoots (oven-dried) had the highest water content, at 4.47%
8: Three to four week-old *Bambusa vulgaris* bamboo shoots (freeze dried) had the largest ash content (0.98 g) and *Gigantochloa apus* kurz had the smallest ash content (0.76 g)

9: The highest content of Vitamin E was in extracts of 1-2 week-old *Gigantochloa apus* kurz bamboo shoots (0.4358%)
10: The highest content of total flavonoids was in extracts from freeze dried 1-2 week-old *Gigantochloa apus* kurz bamboo shoots (0.03982%)
11: The largest of phenol content was in 1-2 week-old *Gigantochloa apus* kurz bamboo shoots(3.506%)
12: The highest antioxidant activity was in the extracts from 1-2 week-old *Gigantochloa apus* kurz bamboo shoots (IC50: 22 388 ug 8 µg/mL)

REFERENCES

Akao, Y., N. Seki, Y. Nakagawa, H. Yi, K. Matusumoto, Y. Ito, K. Ito, M. Funaoka, W. Maruyama, M. Naoi and Y. Nozawa, 2004. A highly bioactive lignophenol derivative from bamboo lignin exhibit a potent activity to suppress apoptosis induced by oxidative stress in human neuroblastoma SH-SY5Y cells. Bio. and Med. Chem., 12: 4791-801.

Ganong, W.F., 1983. Buku Ajar Fisiologi Kedokteran. Jakarta: EGC.

Hanani, E., M. Abdul and S. Ryany, 2005. Identifikasi Senyawa Antioksidan dalam Spons *Callyspongia* sp dari Kepulauan Seribu. Majalah Ilmu Kefarmasian, 2: 127-133.

Hernawati, 2005. Peran berbagai sumber serat dalam dinamika kolesterol pada individu hiperkolesterolemia dan normokolesterolemia, Bandung (tidak dipublikasikan).

Hu, C.H., Y. Zhang and D.K. David, 2000. Evaluation of antioxidant and prooxidant activities of bambooPhyllostachys nigravar.henonisleaf extractin *in vitro*. J. Agric. Food Chem., 48: 3170-3176.

Jiao, J., Y. Zhang, D. Lou and X. Wu and Y. Zhang, 2008. Antihyperlipidemic and antihypertensive effect of a triterpenoid-rich extract from bamboo shavings and vasodilator effect of friedelin on phenylephrine-induced vasoconstriction in thoracic aortas of rats. Phytotherapy Res., 21: 1135-1141.

Jiao, J., 2008. Separation and purification of tricin from an antioxidant product derived from bamboo leaves. J. Agric. Food Chem., 55: 10086-10092.

Kamaluddin, M.T., 1992. Farmakologi Obat Anti Hiperlipidemia. Available in: http://www.cermindunia kedokteran.com.

Lu, B., X. Wu, J. Shi, Y. Dong and Y. Zhang, 2006. Toxicology and safety of antioxidant of bamboo leaves. Part 2: developmental toxicity test in rats with antioxidant of bamboo leaves Food and chemical toxicology: An Int. J.Published for the Br. Indust. Biolog. Res. Assoc., 11/44: 1739-1743.

Maydani, M., 2001. Vitamin E and Atherosclerosis: Beyond Prevention of LDL Oxidation. J. Nutr., 131: 366S-368S.

Olwin Nainggolan and Cornelis Adimunca 2005. Diet Sehat dengan Serat, Cermin Dunia Kedokteran No, 147: 43-46.

Parekh, J. and S. Chanda, 2007. *In vitro* antibacterial activity of the crude methanol extract of woodfordia fruticosa kurz flower (lythraceae). Brazil. J. Microbial., 38: 204-207.

Park, E.J. and D.Y. John, 2009. Effect of bambooshoot consumption on lipid profiles and bowel function in healthy young women. Nutr. J., 25: 723-728.

Rana, M., J.A. Khanam and M. dan Asad-Ud-Daula, 2008. Antineoplastic screening of some medicinal plants against Ehrlich ascites carcinoma in mice. J. Med. Sci., 4: 142-145.

Soesanto, E., 2010. Faktor-faktor yang berhubungan dengan praktik pengendalian kesehatan pada lanjut usia Hipertensi di Wilayah kerja Puskesmas Mranggen, Demak, Tesis, UNDIP.

TKPI (Tabel Komposisi Pangan Indonesia), 2009. Mahmud, Mien K, *et al*. (Ed). Jakarta: Kompas Gramedia

Widiarti, A., 2013. Pengusahaan rebung bambu oleh masyarakat, studi kasus di kabupaten Demak dan Wonosobo, Jurnal penelitian hutan dan konservasi Alam, 10: 51-61.

Winarno, F.G., 1993. Pangan, Gizi, Teknologi dan Konsumen. PT Gramedia, Jakarta.

Zhang, Y., X. Tie, B. Bao, X. Wu and Y. Zhang, 2007. Metabolism of flavone C-glucosides and p-coumaric acid from antioxidant of bamboo leaves (AOB) in rats. Br. J. Nutr., 97: 484-494.