Effect of the Stems Lemongrass (*Cymbopogon citratus*) in Pallumara and Pepes Anchovy (Stolephorus Sp.) to Uric Acid Levels of Hyperuricemia Elderly Women

Diany Maulid[1], Burhanuddin Bahar[1], Saifuddin Sirajuddin[1]*, Veni Hadju[1], Citrakesumasari Citrakesumasari[1], Masni Masni[2]

[1]*Department of Nutrition, Faculty of Public Health, Hasanuddin University, Makassar, Indonesia;* [2]*Department of Biostatistics, Faculty of Public Health, Hasanuddin University, Makassar, Indonesia*

Abstract

BACKGROUND: Compliance with food-base dietary guidelines has been known delivered positive effect on nutrition and public health.

AIM: The aim of the study was to assess the effect of lemongrass stems in pallumara and anchovy pepes on changes in uric acid levels in elderly women in hyperuricemia.

METHODS: This research is a quasi-randomized pre-test-post-test control group design experiment. The study sample was elderly women with hyperuricemia who met the inclusion and exclusion criteria of 45 persons divided into two intervention groups and one control group. The first group was given lemongrass stems in pallumara anchovy, the second group was given lemongrass stems in anchovy pepes, and the control group only consumed family food. Data were analyzed using paired t test, one-way ANOVA, Chi-square, and Kruskal–Wallis.

RESULTS: The results showed that a significant change in uric acid levels in both intervention groups (p = 0.001 < 0.05), whereas the control group was not significant. There was a difference in changes in uric acid levels between the intervention group and the control group (p = 0.000 < 0.05).

CONCLUSION: It was concluded that the large difference in uric acid levels between the intervention group and the control group was 26.5% and 28.3%. It is recommended to use lemongrass in preventing elevated blood uric acid levels.

Introduction

The rate of development of the world's population, including Indonesia, is now heading toward an aging process, marked by an increasing number and proportion of elderly populations (residents aged 60 years and over) that have exceeded 7% [1]. Indonesia is among the top five countries with the largest number of elderly people in the world. The 2016 Susenas results showed an increase in the number of elderly people reaching 22.4 million people or 8.69% of the total population, while in 2018 the percentage of elderly people reached 9.27% or around 24.49 million people [2].

Various problems arise in line with the aging process, such as physical, psychological, social, economic, cultural, and health problems that can cause the condition of the elderly to be vulnerable to an illness. Hyperuricemia is an increase in uric acid levels above normal, in men above 7 mg/dl and in women above 6 mg/dl. The average level of uric acid in the blood depends on age and sex [3]. The prevalence of hyperuricemia continues to increase. In Taiwan the prevalence of hyperuricemia is 30.4%, in men (30.2%), and women (30.6%). This prevalence will increase significantly with age [4].

In Indonesia according to the World Health Organization in 2013, the prevalence of hyperuricemia was 81% [4]. While a study in North Halmahera also showed that the prevalence of hyperuricemia was high, namely, 60% (men 50.83% and women 69.17%) [5].

Risk factors associated with hyperuricemia include sex and increasing age, hypertension, obesity, smoking and increased serum triglycerides, type 2 diabetes, and alcohol consumption, hyperuricemia plays an important role in the occurrence of cardiovascular morbidity in the general population, hypertension, and type 2 diabetes mellitus [6], [7], [8].

Lemongrass (*Cymbopogon citratus* Stapf.) is a type of grass plant that contains 1–2% essential oils containing various active chemicals that are biologically functioning therapeutically [9], [10]. Lemongrass launched has antibacterial, antifungal properties. antiprotozoal, anti-carcinogenic, anti-inflammatory, antioxidant, cardioprotective, antitussive, antiseptic, and anti-rheumatic activity [11].

The antioxidant activity of lemongrass was analyzed by DPPH scavenging test and the highest inhibition was obtained with essential oils extracted from lemongrass stems (89.5%). The anti-gout test was examined through the xanthine oxidase inhibition (XOI) test with a maximum percentage of xanthine oxi XOI 81.34% obtained from essential oils on the lemongrass stalk [9], [12]. Pelleng research [13] showed a decrease in blood uric acid levels in male white Wistar rats fed with lemongrass herbal steeping.

Pallumara fish and Pepes fish are types of dishes that are favored by the community. Anchovy is a type of high-quality fish, contains a lot of protein and calcium, is very easy to obtain in the market, with a relatively cheap selling power [14]. Jeneponto Regency is one of the regencies in South Sulawesi Province that is currently still a disadvantaged region where the number of elderly people in this Regency continues to increase. In 2014, the number of the elderly was 8.78%, in 2016, it increased to 9.12% and, in 2017, it became 9.32%. In this region, we have encountered a lot of lemongrass plants, both in the garden land and in the yard of the house. Likewise, anchovies are easily obtained and become one of the types of fish that are widely consumed by Jeneponto residents.

Barana Health Center is one of the remote health centers in Jeneponto District where hyperuricemia cases were found to show an increase from 71 cases in 2017 to 122 in 2018. This study aims to assess the effect of lemongrass stems in anchovy anchovies and anchovy pepes on changes in uric acid levels in elderly women suffering from hyperuricemia.

Materials and Methods

This research was conducted in the working area of Barana Health Center, West Bangkala District, Jeneponto Regency, South Sulawesi. This type of research is a non-randomized pre-test-post-test control group design experiment.

The study population was all elderly women who suffer from hyperuricemia in the work area of Barks Puskesmas, Bangkala Barat District, and Jeneponto Regency. Samples amounted to 45 people who met the inclusion and exclusion criteria divided into three groups: Fifteen people in the intervention group who were given lemongrass stems in pallumara anchovy cooking, 15 people in the intervention group who were given lemongrass stems in anchovies pepes, and 15 people in the control group.

Characteristic data (age, disease history, occupation, and BMI) were obtained directly from respondents using questionnaire sheets and taking anthropometric measurements, while intake data

(energy, protein, and purines) were obtained using food record sheets. Data of uric acid levels pre- and post-test were obtained from the Prodia Makassar laboratory.

Food intake data were processed using Nutraclin software, while other determinant factor data (characteristic data and changes in uric acid levels) were processed using SPSS for windows 21.

To compare the results of examination of blood uric acid levels before and after the intervention, the paired t-test was used. For categorical scale characteristics data were analyzed using the Chi-square test. To compare the difference in changes in uric acid levels between groups, the one-way ANOVA test was used, and to find out which pair experienced different changes, further test analysis was performed using the *post hoc* Bonferroni test.

Results

Table 1 shows that the majority of respondents in each group were aged 60–69 years with a percentage of 86.7% in the lemongrass intervention group in anchovy pallumara cooking, 53.3% in the lemongrass intervention group in anchovy pepes cooking, and 66.7% in the control group.

Based on the history of the disease, Table 1 shows that the majority of respondents suffer from hypertension, in the lemongrass stem intervention group in pallumara anchovy cooking by 53.3%, the lemongrass intervention group in anchovies pepper cooking by 80%, and the control group in 46.7%.

Table 1 also shows that in the occupational variable, it is known that respondents generally work as farmers, 60% in the first intervention group, 80% in the second intervention group, and in the control group 46.7%. In the IMT variable, it can be seen that the majority of respondents are in the normal category, in the lemongrass stem intervention group in pallumara anchovy cooking by 53.3%, the lemongrass intervention group in anchovy pepes cuisine 60%, and the control group by 66.7%.

The uric acid levels in the pre-test in Table 1 showed that the mean uric acid levels of respondents in the lemongrass intervention group in anchovy pallumara cooking was 6.68 ± 0.32, the lemongrass intervention group in anchovy pepes 6.67 ± 0.33, and in the group control 6.92 ± 0.50. Statistical test results in Table 1 showed that there were no significant differences in all of the respondent's characteristic variables (p > 0.05), this meant that all the characteristics that were sampled as research samples were homogeneous. In other words, the results of the study are not the influence of the characteristics of the study sample.

Table 2 shows that the level of energy sufficiency in the lemongrass stem intervention group

in pallumara anchovy cooking (90.47%) and the lemongrass stem intervention group in anchovy pepes cooking (90.08%) was classified as good, while the control group was low (89.78%).

The level of protein adequacy in Table 2 shows, lemongrass stem intervention group in pallumara anchovy cooking 100.97%, lemongrass stem intervention group in anchovy pepes cooking 100.54%, and 98.78% control group, all groups were classified as good.

Likewise, with the adequacy level of purines, lemongrass stem intervention group in pallumara anchovy cooking is 116.36%, lemongrass stem intervention group in anchovy pepes cooking 111.12%, and control group 114.36%.

Through the Kruskal–Wallis test in Table 2 is known that the level of energy, protein, and purine adequacy did not differ significantly between the lemongrass intervention groups in pallumara anchovy cooking, lemongrass intervention groups in anchovy pepes cooking, and the control group with $p > 0.05$.

Table 3 shows in the group given lemongrass stems in anchovy pallumara cooking, a decrease in uric acid levels with an average decrease of 0.95 mg/dl or 31.6%, whereas in the group given lemongrass stems in anchovy pepes, there was a decrease in uric acid levels with an average decrease of 1.06 mg/dl (33.4%).

Statistical test results in Table 3 showed that the decrease in uric acid levels in both intervention groups was a significant change with a value of $p = 0.001 < 0.05$, in the control group found an increase in uric acid levels of 0.12 mg/dl (5.13%) and the change was not statistically significant ($p = 0.582 > 0.05$).

Then, the results of the analysis of the comparison of the differences in uric acid levels in each group in Table 3, where the uric acid levels in the pre-test did not differ significantly, on the contrary in the post-test the uric acid level was significantly different. For comparison of the large differences in changes in uric acid levels in each group was analyzed using the one-way ANOVA test which showed a significant difference ($p = 0.000 < 0.05$).

Further test analysis in Table 3 showed that the different groups were the groups that were given lemongrass stems in pallumara anchovy cooking with the control group ($p = 0.001 < 0.05$) with a large comparison percentage of change of 26.5% and between groups that were given lemongrass stems in pepes cooking anchovies with a control group ($p = 0.001 < 0.05$), with a large percentage change in change of 28.3%, while for the two intervention groups, the results of statistical tests showed no significant differences.

Based on the analysis results in Table 3, it can be said that there is an effect of providing lemongrass stems in pallumara anchovy and anchovy pepes cooking on changes in uric acid levels.

Table 1: Characteristics of research respondents

Characteristics of research respondents	Stems lemonggrass+Pallumara anchovy		Stems lemonggrass+Paepes anchovy		Control		p value
	n	%	n	%	n	%	
Age							0.391[a]
60–69 (years old)	13	86.7	8	53.3	10	66.7	
70–79 (years old)	2	13.3	7	46.7	5	33.3	
Disease history							0.570[b]
DM	4	26.7	0	0	5	33.3	
Hypertension	8	53.3	12	80	7	46.7	
There is no	3	20.0	3	20	3	20.0	
Work							0.808[b]
Housewife	5	33.3	3	20	7	46.7	
Farmers	9	60.0	12	80	7	46.7	
Trader	1	6.7	0	0	1	6.7	
BMI							0.515[b]
Stunting	3	20,0	3	20.0	2	13.3	
Normal	8	53.3	9	60.0	10	66.7	
Overweight	4	26.7	3	20.0	3	20.0	
Uric acid level							0.148[a]
Mean ± SD	6.68 ± 0.32		6.67 ± 0.33		6.92 ± 0.50		
Minimum–Maximum	6.2–7.1		6.1–7.2		6.2–8.1		

[a]One-way ANOVA test; [b]Chi-square; $P<0.05$.

Table 2: Energy, protein, and purine adequacy levels during the intervention

Intake	Mean ± SD						p value
	Stems lemonggrass+Pallumara anchovy		Stems lemonggrass+Paepes anchovy		Control		
	Mean intake	%	Mean intake	%	Mean intake	%	
Energy (cal)	1526.4 ± 148.98	90.47 ± 5.23	1445.5 ± 118.70	90.08 ± 3.52	1452.2 ± 126.58	89.78 ± 3.69	0.92*
Protein (g)	42.53 ± 3.12	100.97 ± 5.51	40.28 ± 3.21	100.54 ± 6.62	39.95 ± 3.83	98.78 ± 5.82	0.35*
Purine (mg)	202.33 ± 18.31	116.36 ± 10.53	193.25 ± 12.57	111.12 ± 7.22	198.89 ± 17.82	114.36 ± 10.26	0.35*

*Kruskal–Wallis; $P<0.05$.

Table 3: Changes in uric acid levels

Group	n	Mean ± SD Uric acid level (mg/dl)		p	%	Different couple	% Different couple
		Pre	Post				
Stems lemonggrass+Pallumara anchovy	15	6.68 ± 0.32	5.73 ± 0.86	0.001*	31.6	1.000[a,b]	1.8[a,b]
Stems lemonggrass+Paepes anchovy	15	6.67 ± 0.33	5.61 ± 0.84	0.001*	33.4	0.001[a,c]	26.5[a,c]
Control	15	6.93 ± 0.50	7.05 ± 0.92	0.582*	5.13	0.001[b,c]	28.3[b,c]
p value		0.210**	0.000**				0.837[a,b***]

*Paired t-test; **One-way ANOVA; Different couple *post hoc* test – Bonferroni. ***t independent; $P<0.05$. Source: Primary data, 2019.

Discussion

The statistical test results in this study show that the decrease in uric acid levels after the intervention is not the influence of the respondent's characteristic variables.

One of the risk factors for hyperuricemia is age and sex in which various research results indicate that the age range that is usually at risk of developing gout is 30–50 years in men, whereas in women it increases after entering menopause. This is consistent with the results of research showing that the incidence of gout arthritis is more experienced by women as much as 45.2% (42 people) because the majority of the age of respondents in this study is >50 years [15].

Obesity and body mass index contribute significantly to the risk of gouty arthritis where the risk is very low for men with a body mass index between 21 and 22 but is tripled for men who have a body mass index of 35 or greater [16]. Diabetes mellitus will lead to insulin resistance; as a result glucose will accumulate in the bloodstream and disrupt blood circulation, which will make the kidneys work more slowly and inefficiently when releasing waste or uric acid into the urine so that the kidney is difficult to remove excess uric acid from the body [15].

The relationship between gout and hypertension has been described since the early 1960s. It was found that hyperuricemia, in some populations, stimulates the onset of hypertension through the formation of an inflammatory cascade, in which endothelial dysfunction occurs, smooth muscle proliferation, and renal afferent artery arteriosclerosis. In addition, hypertension is a comorbid gout which affects more than 74% of patients with gouty arthritis [17].

Protein especially derived from animals can increase uric acid levels in the blood. Food sources contain animal protein in high amounts such as liver, kidney, brain, and spleen. Recommended protein intake is 50–70 g/day or 0.8–1 g/kg body weight/day. The recommended source of protein is vegetable protein derived from milk, cheese, and eggs [17].

High protein diets usually contribute to an increase in purine intake which is associated with hyperuricemia. Based on the description of the adequacy of purine intake, subjects consume purines <400 mg/day, so the daily purine consumption of most subjects tends to be low [18].

The results of this study are similar to the results of Hastuti *et al*. [18] which showed that there was no relationship between total protein intake and uric acid levels (p ≥ 0.05). This shows that the decrease in uric acid levels in the intervention group was not influenced by protein and purine intake. In this study, the results of analysis of changes in uric acid levels after the intervention showed that there was an effect of lemongrass stems in pallumara anchovy and anchovy pepes cooking on changes in uric acid levels.

The results of this study are in line with the results of a study that showed that lemongrass can reduce uric acid levels. Increasing the dose of lemongrass is also directly proportional to the decrease in uric acid levels, which means that the more doses used, the active substances contained in lemongrass will be more effective in reducing uric acid levels [13]. Lemongrass (*C. citratus*) is a plant commonly used as a spice by people in Indonesia, in tropical countries, especially in Southeast Asia [11]. This plant contains 1–2% of the dried essential oil with a very wide variation in chemical composition [9]. The oil is a yellow liquid containing about 75–85% of aldehydes [11].

Boukhatem *et al*. [19] revealed 23 compounds from essential oils of lemon grass whereas in other studies showed the chemical composition of essential oils from searai stems consisting of 68 compounds, while the chemical composition of essential oils from lemongrass leaves consisted of 72 compounds. GCMS analysis results are geranial (32.10% and 29.64%), Neral (22.36% and 21.73%), geraniol (5.40% and 7.75%), limonene (5.71% and 5.92%), and β-myrcene (2.20% and 2.28%), where the essential oil content of lemongrass stems is 67.77% and in lemongrass leaves is 67.33% [12], [20].

In addition, *C. citratus* is also reported to contain flavonoids and phenolic compounds, which consist of luteolin, isoorientin 2'-O-rhamnoside, quercetin, kaempferol, and apigenin [11], [21]. It contains alkaloids, saponins, tannins, anthraquinones, steroids, and phenols. Wherein, the ethanol extract of lemongrass contains 535.44–1007.35 mg/100 g phenolic total and has antioxidant activity of 80.38–93.31% [22].

Various studies have been conducted regarding the antioxidant activity of lemongrass, a study showed that infusions and decoctions made from lemongrass showed antioxidant properties by cleaning superoxide anions, inhibiting lipoperoxidation, and DPPH decolorization. This effect is higher in infusion than stew [23] likewise, lemongrass infusion showed stronger antioxidant activity in relation to other extracts (methanol, 80% ethanol, and water stew) [23].

The antioxidant activity of lemongrass analyzed by DPPH scavenging test showed that the highest inhibition was obtained with essential oils extracted from lemongrass stems (89.5%), and the anti-gout test was examined through the XOI test with a maximum percentage of xanthine oxi XOI 81.34% obtained from essential oils in the lemongrass stalk [9], [12].

These results are in line with the results of research by Anggraeni *et al*. [24] which shows that essential oils extracted from lemongrass stems have antioxidant activity with inhibition of up to 809 ppm at a ratio of 1:2 for the concentration of volatile oil volume per volume of solvent. Similar research also

shows that the β myrcene content in lemongrass has antigout properties [23] and kaempferol compounds are anti-inflammatory [25], it was also reported that the inhibitory activity of essential oils will decrease when the concentration of essential oils decreases [26].

Xanthine oxidase is a source of oxygen free radicals. In the reperfusion phase (i.e., reoxygenation), xanthine oxidase reacts with oxygen molecules, and releasing superoxide free radicals. Two types of flavonoids, quercetin and silibin, can inhibit the activity of xanthine oxidase, resulting in decreased oxidative injury [27]. Flavonoids are secondary metabolites that have potential as XOI and have similar structures with xanthine. This is due to the presence of two aromatic rings that have hydroxyl groups as electron acceptors of the xanthine oxidase enzyme [28].

The structure of flavonoids generally consists of three benzene rings. Where the C atom in the structure has a double bond, so it easily binds to the xanthine oxidase enzyme which causes that the formation of xanthine is reduced and the production of uric acid is reduced [29]. Flavonoids inhibit xanthine oxidase enzyme activity through interactions with enzymes in side groups and competitive inhibition mechanisms. With the increase of XOI, it shows that the production of uric acid will be lower so that this condition will reduce the risk of developing gout [30], [31], [32]. Thus, citronella essential oil has high potential to be an alternative source of antigout medication because it contains a potential compound of XOI [12].

Recommendation

It is recommended to use lemongrass in preventing elevated blood uric acid levels.

References

1. Andini NK, Nilakusmawati DP, Susilawati M. Faktor-faktor yang mempengaruhi penduduk lanjut usia masih bekerja. J Piramida. 2013;9(1):44-9. https://doi.org/10.21776/ub.jiae.2009.003.02.6

2. Badan Pusat Statistik. Statistik Penduduk Lanjut Usia 2016. Jakarta: Badan Pusat Statistik; 2018.

3. Kurnia. Solusi Tepat Brantas Asam Urat, Edisi Kedua. Yogyakarta: Cemerlang Publishing; 2009.

4. Yu Q, Shen H, Hu Y, Chen Y, Tung T. Prevalence and metabolic factors of hyperuricemia in an elderly agricultural and fishing population in Taiwan. J Arch Rheumatol. 2017;32(2):149-57. https://doi.org/10.5606/archrheumatol.2017.6075

5. Jaliana J, Suhadi S, Sety LO. Faktor-faktor yang berhubungan dengan kejadian asam urat pada usia 20-44 tahun Di RSUD bahteramas provinsi sulawesi tenggara tahun 2017. J Ilmiah Mahasiswa Kesehatan Masyarakat. 2017;3(2):1-13. https://doi.org/10.37887/jimkesmas.v5i1.12361

6. Boleu FI, Mangimbulude JC, Karwu FF. Hyperurisemia dan hubungan antara asam urat darah dengan gula darah sewaktu dan IMT pada komunitas etnik asli di halmahera utara. J Ilmu Kesehatan Masyarakat. 2018;9(2):96-106. https://doi.org/10.26553/jikm.2018.9.2.96-106

7. Ewenighi C, Uchechukwu D, Uchechukwu E, Joel O, Linus O, Babatunde A, *et al*. Prevalence of hyperuricemia and its risk factors in healthy male adults from abakaliki metropolis. Niger J Mol Pathophysiol. 2015;4(3):94-8. https://doi.org/10.5455/jmp.20150915011842

8. Djafri D, Monalisa FE, Machmud R. Efek modifikasi faktor risiko modifiable penyakit jantung koroner: A hospital-based matched case control study. J Kesehatan Masyarakat Andalas. 2016;11(2):93-9. https://doi.org/10.24893/jkma.11.2.93-99.2017

9. Lawrence R, Lawrence K, Srivastava R, Gupta D. Antioxidant activity of lemongrass essential oil (*Cympopogon citratus*) grown in North Indian plains. J Sci Temper. 2015;4:23-9.

10. Promila P, Madan VK. A review on the phytochemistry and pharmacology of *Cymbopogon citratus* Stapf (Lemongrass). Pharm Innov J. 2018;7(3):300-4.

11. Hasim, Falah S, Ayunda RD, Faridah DN. Potential of lemongrass leaves extract (*Cymbopogon citratus*) as prevention for oil oxidation. J Chem Pharm Res. 2015;7(10):55-60.

12. Mirghani ME, Liyana Y, Parveen J. Bioactivity analysis of lemongrass (*Cymbopogan citratus*) essential oil. Int Food Res J. 2012;19(2):569-75.

13. Pelleng MY. Efektivitas Seduhan Herbal Serai (*Cymbopogon citratus*) Terhadap Kadar Asam Urat Darah Tikus Putih (*Rattus norvegicus*) Jantan Galur Wistar Yang Diinduksi Streptozotocin (Stz) (Disertasi). Yogyakarta: Politeknik Kesehatan Kementerian Kesehatan; 2019. https://doi.org/10.22219/sm.v9i2.4133

14. Aryati E, Dharmayanti AW. Manfaat ikan Teri segar *(Stolephorus* Sp) terhadap pertumbuhan tulang dan gigi. J Odonto Dent. 2014;1(2):52-6. https://doi.org/10.30659/odj.1.2.52-56

15. Anggriani E, Dewi AP, Novayelinda R. Faktor-faktor yang berhubungan dengan kejadian gout arthritis masyarakat melayu. J Jom Fkp. 2018;5(2):683-92. https://doi.org/10.36729/jam.v4i3.202

16. Widyanto FW. Artritis gout dan perkembangannya. J Kesehatan. 2014;10(2):145-52. https://doi.org/10.22219/sm.v10i2.4182

17. Sholihah FM. Diagnosis and treatment gout arthritis. J Majority. 2014;3(7):39-45.

18. Hastuti VN, Murbawani EA, Wijayanti HS. Hubungan asupan protein total dan protein kedelai terhadap kadar asam urat dalam darah wanita menopause. J Nutr Coll. 2018;7(2):54-60. https://doi.org/10.14710/jnc.v7i2.20823

19. Boukhatem MN, Ferhat MA, Kameli A, Saidi F, Kebir HT. Lemongrass (*Cymbopogon citratus*) essential oil as a potent anti-inflammatory and antifungal drugs. Libyan J Med. 2014;9(1):25-31. https://doi.org/10.3402/ljm.v9.25431

20. Jumepaeng T, Prachakool S, Luthria DL, Chanthai S. Determination of antioxidant capacity and α-amylase inhibitory activity of the essential oils from citronella grass and lemongrass. Int Food Res J. 2013;20(1):481-5.

21. Shah G, Shri R, Panchal V, Sharma N, Singh B, Mann AS. Scientific basis for the therapeutic use of *Cymbopogon citratus*, Stapf (Lemongrass). J Adv Pharm Technol Res. 2011;2(1):3-8. https://doi.org/10.4103/2231-4040.79796

22. Sari DM, Lestarisa T, Alexandra FD, Jelita H, Thalib I. Antioxidant and anti-glycation activity of ethanol lemongrass (*Cymbopogon citratus*) leaves extract. Int J Pharmacogn Phytochem Res. 2017;9(5):710-715. https://doi.org/10.25258/phyto.v9i5.8153

23. Olorunnisola SK, Asiyanbi HT, Hammed AM, Simsek S. Biological properties of lemongrass. Int Food Res J. 2013;21(2):455-62.

24. Anggraeni NI, Hidayat IW, Rachman SD, Ersanda. Bioactivity

of Essential Oil from Lemongrass (*Cymbopogon citratus* Stapf) as Antioxidant Agent. In: AIP Conference Proceedings; 2018 Feb 09. Jakarta: AIP Publishing; 2018. https://doi.org/10.1063/1.5021200

25. Miean KH, Mohamed S. Flavonoid (myricetin, quercetin, kaempferol, luteolin, and apigenin) content of edible tropical plants. J Agric Food Chem. 2000;49(6):3106-12. https://doi.org/10.1021/jf000892m

26. Sukriti D, Munda S, Lal M, Bhattacharyya PR. A short review on chemical composition therapeutic use and enzyme inhibition activities of *Cymbopogon* species. Indian J Sci Technol. 2016;9(46):1-9. https://doi.org/10.17485/ijst/2016/v9i46/87046

27. Nijveldt RJ, Nood E, Hoorn DE, Boelens PG, Norren K, Leeuwen PA. Flavonoids: A review of probable mechanisms of action and potential applications. Am J Clin Nutr. 2001;74(4):418-25. https://doi.org/10.1093/ajcn/74.4.418 PMid:11566638

28. Wulandari S, Subandi, Muntholib D. Inhibisi Xantin Oksidase Oleh Ekstrak Etanol Kulit Melinjo (*Gnetum gnemon*) Relatif Terhadap Allopurinol (Skripsi). Malang: Universitas Negeri Malang; 2013.

29. Setianingrum PD, Kusumaningrum ID, Rini DK. Pemberian air rebusan daun salam (*Syzygium polyanthum*) terhadap penurunan kadar asam urat pada penderita asam urat di dusun kadisoro desa gilangharjo Kecamatan Pandak Kabupaten Bantul DIY tahun 2017. J Kesehatan Ed Khusus. 2019;1:12-23. https://doi.org/10.22216/jit.2018.v12i3.430

30. Mallongi A, Syamsuar S, Natsir MF, Astuti RD, Rauf AU, Rachmat M, Muhithd A. Potential ecological risks of mercury contamination along communities area in tonasa cement industry Pangkep, Indonesia. Enferm Clín. 2020;30(4):119-22. https://doi.org/10.1016/j.enfcli.2019.10.054

31. Mallongi A, Limbong E, Naiem F, Ishak H, Basri S, Saleh M, *et al*. Health risk analysis of exposure to mercury (Hg) and cyanide (CN) in Kayeli village communities Teluk Kayeli district Buru regency. Enferm Clín. 2020;30(4):427-30. https://doi.org/10.1016/j.enfcli.2020.03.007

32. Aprilita R, Rahayu ST, Syachfitri RD. Uji aktivitas penghambatan xantin oksidase secara *in-vitr*o Oleh Isolat 6,4'-dihidroksi-4-metoksibenzofenon-2-O–B-D glukopiranosida (C20H22O10) yang diisolasi dari mahkota dewa *(Phaleria macrocarp*a (Scheff.) Boerl). J Pharm Sci Res. 2016;3(1):1-11. https://doi.org/10.7454/psr.v3i1.3213