Trad. Med. J., January – April 2019
Vol. 24(1), p 52-58
ISSN-p : 1410-5918 ISSN-e : 2406-9086

Submitted : 15-02-2019
Revised : 04-04-2019
Accepted : 10-04-2019

Potency of Black Soybean (*Glycine max* (L.) Merr) Extract and Daidzein as Antioxidant and Antihyaluronidase

Tandiah Asan[1], I Nyoman E. Lister[1*], Edy Fachrial[1], Annisa Amalia[2], Wahyu Widowati[3], Buter Samin[1], Liena Liena[1]

[1]Master in Biomedical Sciences Faculty of Medicine, Universitas Prima Indonesia, Medan, North Sumatera
[2]Aretha Medika Utama, Biomolecular and Biomedical Research Center, Bandung, West Java
[3]Faculty of Medicine, Maranatha Christian University, Bandung, West Java

ABSTRACT

Black soybean (*Glycine max* (L.) Merr.) is a plant that is widely planted and consumed in Indonesia. In addition, black soybean has unique content of isoflavones, such as *daidzein*, which is one of the active compounds that have the effect of fighting free radicals and can inhibit the aging process. The purpose of this study is to analyze the antioxidant potency possessed by black soybean extract (BSE) and daidzeinin inhibiting aging of the skin. The method used is a colorimetric test. The type of antioxidant test used is H_2O_2 scavenging and inhibiting the activity of the hyaluronidase enzyme for *antiaging*. BSE has better effectiveness of H_2O_2 scavenging (IC_{50}: 286.24±11.16 (µg/mL)) than daidzein compound (IC_{50}: 366.16±2.54 (µg/mL)). In the inhibition of hyaluronidase enzyme, the daidzein has more effective activities (IC_{50}: 95.80±3.98 (µg/mL)) compared to BSE (IC_{50}: 152.56±13.98 (µg/mL)). The antioxidant and anti-aging activities possessed by BSE make it possible to be used as a cosmetic ingredient for skin aging therapy.
Keywords: Antioxidant, antiaging, *Glycine max* (L.), Hyaluronidase, H_2O_2 scavenging

INTRODUCTION

People who live in the modern era such as the present day have a very high desire to treat skin health so they could look young. This has triggered the cosmeceutical industry where cosmetics are one of the products used to treat skin health. The high demand in skin health care has increased research on ingredients to inhibit skin aging which are effective for use in cosmetic ingredients. Cosmetic chemicals used often have a harmful effect on health. Thus, natural ingredients are needed to overcome the adverse effects of the use of cosmetic chemicals and skin care (Jadhav, Dhande, & Kadam, 2016).

Aging of the skin is influenced by various intrinsic and extrinsic factors such as the sun exposure, lifestyle, smoking, genetic, and hormone that are not stable. Ultraviolet rays of the sun are a major factor causing skin aging or commonly called photoaging (Garg, Khurana, & Garg, 2017; Widowati et al., 2018). The extracellular matrix of the skin consists of collagen, elastin and hyaluronic acid to maintain skin moisture and elasticity. The formation of free radicals by ultraviolet light such as Reactive Oxygen Species and oxidative stress affects the enzymes that work in maintaining the balance of the skin, one of which is the enzyme hyaluronidase (Ndlovu, Fouche, Tselanyane, Cordier, & Steenkamp, 2013; Widowati et al., 2018).

***Corresponding author : I Nyoman E. Lister**
Email : yysunpri@gmail.com

Under normal circumstances, this enzyme works as a binding site for collagen and elastin. A variety of free radicals and oxidative stress causes an increase in the activity of the hyaluronidase enzyme, causing signs of aging such as wrinkles on the skin. Because of this, antioxidants are needed which play a role in inhibiting the aging process (Ndlovu *et al.,* 2013; Widowati *et al.,* 2016).

Antioxidants are responsible for reducing damage caused by free radicals to avoid damage at the cellular level. Antioxidants also help to inhibit inflammation and provide protection against damage to photoaging and skin cancer. Topical application of sunscreen does not provide complete protection against ultraviolet light damage, while antioxidants play a major role in the prevention and treatment of ultraviolet-induced skin aging and the addition of formulations for sun protection (Ramos-e-Silva, Celem, Ramos-e-Silva, & Fucci-da-Costa, 2013).

Black soybeans are plants that are widely planted and consumed by Indonesian people. Black soybean seeds have various bioactive ingredients including isoflavones, phenols, flavonoids, saponins, and phytosterols (Alghamdi et al., 2018; Gupta, 2017; Zhou, Cai, & Xu, 2017). Isoflavones are secondary metabolites which are mostly found in these nuts, such as genistein and daidzein. These compounds have antioxidant activity that is able to fight free radicals and also acts as an anti-inflammatory, anti-viral, and anti-microbial (D Sumardi *et al.,* 2017; Wójciak-Kosior *et al.,* 2016).

Hence, in this study, it is needed to reveal the antioxidant and antiaging potential possessed by black soybeans using H_2O_2 scavenging assay and inhibition of hyaluronidase as antiaging test.

METHODOLOGY

Materials

Black soybeans were obtained from Unit Pengelolaan Benih Sumber (UPBS) Balai Penelitian Tanaman Aneka Kacang dan Umbi, Malang, East Java, Daidzein (Chengdu Biopurify, BP0445), *Ferrous Ammonium Sulfate* (Sigma 7783859), DMSO (Merck 1.02952.1000), H_2O_2 (Merck 1.08597.1000), 1,10-*phenanthroline* (Sigma 131377), *Sodium phosphate monobasic* (Merck 567545), *Hyaluronic acid* (Sigma H5542), *Hyaluronidase from bovine testes type I-S* (Sigma H3506), *Sodium chloride* (Merck 1064040500), *Bovine Serum Albumin* or BSA (Sigma A4503), *Sodium Acetate* (Merck 1062681000), *Acetic Acid* (Merck 100063), *Hydrochloride acid solution* (Merck 109057), *Sodium hydroxide* (Merck 106498), aquades.

Preparation of Black Soybean Extract (BSE)

A total of 250g of dried black soy bean was milled and stored to the maserator for extraction. The solvent used was ethanol 70%. The filtrate was collected every 24 hours and ethanol was added until the resulting filtrate was colorless. The filtrate was then evaporated using a *rotary evaporator* at 50 ° C until a paste extract was formed. The extract from black soybeans was then stored at -20 ° C (Widowati et al., 2018, 2016, 2017).

H_2O_2 Scavenging Assay

60 µL black soybean extract and daidzein in various concentration was added to well test and in well blanks in 96-well plate (TPP 92096). Furthermore,12 µL of *Ferrous Ammonium Sulfate* (1 mM) was added to the well control and sample wells. 63 µL DMSO was added in the well control and 90 µL in the well blank, followed by 3 µL of H_2O_2 (5 mM) to the well sample. Then, after adding H_2O_2 mixed solution of the controls, samples and blanks into *96-well plates*, itwas then incubated for 5 minutes in a dark room at RT. Then each mixture of sample and blank was added 75 µL of 1,10-*phenanthroline*, then incubated again for 10 minutes in a dark room with room temperature. Absorbance was measured at 510 nm using spectrophotometer *Multiskan Go Reader* (Thermo Fisher Scientific 1510).

$$\%\ H_2O_2\ \text{scavengingActivity} = \text{Absorbance Sample/Absorbance Control} \times 100$$

Hyaluronidase Inhibition Assay

Inhibition of hyaluronidase enzyme activity was measured based on the method described by Sigma Aldrich and (Tu & Tawata, 2015), with slight modifications (Widowati et al., 2018, 2016, 2017). A mixture of solutions consisted of 25 µL samples (0.78 - 50 µg / mL), 3 µL enzyme *hyaluronidase from IS type bovine testes* (0.02 mg / mL) and 12 µL phosphate buffer (300 mM of NaH_2PO_4 pH5.35 adjusted with HCl and NaOH), then incubated at 37 ° C for 10 minutes. In addition, it was also prepared for controls containing only 3 µL enzymes and 37 µL phosphate buffers and blanks containing only 15 µL phosphate buffers and 25 µL samples. Furthermore, a mixture of 10 µL of *hyaluronic acid* as a substrate was added and re-incubated at 37 ° C for 45 minutes. The stop solution in the form of *acid albumin,* contains 0.1% BSA, *Sodium Acetate* 24 mM and *Acetic Acid* 79 mM, was added as much as 100 µL into the solution and left at RT for 10 min. Absorbance was measured at 600 nm using *Multiskan Go Reader* (Thermo Fisher Scientific 1510).

$$\%\ \text{Hyaluronidase inhibition activity} = (C-S)/C \times 100$$

C : absorbance of enzyme activity without sample;
S : absorbance of enzyme activity with the addition of the tested sample

Data analysis

The results in group were analyzed using the SPSS program with One-Way test and followed by Post Hoc Test with Tukey HSD test to see significances among concentration in group. The significances between BSE and Daidzein activities were also analyzed using Mann-Whitney U Test with significance level is 0.05. The test results of H_2O_2 scavenging activity and antihyaluronidase were continued by determining the inhibition concentration 50 (IC_{50}) value.

RESULTS AND DISCUSSION

Human skin aging is one of the complex biological processes. Aging on the skin can be caused by two factors, namely internal and external. Internal factors are impact of aging on the skin caused by a person's genetic changes that cause disruption of physiology, metabolism and cell reproduction (Kenyon, 2010). Unlike internal factors, the causes of external skin aging or from outside the body are usually caused by UV radiation or called *photoaging*.

UV radiation is absorbed directly by the skin, causing an increase of *Reactive Oxygen Species*

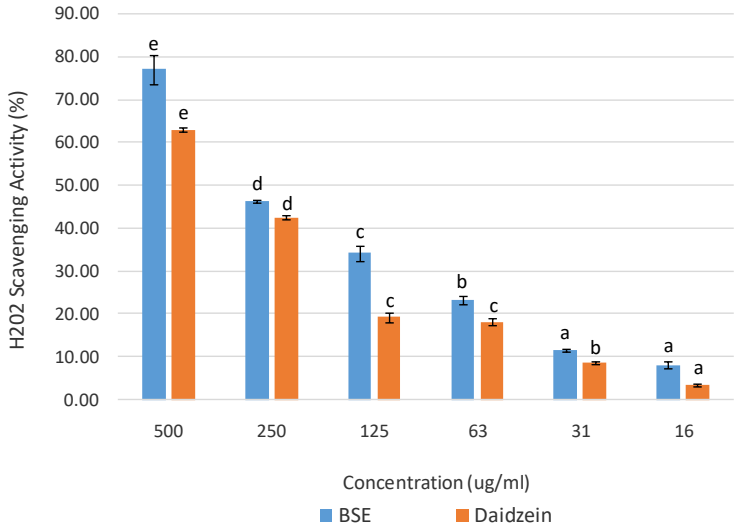

Figure 1. Effect Concentrations of BSE and Daidzein toward H_2O_2 Scavenging Activity. Each value is expressed as the mean ± SD of triplicate determinations. Statistical analysis was performed using one-way ANOVA ($p<0.05$). Different letters (a, b, c, d, e, f) above the bars in the same group show significant differences at the 0.05 significance level, based on the Tukey HSD Post Hoc Test.

Table I. The IC_{50} Value of H_2O_2 Scavenging Activity of BSE and Daidzein

Sample	Linear Equation	R2	IC_{50} (µg/mL)	IC_{50} (µg/mL)
BSE	Y = 0.1425x + 11.045	0.97	273.37	286.24 ± 11.16
	Y = 0.1323x + 11.345	0.95	292.18	
	Y = 0.1334x + 10.891	0.97	293.17	
	Y = 0.1361x + 11.094	0.97	285.86	
Daidzein	Y = 0.1182x + 6.5597	0.96	367.62	366.16 ± 2.54
	Y = 0.1205x + 5.7014	0.96	367.62	
	Y = 0.1196x + 6.5574	0.96	363.23	
	Y = 0.1194x + 6.2728	0.96	367.52	

(ROS) which results in oxidative stress in cells and damages the cell membrane, damage to mitochondria and DNA. In addition, ROS also plays a very important role in the aging process (Wlaschek *et al.,* 2001). ROS or free radicals has unpaired electrons in their outer orbitals (Clarkson & Thompson, 2000). UV radiation increases ROS results in damage to the formation of collagen fibers. Collagen is an important molecule in the formation of the skin (Mukherjee, Maity, Nema, & Sarkar, 2011).

ROS caused by UV radiation is very dangerous for body. It is needed compounds to balance ROS in the body. Antioxidants are an important compound that can protect damage caused by oxidative stress (Mahdi-Pour, Jothy, Latha, Chen, & Sasidharan, 2012). Antioxidants work by donating one electron, this can balance the ROS that has free electrons outside their orbit.

The hydrogen peroxide (H_2O_2) scavenging activity was measured by the reaction method of ferrous ammonium sulphate and phenanthroline with a little modification. Ferrous ammonium sulphate was reacted with phenanthroline, forming Fe^{2+}-tri-phenanthroline complex (orange in color), the existence of H_2O_2 in the reaction will not form orange complex (Mukhopadhyay *et al.,* 2016). H_2O_2 scavenging activity from BSE and daidzein (Figure 1)

At the highest concentration 500 µg/mL, BSE showed higher H_2O_2 scavenging activity (76.94 %) compared to Daidzein (62.92 %) (Figure 1). Based on (Table I), BSE suggested smaller IC_{50} value (286.24 ± 11.16µg/mL) than daidzein (366.16 ± 2.54µg/mL), implicating BSE had better antioxidant activity than daidzein. Nevertheless, there is no significant difference between BSE and daidzein at scavenging H_2O_2.

Hyaluronidase is a group of proteases that function in the degradation of hyaluronic acid (HA), one of the extracellular matrix constituents (ECM), by catalyzing hyaluronic hydrolysis

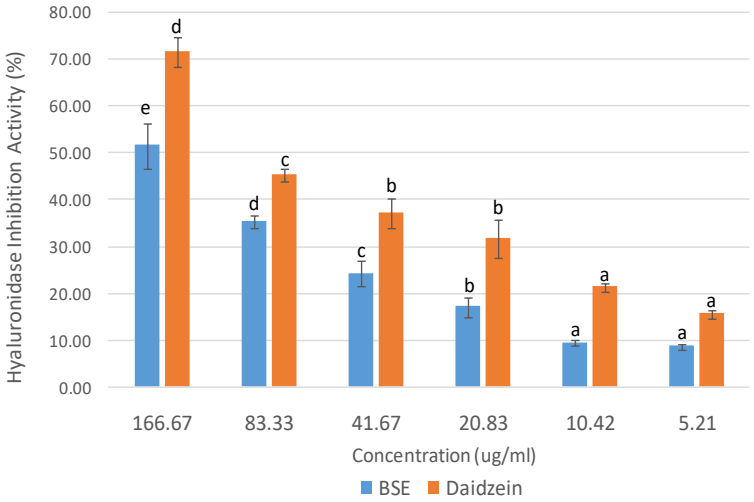

Figure 2. Effect Concentrations of BSE and Daidzein toward H_2O_2 Scavenging Activity. Each value is expressed as the mean ± SD of triplicate determinations. Statistical analysis was performed using one-way ANOVA ($p<0.05$). Different letters (a, b, c, d, e) above the bars in the same group show significant differences at the 0.05 significance level, based on the Tukey HSD Post Hoc Test.

Table II. The IC_{50} Value of Hyaluronidase Inhibition Activity of BSE and Daidzein

Sample	Linear Equation	R2	IC_{50} (µg/mL)	IC_{50} (µg/mL)
BSE	Y = 0.2651x + 9.7338	0.97	151.89	152.56 ± 13.98
	Y = 0.2405x + 9.8709	0.94	166.86	
	Y = 0.2873x + 10.087	0.96	138.92	
	Y = 0.2643x + 9.8972	0.96	151.73	
Daidzein	Y = 0.3283x + 19.570	0.96	92.69	95.80 ± 3.98
	Y = 0.3235x + 19.457	0.93	94.41	
	Y = 0.2956x + 20.355	0.94	100.29	
	Y = 0.315x + 19.79	0.96	95.65	

reactions. Hyaluronidase decreases hyaluronan viscosity thereby increasing ECM and tissue permeability (Widowati *et al.,* 2018, 2016, 2017).

This study showed that at highest concentration (166.67 µg/mL), daidzein had (71.44 ± 3.13%) better inhibition activity than BSE (51.50 ± 4.75%), performing daidzein had stronger ability than BSE to inhibit hyaluronidase enzyme (Fig. 2). BSE had higher IC_{50} value (152.56 ± 13.98 µg/mL) than daidzein (95.80 ± 3.98 µg/mL), suggesting that daidzein showed more effective inhibitory activity of hyaluronidase enzyme compared to BSE (Table II).

The antioxidant activity of black soybeans and daidzein compound was proven by activity tests using the H_2O_2 scavenging activity. Hydrogen peroxide (H_2O_2) is an important compound in the body because it has the ability to penetrate into cell membranes. However, excess hydrogen peroxide in the body can be toxic because it can increase hydroxyl radicals in cells(Gülçin, Huyut, Elmastaş, & Aboul-Enein, 2010). Hydroxyl radicals are *Reactive Oxygen Species* (ROS) which can cause some damage to cells (Pavithra & Vadivukkarasi, 2015).

BSE had better antioxidant acivity than daidzein which can be seen from the concentration of IC_{50} value. This was presumably because BSE was a *crude extract* which still allowed the potential of other compounds while daidzein is a pure compound. Research conducted by showed that 70% ethanol extract from BSE was able to reduce ABTS as free radicals, showing that BSE had a high antioxidant potential (Prvulović, Malenčić, & Miladinović, 2017).

Even though BSE has better antioxidant activity than daidzein and daidzein has better antihyaluronidase activity than BSE, there is no significance activity between the groups. According to Mann-Whitney U Test, significant level between BSE and daidzein is 0.080 (the significance level of the test is 0.05). Meanwhile, significance level in inihibition of hyaluronidase activity is 0.314 which shows insignificance. It meant that BSE possessed antioxidant and antihyaluronidase activity as well as daidzein, one

of the strongest compound that has antioxidant ability in black soy bean.

The presence of antioxidant activity through H_2O_2 scavenging activity of BSE and daidzein compound had the potential as an aging inhibitor. Aging of the skin is associated with loss of moisture in the skin. Important molecules play a role in the moisture in the skin including glycosaminoglycan, hyaluronic acid and water (Baumann, 2007). Hyaluronic acid is the main molecule in extracellular matrix preparation. The main function of hyaluronic acid is to repair damage that occurs to the skin. Degradation of the extracellular matrix is directly related to enzymes that play a role in skin aging (Longo, 2003; Makrantonaki et al., 2012).

Enzymes playing a role in degrading hyaluronic acid is hyaluronidase. The *antiaging* activity of BSE and daidzein compound was proven by the hyaluronidase inhibition test. The results showed that the two treatments had the ability to inhibit the hyaluronidase enzyme. The daidzein compound had better potential compared to the black soybean extract in inhibiting the activity of hyaluronidase enzymes. Isoflavones were included in phenolic compounds that have antioxidant activity and the most secondary metabolites produced by plants. In addition, isoflavone compounds are important for human health (Kim et al., 2006).

Black soybean (*Glycine max* (L.) Merr.) has two aglicans namely daidzein and genistein compounds and also has two glucosides namely daidzein and genistin (Silva et al., 2013). Daidzein is a natural antioxidant that has two mechanisms to inhibit free radicals. First, in the membrane liposomes, daidzein inhibits lipid oxidation by directly capturing free radicals (Liang et al., 2008). Both mechanisms of antioxidants indirectly by increasing the activity of antioxidant enzymes (Kampkötter et al., 2008).

CONCLUSION

Black soybean extract can be used as an alternative aging therapy material because it contains phenolic compounds such as daidzein which functions as an antioxidant. This is supported by the results of the antioxidant activity test and the inhibition test of the hyaluronidase enzyme which is owned by BSE and daidzein compounds. The lack of side effects from BSE makes this extract and comparative compound as an alternative ingredient in making cosmetics.

ACKNOWLEDGMENTS

This research was supported by Biomolecular and Biomedical Research Center, Aretha Medika Utama, Bandung, Indonesia. We thank to Rizal Rizal, Fajar Sukma Perdana, Zakiyatul Khoiriyah, Rismawati Laila Q, Ni Luh Wisma Ekayanti, Satrio Haryo B, Ubaydillah Munshy from Biomolecular and Biomedical Research Center, Aretha Medika Utama for their technical support.

REFERENCES

Alghamdi, S., Migdadi, H., Khan, M., El-Harty, E. H., Ammar, M., Farooq, M., & Afzal, M. (2018). Phytochemical Profiling of Soybean (Glycine max (L.) Merr.) Genotypes Using GC-MS Analysis. In *Phytochemicals - Source of Antioxidants and Role in Disease Prevention*. InTech. https://doi.org/10.5772/intechopen.78035

Baumann, L. (2007). Skin ageing and its treatment. *The Journal of Pathology*, *211*(2), 241–251. https://doi.org/10.1002/path.2098

Clarkson, P. M., & Thompson, H. S. (2000). Antioxidants: what role do they play in physical activity and health? *The American Journal of Clinical Nutrition*, *72*(2), 637S–646S. https://doi.org/10.1093/ajcn/72.2.637S

D Sumardi, Pancoro, A., Yulia, E., Musfiroh, I., Prasetiyono, J., Karuniawan, A., & Syamsudin, T. S. (2017). Potential of local black soybean as a source of the isoflavones daidzein and genistein. *International Food Research Journal*, *24*(5), 2140–2145.

Garg, C., Khurana, P., & Garg, M. (2017). Molecular mechanisms of skin photoaging and plant inhibitors. *International Journal of Green Pharmacy*, *11*(2), 217–219.

Gülçin, İ., Huyut, Z., Elmastaş, M., & Aboul-Enein, H. Y. (2010). Radical scavenging and antioxidant activity of tannic acid. *Arabian Journal of Chemistry*, *3*(1), 43–53. https://doi.org/10.1016/j.arabjc.2009.12.008

Gupta, R. (2017). Soybean seed: A treasure trove of bioactive compounds. *Journal of Microbiology and Biotechnology Reports*, *1*(1), 5.

Jadhav, V., Dhande, S., & Kadam, V. (2016). Cosmetic Sides Effect. *World Journal of Pharmacy and Pharmaceutical Sciences*, *6*(1), 327–343.

Kampkötter, A., Chovolou, Y., Kulawik, A., Röhrdanz, E., Weber, N., Proksch, P., & Wätjen, W. (2008). Isoflavone daidzein possesses no antioxidant activities in cell-free assays but induces the antioxidant enzyme catalase. *Nutrition Research*, *28*(9), 620–628.

https://doi.org/10.1016/j.nutres.2008.06.002.

Kenyon, C. J. (2010). The genetics of ageing. *Nature*, *464*(7288), 504–512. https://doi.org/10.1038/nature08980.

Kim, J. A., Jung, W. S., Chun, S. C., Yu, C. Y., Ma, K. H., Gwag, J. G., & Chung, I. M. (2006). A correlation between the level of phenolic compounds and the antioxidant capacity in cooked-with-rice and vegetable soybean (Glycine max L.) varieties. *European Food Research and Technology*, *224*(2), 259–270. https://doi.org/10.1007/s00217-006-0377-y.

Liang, J., Tian, Y.-X., Fu, L.-M., Wang, T.-H., Li, H.-J., Wang, P., … Skibsted, L. H. (2008). Daidzein as an Antioxidant of Lipid: Effects of the Microenvironment in Relation to Chemical Structure. *Journal of Agricultural and Food Chemistry*, *56*(21), 10376–10383. https://doi.org/10.1021/jf801907m.

Longo, V. D. (2003). Evolutionary Medicine: From Dwarf Model Systems to Healthy Centenarians? *Science*, *299*(5611), 1342–1346. https://doi.org/10.1126/science.1077991.

Mahdi-Pour, B., Jothy, S. L., Latha, L. Y., Chen, Y., & Sasidharan, S. (2012). Antioxidant activity of methanol extracts of different parts of Lantana camara. *Asian Pacific Journal of Tropical Biomedicine*, *2*(12), 960–965. https://doi.org/10.1016/S2221-1691(13)60007-6.

Makrantonaki, E., Brink, T. C., Zampeli, V., Elewa, R. M., Mlody, B., Hossini, A. M., … Zouboulis, C. C. (2012). Identification of Biomarkers of Human Skin Ageing in Both Genders. Wnt Signalling - A Label of Skin Ageing? *PLoS ONE*, *7*(11), e50393. https://doi.org/10.1371/journal.pone.0050393.

Mukherjee, P. K., Maity, N., Nema, N. K., & Sarkar, B. K. (2011). Bioactive compounds from natural resources against skin aging. *Phytomedicine*, *19*(1), 64–73. https://doi.org/10.1016/j.phymed.2011.10.003.

Mukhopadhyay, D., Dasgupta, P., Sinha Roy, D., Palchoudhuri, S., Chatterjee, I., Ali, S., & Ghosh Dastidar, S. (2016). A Sensitive In vitro Spectrophotometric Hydrogen Peroxide Scavenging Assay using 1,10-Phenanthroline. *Free Radicals and Antioxidants*, *6*(1), 124–132. https://doi.org/10.5530/fra.2016.1.15.

Ndlovu, G., Fouche, G., Tselanyane, M., Cordier, W., & Steenkamp, V. (2013). In vitro determination of the anti-aging potential of four southern African medicinal plants. *BMC Complementary and Alternative Medicine*, *13*(1), 304. https://doi.org/10.1186/1472-6882-13-304.

Pavithra, K., & Vadivukkarasi, S. (2015). Evaluation of free radical scavenging activity of various extracts of leaves from Kedrostis foetidissima (Jacq.) Cogn. *Food Science and Human Wellness*, *4*(1), 42–46. https://doi.org/10.1016/j.fshw.2015.02.001.

Prvulović, D., Malenčić, Đ., & Miladinović, J. (2017). Antioxidant Activity and Phenolic Content of Soybean Seeds Extracts. *АГРОЗНАЊЕ*, *17*(2), 121. https://doi.org/10.7251/AGREN1602121P.

Ramos-e-Silva, M., Celem, L. R., Ramos-e-Silva, S., & Fucci-da-Costa, A. P. (2013). Anti-aging cosmetics: Facts and controversies. *Clinics in Dermatology*, *31*(6), 750–758. https://doi.org/10.1016/j.clindermatol.2013.05.013.

Silva, L. R., Pereira, M. J., Azevedo, J., Gonçalves, R. F., Valentão, P., de Pinho, P. G., & Andrade, P. B. (2013). Glycine max (L.) Merr., Vigna radiata L. and Medicago sativa L. sprouts: A natural source of bioactive compounds. *Food Research International*, *50*(1), 167–175. https://doi.org/10.1016/j.foodres.2012.10.025.

Tu, P., & Tawata, S. (2015). Anti-Oxidant, Anti-Aging, and Anti-Melanogenic Properties of the Essential Oils from Two Varieties of Alpinia zerumbet. *Molecules*, *20*(9), 16723–16740. https://doi.org/10.3390/molecules200916723.

Widowati, W., Fauziah, N., Heddy Herdiman, Afni, M., Afifah, E., Kusuma, H. sari W., … Rihibiha, D. D. (2018). Antioxidant and Antiaging Activities of Jasminum Sambac Extract, and its Compounds. *Journal Report in Phamrceutical Sciences*, *7*(3), 270–285.

Widowati, W., Fauziah, N., Herdiman, H., Afni, M., Afifah, E., Kusuma, H. S. W., … Rihibiha, D. D. (2016). Antioxidant and Anti Aging Assays of Oryza sativa Extracts, Vanillin and Coumaric Acid. *Journal of Natural Remedies*, *16*(3), 88. https://doi.org/10.18311/jnr/2016/7220.

Widowati, W., Rani, A. P., Hamzah, R. A., Arumwardana, S., Afifah, E., Kusuma, H. S. W., … Amalia, A. (2017). Antioxidant and Antiaging Assays of Hibiscus sabdariffa Extract and Its Compounds. *Natural Product Sciences*, *23*(3), 192. https://doi.org/10.20307/nps.2017.23.3.192.

Wlaschek, M., Tantcheva-Poór, I., Naderi, L., Ma, W., Schneider, L. A., Razi-Wolf, Z., …

Scharffetter-Kochanek, K. (2001). Solar UV irradiation and dermal photoaging. *Journal of Photochemistry and Photobiology B: Biology*, *63*(1–3), 41–51. https://doi.org/10.1016/S1011-1344(01)00201-9.

Wójciak-Kosior, M., Sowa, I., Blicharski, T., Strzemski, M., Dresler, S., Szymczak, G., … Świeboda, R. (2016). The Stimulatory Effect of Strontium Ions on Phytoestrogens Content in Glycine max (L.) Merr. *Molecules*, *21*(1), 90. https://doi.org/10.3390/molecules21010090

Zhou, R., Cai, W., & Xu, B. (2017). Phytochemical profiles of black and yellow soybeans as affected by roasting. *International Journal of Food Properties*, *20*(12), 3179–3190. https://doi.org/10.1080/10942912.2017.1280678.