JSAT
Journal of Science and Agricultural Technology
Review Article
https://doi.org/10.14456/jsat.2021.2
e-ISSN 2730-1532, ISSN 2730-1524

Soybean (*Glycine max* L.) as a vitamin rich food to boost immune system for post-pandemic era

Qonita[1*], Hana Azizah Salsabila[1], Gitta Gantari Utomo[1], Naomi Grace Deborah Napitupulu[1], Aditya Baghaswara[1], Fajril Akbar Ath-Thoriqo Haq[1], Imaniar Ilmi Pariasa[1] and Dian Islami Prasetyaningrum[1]

[1]Faculty of Agriculture, Brawijaya University, Malang, 65145, Indonesia.

***Corresponding author**: qonita.ratna00@student.ub.ac.id*
Received: April 2, 2021. Revised May 16, 2021. Accepted: May 17, 2021.

ABSTRACT

The immune system of the human body plays a significant role in preventing COVID-19. Gibson et al. (2012) stated that the consumption of vitamin-rich and functional foods could boost the immune system to suppress the virus, especially in this pandemic era. This pandemic also affects the agricultural sector in Indonesia, especially in food security, supply, and chain. Coping with this problem, the Indonesian government has introduced *Gerakan Ketahanan Pangan* (GKP) program to support the agricultural sector. The program focuses on primary and functional food, particularly soybeans (*Glycine max* L.). The nutrition in soybeans may become the substitute for red meat, fish, and egg that considered expensive for several people. This situation may enhance soybean farmers, specifically in Indonesia, to face the post-pandemic period anticipating the return of similar viruses or conditions. This study was a qualitative analysis using a constructivist paradigm, and the data used were secondary data from literature and narrative review. The results of this study highlighted the need for immune-boosting food, especially soybeans. Shortly, soybeans are considered a long-term commodity that helps the food security and improves the Indonesian economy during the COVID-19 pandemic situation.

Keywords: immune system, food security, pandemic, soybeans, agriculture

INTRODUCTION

COVID-19 has claimed more than 500 billion souls worldwide, and the spread of COVID-19 has increased rapidly. COVID-19 attacks the human respiratory system. This situation impacts human health and leads to a global food crisis (Balkan, 2020). With the discovery of a new kind of Coronavirus variant, researchers are required to make vaccines that took a long time. Researchers have attempted to improve the immune system against this COVID-19. Especially, humans can boost their immunity with natural food crops. Several actions and policies have been implemented to address food security (Ge et al., 2018; Blay-Palmer et al., 2013; Johnson et al., 2012). Affordability, availability, and food accessibility for the communities have focused on the government, the private sector, and other stakeholders (Deng et al.,2015).

On the other hand, consumers try to protect themselves and improve their immune systems and are concerned about changing their food consumption habits, bioactive ingredients, and nutritional content (Galanakis, 2020; Rizou et al., 2020; Zinoviadou et al., 2015). However, security protocols are required applied following health standards for the prevention of COVID-19 (Rizou et al., 2020). One of the industrial sectors that had to overcome different challenges during the pandemic is the food sector, striving to produce and secure sufficient and safe food. Food security, food safety, and food sustainability are recognized as strongly affected dimensions of food systems during the COVID-19 pandemic (Galanakis, 2020). Finally, food ingredients and bioactive compounds supporting immune functions in humans, such as vitamin C, vitamin D, polyphenols, and flavonoids have also been in research focus in preventing and treating COVID-19 as outlined in the review by Djekic et al. (2021). A multi-country study in 16 countries identified health as one of six determinants in eating behaviors (Djekic et al., 2021), so scientific evidence of the promising effects of food supplements and nutraceuticals can help citizens in protecting themselves during the pandemic and post-COVID-19 pandemic era.

Therefore, to protect humans during the pandemic and prepare for the post-pandemic era, consuming food with ingredients supporting the immune system is essential, such as soybeans. Soybeans represent a remarkable source of high-quality protein, vitamins, and minerals with a low saturated fat content and high in dietary fiber. Soybean protein is considered a suitable substituent for animal protein. Except for sulfur amino acids (methionine and cysteine), their nutritional profile is

almost similar to animal protein because soybean proteins contain most of the essential amino acids for animal and human nutrition (Hassan, 2013). Soybeans also contain a high level of isoflavone and vitamin C as an immune booster for the human body. This statement is supported by Makmun and Rusli (2020), who state that vitamin C or known as ascorbic acid, acts as an antidote for free radicals (pathogens) that could enter the body like the COVID-19 virus. A high concentration of isoflavone in soybeans is beneficial for health, such as anti-inflammation, anti-cancer, anti-allergic, antivirus, preventing osteoporosis, and lower heart disease risk, and could block the potentially harmful effects against the excess estrogen production in the human body (Krisnawati, 2017).

Furthermore, the agri-food chain is labor-intensive and can be affected by limitations in the workforce due to infection and/or limited ability to travel (Delhey and Dragolov, 2014). There should be efforts to allow for global trade and overall to minimize logistics disruptions so that major staple commodities can be moved across countries. Availability of food products is expected to affect the nutritional habits of consumers directly. It would be worth ensuring that diets during this crisis provide the necessary macro and micronutrients.

MATERIALS AND METHODS

The research approach we use is the qualitative approach with a descriptive method to analyze the literature review research. Descriptive research is a method that is intended for describing phenomena that have occurred recently or happened in the past. According to Furchan (2004), descriptive research tends to represent a phenomenon's existence by reviewing regularly, prioritizing objectivity, and doing carefully. Several aspects of the focus of the information collected in this study include the role of soybeans in health aspects, production and financial effects, food security, and the influence of soybeans on the body's immune system. The scope of the research location as a reference and case study data collection used is the Asian area, especially Indonesia.

RESULTS AND DISCUSSION

Soybeans are one of the world's most important crops with multifunction uses, including food, feed, fuel, and other industrial usages such as paint, ink, and plastics. Soybeans themselves also have various roles in our livelihoods, including in health aspects, production and financial effects, food security, and the influence of soybeans on the body's immune system.

The role of soybeans in health aspects

Soybeans are used for thousands of years ago, especially in the food industry. Currently, the global soybean production is up to 219.8 million metrics tons (Gandhi, 2009). The values of soybean in human nutrition and health are used in human foods in various forms, including infant formulas, flours, protein isolates and concentrates, and textured fibers. New soy foods are continually developed. Consumption of soy foods is increasing because of reported beneficial effects on nutrition and health. These effects include lowering plasma cholesterol, prevention of cancer, diabetes, and obesity, and protection against bowel and kidney disease. Soy-based infants are widely used to feed children suffering from allergies to cow's milk and prevent illness when breast milk is not available. The soy formulas are inexpensive and nutritionally adequate to replace milk-based formula and rarely elicit allergic reactions.

The role of soybeans in production and financial aspects

According to Chianu et al. (2010) many countries import soybeans as it became the number one priority of protein source and the second-highest for its oil (vegetable oil). Exporter countries import soybean, whether it's in the form of grain, biodiesel, or even soybean production, to another country with high demand. In 2001-2003, the world supply/demand for soybeans reached 183.9 million tons. About 10% of them were directly consumed as food (5.9%) and for feed (3.8%), and 84.2% were processed into soy oil and soy meal. Despite the fact that soybeans are mainly used as an industrial product in the form of feed, fiber, fuel, and food ingredients, they can be found in Asian and specialty markets as final consumer goods (Masuda and Peter, 2009).

According to Voora et al. (2020), soybean stocks maybe even higher than predicted, given the effect of COVID-19 on the food supply chain. This might affect the soybean prices if accumulated soybean stocks of soybean get dumped all at once into international markets. Furthermore, since the soybean market can be segmented into animal feed, food and beverage, personal care, dietary supplements, pharmaceuticals, and biomaterials, including biofuels, the versatility of soybeans will be a major factor in maintaining demand growth. From the information above, soybean will become one of the most potent food markets and also a higher

demand as the population keeps growing in the future (Wang, 2017).

The role of soybeans in food security aspects

In Indonesia, the government has launched a Food Security Movement program during the pandemic. Through the Agricultural Human Resources Extension and Development Agency, the Ministry of Agriculture has formulated 4 Ways of Action Method to achieve food security. First, increasing production capacity. The Ministry of Agriculture invites agricultural actors to accelerate rice planting in Season II 2020, covering an area of 6.1 million ha, development of swamps in Central Kalimantan Province 164,598 ha, including the intensification of 85,456 ha of lawn and extensification of agricultural land 79,142 ha. Second, diversification of local food. The Ministry of Agriculture will develop local food diversification based on local wisdom that focuses on one main commodity. Third, strengthening food reserves and logistics systems by provincial government rice reserves (CBPP), then strengthening regency/city government rice reserves (CBPK). Fourth, the development of modern agriculture, through the development of smart farming, are developing the use of screen houses to increase the production of horticultural commodities outside the planting season, the development of farmer corporations, and the development of food estates to increase the production of main food (rice/corn) (Caron and Kalafatic, 2016).

Immune link with COVID-19

The immune system becomes vital once an individual is exposed to an infectious agent. However, the nature of contagious agents varies, and the immune system requires different approaches to deal with different types of infectious agents. These different approaches follow similar general strategies, which aim to seek out and destroy, but the precise immune mechanisms involved can differ. Thus, the roles for nutrients in supporting the function of the immune system are many and varied, and it is easy to appreciate that an adequate and balanced supply of these is essential if an appropriate immune response is to be mounted. Nutrition contents in soybeans can be seen in Table 1.

Table 1. Nutrition contents in soybean seeds per 100 g.

Nutrients	Amount
Energy	1,866.0 kJ (446 kcal)
Carbohydrate	30.16 g
Sugar	7.33 g
Fiber	9.3 g
Fat	19.94 g
Monounsaturated	4.404 g
Polyunsaturated	11.255 g
Protein	36.49 g
Tryptophan	0.591 g
Threonine	1.766 g
Isoleucine	1.971 g
Leucine	3.309 g
Lysine	2.706 g
Methionine	0.547 g
Phenylalanine	2.122 g
Tyrosine	1.539 g
Valine	2.029 g
Arginine	3.153 g
Histidine	1.097 g
Alanine	1.915 g
Aspartic acid	5.112 g
Glutamic acid	7.874 g
Glycine	1.880 g
Proline	2.379 g
Serine	2.357 g
Water	8.54 g
Vitamin A	1 mg
Vitamin B6	0.377 mg
Vitamin C	6.0 mg
Vitamin K	47 mg
Calcium	277 mg
Phosphorus	704 mg
Potassium	1797 mg
Magnesium	280 mg
Sodium	2 mg
Iron	15.70 mg
Zinc	4.89 mg

Source:Wardani and Sujana (2020)

In essence, good nutrition creates an environment in which the immune system can respond appropriately to challenges, irrespective of the nature of the challenge. Conversely, poor nutrition creates an environment in which the immune system cannot respond well. The innate immune system acts fast (in minutes) after it recognizes a pathogen and, in most cases, eradicates

the invading pathogens. During this process, the cells of the innate immune system, and their derived immune mediators/proteins, also activate the cells of the adaptive immune system which then develop memory immune responses toward these pathogens. Therefore, upon reinfection, the intensity of the innate immune system remains the same.

Food is one of the factors that can affect the immune system. The three main categories of food that can boost the immune system, one of those is vegetables, berries, and nuts. These foods are categorized as functional food (Smith and Charter, 2010). As previously known, soybeans are a food or food ingredient that contains lots of vitamins. The vitamins contained in soybean include water-soluble vitamins, such as thiamine, riboflavin, niacin, vitamin C, pyridoxine, biotin, and folic acid. Second is fat-soluble vitamins, such as vitamin A, E, D, and K (Hassan, 2013; François et al., 2020). These vitamins have benefits as an immune booster because of their respective functions and reactions to the human body.

Immuno-nutrition plays an essential role in regulating either the action of the immune system or the activation effects of the immune system on specific nutrients or foods. (François et al., 2020). It is known that undernourished people have low immune functions to provide a guard against pathogenic species (Derbyshire and Delange, 2020). There are no medicines or nutrients capable of optimizing the immune system. However, there are methods, supported by scientific evidence, that can strengthen our immune systems, such as exercise, diet or nutrition, and immunity, and mental wellbeing and immunity, which result in better health and better quality of life, as described above. (Calabrese and Fasenmyer, 2017).

Soybean vitamins role as an immune booster

Soy vitamins are micronutrients that play an important role as cofactors in the metabolic machines involved in the generation of energy and biosynthesis required for immune response and multiple micronutrient supplementations immune-supporting functions, which can modulate immune function and reduce the risk of infection. (Gibson et al., 2012; François, et al., 2020; Gombart et al., 2020). It can be inferred that micronutrients play an important role in the need to defend or protect against infections such as COVID-19. Soy vitamins such as A, C, K, and B6 may play a role in preventing this pandemic. About micronutrients in soybeans can be seen in Table 2.

Fauziah et al. (2016) researched soybeans using the visible spectrophotometry method to determine the vitamin B1 content in soybean; in determining the wavelength maximum, vitamin B1 absorbance obtained a maximum of 0.678 in length wave 423 nm. Once obtained, the maximum absorption wavelength then measured the absorbance of vitamin B1 on concentration 1.25 ml (10 ppm), 1,875 ml (15 ppm), 2.5 ml (20 ppm), 3.125 ml (25 ppm), 3.75 ml (30 ppm). From this measurement gets the equation of the line straight i.e. Y = - 0.0020 + 0.0228X and the correlation coefficient (r) is 0.9997. Since the value of the correlation coefficient (r) ≤ 1, then the calibration curve obtained is linear. From this equation, the level of the total vitamin B1 can be determined from the sample solution.

The several literature reviews of nutrient analysis in soybeans show that soybeans contain many beneficial vitamins. These vitamins are B1, C, E, and B12. Vitamin B1 content based on the study research can be found by visible spectrophotometry. From the measurement of the calibration curve, obtained a standard deviation (SD) of 0.0066 limits of detection (BD) 0.8684 µg/mL and limit quantization (BK) 2.8947 µg/mL. Accuracy is measured as a coefficient variation (CV).

Table 2. Nutrition contents in soybean seeds per 100 g.

Items	Nutrient value[1]
Water soluble vitamin[2]	
Thiamin (B1)	0.874 mg
Riboflavin (B2)	0.870 mg
Niacin (B3)	1.623 mg
Pantothenic acid (B5)	0.793 mg
Pyridoxine (B6)	0.377 mg
Folic acid (B9)	375 µg
Fat soluble vitamin[2]	
Vitamin A	22 IU
Vitamin C	6 mg
Vitamin E	0.85 mg
Vitamin K	47 µg

Source: Haytowitz et al. (2019)[1]; Saghiri et al. (2017)[2]

Soybean fat-soluble vitamins, vitamin A, have a significant effect on human immune response, deficiency of vitamin A can change in immune response, increased susceptibility to disease or infection, and loss of membrane function in the immune system (François et al., 2020). Vitamin D also contributes to the innate of adaptive immune responses as it enhances phagocytosis, superoxide output, and bacterial killing of innate immune cells. This vitamin will play a role in the prevention and recovery of COVID-19 because, if we have lower amounts of this vitamin in the body, it has been shown to cause a rise in infection rates and has documented to increase the risk of coronavirus

infection (François et al., 2020; Nonnecke et al., 2014; Azrielant and Shoenfeld, 2017; Aslam et al., 2017). The role of vitamin E in the immune system is the vitamin needed to prevent the high risk of oxidative damage to immune cells against oxygenizing agents and to improve their physiological activity, and reduce immunosuppressive factors such as PGE2 prostaglandin (Meydani et al., 2005; Pae et al., 2012). Vitamin E supplementation may modulate host defense against infectious pathogens like COVID-19 (Meydani et al., 2004).

Water-soluble vitamins in soybeans, such as vitamin B6 (pyridoxine), folic acid, and vitamin B12 (cobalamin), which are only used in fermented soya products, including tempeh, are supported by natural killer cells in the immune system, making them essential for antiviral protection. The body requires B6 to consume vitamin B12 and to make the red blood cells and cells of the immune system (Aslam et al., 2017). Vitamin B6 helps to boost the immune response to increased antibody synthesis and also helps in communicative interactions with cytokines and chemokines (Kunisawa and Kiyono, 2013). Vitamin B12 (cobalamin), which is present only in fermented soy products, acts as a destroyer or affects pathogens activity to create infection by enhancing the work of B-cells and T-cells in the immune system (François, et al., 2020; Rowley and Kendall, 2019). As a result, because of its potential to influence the pathogen process that causes infection, cobalamin can allow COVID-19 patients not to be easily threatened by the virus. Vitamin B9 (folic acid or folate) is a vitamin that can boost the body's ability to fight COVID-19 due to its ability to sustain or enhance NK cell cytotoxic activity and its involvement in the intestinal immune system (François et al., 2020; Gombart et al., 2020).

Other vitamins, thiamine (vitamin B1), are used to improve the immune system. Low levels of vitamin B1 (thiamine) in our body can contribute to a lack of immune response in patients with diabetic and chronic tonsillitis (Mahmodi and Rezaei, 2019; Dakshinamurti, 2015; Aleszczyk et al., 2001). Vitamin B2 (riboflavin) maintains healthy blood cells and boosts metabolism. This vitamin is an efficient anti-inflammatory modulator, stimulates phagocytic macrophage function, and its metabolites are involved in MAIT cell simulation (Mahmodi and Rezaei, 2019). Therefore, the importance of riboflavin in health and disease is becoming apparent and can help prevent COVID-19 from occurring in the human body. Vitamin B3 (niacin) is widely prescribed for its anti-inflammatory role in inflammatory disorders. Due to the existence of nicotinic acid receptors on adipocytes and immune cells, niacin supplementation may prove to be an effective way of alleviating the disease (Mahmodi and Rezaei, 2019).

The effectiveness of soybeans for post-pandemic immunity

Among the various functional food ingredients, soybeans contain functional compounds that contribute to health benefits. According to research conducted by Lee et al. (2007), due to host resistance to cancer occurrence or viral infection in mice as the object research is primarily involved with Th1 cell-mediated immunity, the augmented Th1 response in response to the administration of DJ or CGJ fermented soybean products suggests a certain effector function of these fermented soybean products on T helper cell-mediated immune surveillance against infection or oncogenesis. Soybeans contain many biologically functional components, including isoflavones, unsaturated fatty acids, and bioactive peptides, and the fermentation process is known to improve the nutritional and functional properties of soybeans. Thus, the effectiveness of soybeans for the immune system is high because even when it's fermented or processed, it will improve the functional properties, vitamins, and nutrition of soybeans.

Based on the research investigated by Choi et al. (2014), in which they tested the major bioactive compounds such as isoflavones-glycosides in some traditional foods, they found that components of soybeans could affect the immunostimulatory activity at different rates. The immunostimulatory activity of isoflavone aglycones treats immune cells similarly or higher than the immunostimulatory activity with different isoflavone aglycones.

CONCLUSIONS

Soybean is an alternative food for boosting human immune systems. The nutrients in soybeans, such as vitamins, have an abundance amount in them. The vitamins mentioned are A, B1, E, D, and C that can be recognized. There are many vitamins in soybean that are rarely found due to their function to be processed. To enhance the vitamin content of soybean, there are several ways to achieve it; one is the fermentation process. During the fermentation of soybean, vitamin B12, barely found in each soybean, can be enhanced to enough content for human needs. The major bioactive compounds such as isoflavones-glycosides in soybeans could affect the immunostimulatory activity at different rates that treated the immune cells. This stated that soybeans are eligible to be called immune booster food. It is

a recommended choice to consume soybeans daily to prevent viruses or any threats of disease. The act of self-prevention to boost the immune system in the human body can help fight the outbreak such as COVID-19 or similar threats, especially in the post-pandemic situation, so that humans are prepared for health conditions and decrease the mortality rate.

REFERENCES

Aleszczyk, J., Mielanjin, W., Chomicz, T., Gurynowicz, W., Osakowicz, I., and Suszko, L.. 2001. Evaluation of vitamin and immune status of patients with chronic palatal tonsillitis. Otolaryngol Pol. 55(1): 65–7.

Aslam, M.F., Majeed, S., Aslam, S. and Irfan, J. A. 2017. Vitamins: key role players in boosting up immune response- a mini review. Vitam. Miner. 6: 153

Azrielant, S. and Shoenfeld, Y. 2017. Vitamin D and the immune system. Isr. Med. Assoc. J. 19(8):510–511.

Balkan B. A. 2020. Effects of COVID-19 on food & agricultural systems. System Dynamics Society A&F SIG Meeting. DOI: 10.5281/zenodo.3780013

Blay-Palmer, A., Landman, K., Knezevic, I., and Hayhurst, R. 2013. Constructing resilient, transformative communities through sustainable "Food Hubs". Local Environ. 18 (5): 521-528, DOI: 10.1080/13549839.2013.797156

Calabrese, L. H. and Fasenmyer, R. J. 2017. Maintaining a health immune system: that you can do to help. Cleveland Clinic Meded. 5-30.

Caron, P. and Kalafatic, C. 2016. Sustainable agricultural development for food security and nutrition: what roles for livestock? s.l.: High level panel of experts on food security and nutrition of the Committee on World Food Security, Rome.

Chianu, Jonas N., Zegeye, E. W., and Nkonya, E. M. 2010. Global soybean marketing and trade: a situation and outlook analysis (Chapter 20). *In* The soybean: botanu, production and uses. Singh, G. (ed.). p. 461-484.

Choi, J. H., Chung., M. J. Jeong., D. Y.and Oh, D. H. 2014. Immunostimulatory activity of isoflavone-glycosides and ethanol extract from a fermented soybean product in human primary immune cells. J. Med. Food. 7(10).

Dakshinamurti, K. 2015. Vitamins and their derivatives in the prevention and treatment of metabolic syndrome diseases (diabetes). Can. J. Physiol. Pharmacol. 93(5):355–62.

Delhey, J. and Dragolov, G. 2014. Why inequality makes Europeans less happy: the role of distrust, status anxiety, and perceived conflict. European Socio Rev. 30: 151-165.

Deng, Q., Zinoviadou, K. G.,. Galanakis, C. M., Orlien, V., Grimi, N., Vorobiev, E., Lebovka, N., and Barba, F. J. 2015. The effects of conventional and non-conventional processing on glucosinolates and its derived forms, isothiocyanates: extraction, degradation, and applications. Food Eng. Rev. 7(3): 357-381.

Derbyshire, E. and Delange, J. 2020. COVID-19: is there a role for immunonutrition, particularly in the over 65s. BMJ Nutrition. Prevention & Health. bmjnph-2020-000071.

Djekic, I., Nikoli´, A., Uzunovi´c, M., Marijke, A., Liu, A.., Han, J., Brnˇci´c, M., Kneˇzevi´c, N., Papademas, P., Lemoniati, K., Witte, F., Terjung, N., Papageorgiou, M., Zinoviadou, K. G.,. Zotte, A. D., Pellattiero, E., Sołowiej, B. G. , Guin´e, R. P. F., Correia, P., Sirbu, A., Vasilescu, L., Semenova, A. A., Kuznetsova, O. A., Brodnjak, U. V.. Pateiro, M., Lorenzo, J.M., Getya, A., Kodak, T., and Tomasevic, I. 2021. Covid-19 pandemic effects on food safety - Multi-country survey study. Food Control. 122: 107800.

Fauziah, F., Rasyid, R., and Akbar, A.P. 2016. Penetapan kadar vitamin B1 pada kacang kedelai dan tempe yang beredar di pasar raya padang secara spektorfotmetri visibel. Jurnal Farmasi Higea. 8 (1): 1-7.

Francois, L. M., Bajo, W., Victor, B. M., and Moleka., M. 2020. Coronavirus and nutrition: an approach for boosting immune system-a review. European j. nutr. food saf. 12(09):72-76.

Furchan, A. 2004. Pengantar penelitian dalam pendidikan. Yogyakarta: Pustaka Pelajar Offset. 54.

Galanakis, C. M. 2020. The food systems in the era of coronavirus (covid-19) pandemic crisis. Foods. 9(4): 523.

Gandhi, A. P. 2009. Review article quality of soybean and its food products. Int. Food Res. J. 16: 11-19.

Ge, H., Goetz, S., Canning, P., and Perrez, A. 2018. Optimal locations of fresh produce aggregation facilities in the United States with scale economies. Int. J. Prod. Econ. 197: 143-157.

Gibson, A., J. D. Edgar, C. E. Neville, S. E. Gilchrist, M. C. McKinley, and C. C. Patterson. 2012. Effect of fruit and vegetable consumption on immune function in older people: A randomized controlled trial. Am. J. Clin. Nutr. 96(6): 1429–1436.

Gombart, A. F., Pierre, A., and Maggini, S. 2020. A review of micronutrients and the immune system-working in harmony to reduce the risk of infection. Nutrients. 12(1): 236.

Hassan, S. M. 2013. Soybean, nutrition and health-bio-active compounds. IntechOpen. DOI: 10.5772/54545. Available from: https://www.intechopen.com/books/soybean-bio-active-compounds/soybean-nutrition-and-health.

Haytowitz, D. B., Ahuja, J.K.C., Wu, X., Somanchi, M., Nickle, M.., Nguyen, Q. A., Roseland, J.M.., Williams, J. R., Patterson, K.Y., Ying, L., Pehrsson, P.R. 2019. USDA National Nutrient Database for Standard Reference, Legacy Release. Nutrient Data Laboratory, Beltsville Human Nutrition Research Center, ARS, USDA. Available from: https://data.nal.usda.gov/dataset/ usda-national-nutrient-database-standard-reference-legacy-release.

Johnson, R., Aussenberg, R. A. and Cowan, T. 2012. The role of local food systems in US farm policy. Congressional Research Service. Available from: https://community-wealth.org/sites/clone.communitywealth.org/files/downloads/report-johnson-et-al_0.pdf.

Krisnawati, A. 2017. Soybean as source of functional food. Iptek Tanaman Pangan. 12(1). 57-65

Kunisawa, J. and Kiyono, H. 2013. Effect of diet on serotonergic neurotransmission in depression. Neurochem. Int. 62: 324-329.

Lee, S. H., Parka, H. J., Chuna, H. K., Choa, S. Y., Junga, H. J., Choa, S. M., Kimb, D. Y., Kangb, M. S., and Lillehojc, H. S. 2007. Dietary phytic acid improves serum and hepatic lipid levels in aged ICR mice fed a high-cholesterol diet. Nutr Res. 27(8): 505-510.

Mahmoudi, M. and Rezaei, N. 2019. Nutrition and immunity. Vitamin B1, B2, B3, B5, and B6 and the Immune System, (Chapter 7), Mahmoudi, M. and Rezaei, N. (eds.) Springer Nature Switzerland. p. 115–125.

Makmun, A. and Rusli,. F. I. P. 2020. Pengaruh vitamin C terhadap sistem imun tubuh untuk mencegah dan terapi Covid-19. Molucca Medica. 12(2): 60-64.

Masuda, T. and Goldsmith, P. 2008. World soybean production: area harvested, yield, and long-term projections. National Soybean Research Laboratory, University of Illinois.

Meydani, S. N., Han, S. N., Wu, D. 2005. Vitamin E and immune response in the aged: molecular mechanisms and clinical implications. Immunol. Rev. 205: 269–284.

Nonnecke, B. J., McGill, J. L., Ridpath, J. F., Sacco, R. E., Lippolis, J. D., .and Reinhardt, T. A. 2014. Acute phase response elicited by experimental bovine diarrhea virus (BVDV) infection is associated with decreased vitamin D and E status of vitamin-replete pre-ruminant calves. J. Dairy Sci. 97(9): 5566–5579.

Pae, M., Meydani, S. N. and Wu, D. 2012. The role of nutrition in enhancing immunity in aging. Aging Dis. 3(1):91–129.

Rizou, M., Galanakis, I. M., Aldawoud, T. M., and Galanakis, C. M. 2020. Safety of foods, food supply chain and environment within the covid-19 pandemic. Trends Food Sci. Technol. 102: 293–299.

Rowley, C. A. and Kendall, M.M. 2019. To B12 or not to B12: Five questions on the role of cobalamin in host-microbial interactions. PLoS Pathog. 15(1):6–11.

Saghiri, M. A., Asatourian, A., Ershadifar, S., Moghadam, M. M., and Sheibani, N. 2017. Vitamins and regulation of angiogenesis: A, B1, B2, B3, B6, B9, B12, C, D, E, K]. J. Funct. Foods. 38:180–196.

Smith, J. and Charter, E. 2010. Functional Foods that Boost the Immune System. In Functional food product development. Smith, J. and Charter, E. (eds.). Blackwell Publishing Ltd. p. 293–321.

Voora, V., Larrea, C., and Bermudez, S. 2020. Global market report: Soybean. Sustainable Commodities Marketplace Series 2019. Available from: https://www.iisd.org/system/files/2020-10/ssi-global-market-report-soybean.pdf.

Wang, Y. 2017. Soybean futures arbitrage: a literature review. Advances in Intelligent Systems Research. 1951-6851, 156: 903-906.

Wardani, D. and Sujana, D. 2020. Analysis of protein and vitamin C content in black soybean tofu (*GLycine soja* (L.) Merrill) yellow and soybean (*Glycine max* (L.) Merrill) of kjeldahl and iodimetri titration method. Jurnal Ilmiah Famako Bahari. 11(2): 57-66.

Zinoviadou, K.G., Galanakis, C. M., Brncic, M., Grimi, N., Boussetta, N., Mota, M.J., Saraiva, J.A., Patras, A., Tiwari, B., and Barba, F. J. 2015. Fruit juice sonication: implications on food safety and physicochemical and nutritional properties. Food Res. Int. 77: 743–752.