Berkala Hayati

by Budhi Setiawan

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Potential improvement in the safety and quality of traditional fermented soybean products: A narrative review

ABSTRACT

Soybean is one of the important crops in the world because of its nutritional value. It has been processed into various fermented soybean products. During conventional soybean fermentation, microorganisms are involved, biochemical reactions occur, and bioactive components are produced. With the improvement of people's living standard, consumers pay more attention not only to the flavor and nutrition but also the safety and quality of fermented soybean foods. Public health issues related to fermented soybean foods include ~~quality inconsistency,~~ mycotoxins, formation of biogenic amines, and high salt content. This paper reviews the common concerns associated with the safety and quality of fermented soybean foods and discusses the plausible efforts for the improvement. Attempts and methods have been proposed to ensure the safety of the fermentation process and food quality. Official regulations, the use of suitable microorganisms, high-quality cultivars utilization, administration of additives are plausible alternatives for safety and quality improvement. We conclude that implementing International food standard, guidelines and code of practice such as The Codex Alimentarius for fermented soybean products ~~regulations~~ and the use of scientific novel methods (eg. starter combination, high-pressure processing, or low-dose gamma irradiation, additives usage, low salt fermentation technique) are the potential solutions to mitigate the issues and improve the safety and quality of the products.

Keywords: Fermentation, soybean, safety, quality, food, nutrition,

INTRODUCTION

Soybean (*Glycine max* [L.] Merrill) is ~~a legume with high economic values and~~ one of the affordable primary protein sources for the human diet in the world, which can be used as meat substitution (Xiang et al. 2019). Soy-based foods are known as non-fermented (soymilk, okara, tofu, yuba, soy

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nuts, etc.) and fermented (miso, tempe, sufu, natto, etc.) (Liu 2008). Several studies have reported that fermentation of soybean results in numerous beneficial properties. The fermentation process can reduce cooking time, improve the nutritional quality of soybean, increase the bioactive components, such as phytoestrogens, and make soybeans more digestible (Chen et al. 2016). Some fermented soybean products (FSPs) are commonly used as condiments to raise the appetite and enhance the flavor of foods (Xiang et al. 2019).

It is well known that antinutritional factors present in whole soybean exert negative impacts. ~~However,~~ Whole soybean ~~also~~ contains anti-nutritional factors such as trypsin inhibitor, lectins, phytic acid, oligosaccharides, which raise concern for its consumption (Thakur et al. 2019). Anti-nutritional factors in foods ~~may~~ cause negative effects associated with the absorption and utilization of nutrients and the destruction of vitamins (Thakur et al. 2019). The deleterious influence on the absorption of these anti-nutritional factors ~~might~~ can trigger deficiency nutrients, and result in various ~~human~~ health-related issues especially in animals. The trypsin inhibitor activity in unfermented soybean affects negatively on Broiler chicken's growth performance and pancreas weight (Hoffman et al. 2019; Hemetsberger et al. 2021).

Studies have shown that microorganisms used in conventional fermentation could produce toxins that contaminate FSPs (Chen et al. 2016). As an example, *Rhizopus microspores,* a common species used as soybean fermentation starter, can produce two types of mycotoxins, namely rhizoxins and rhizonins. These mycotoxins can be found in tempe (Indonesian fermented soybean cake) and fermented bean curd (Rohm et al. 2010). *Aspergillus oryzae*, another strain frequently used in traditional soybean fermentation, produces also toxic secondary metabolites, such as cyclopiazonic acid, aspergillomarasmine, 3-nitropropionic acid, kojic acid, maltoryzine, and violacetin (Blumenthal 2004).

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Biogenic amines (BA), harmful substances generated during the fermentation process are often found in fermented soybean products from Korea, China, Japan, and Indonesia with significant concentrations (Park et al. 2019). Some fermented soybean products, such as fermented bean curd, soy sauce, douchi and dajiang are usually preserved without sterilization, but through the use of high salt addition. This technique prevents spoilage and prolongs the product's shelf life (Chen et al. 2016; Liu et al. 2020). However, an excessive amount of salt intake may cause an expansion in circulating volumes and lead to an increase in blood pressure in humans (Komnenov et al. 2019). Therefore, this narrative review aims to examine the problems associated with the safety and quality of common fermented soybean products and discuss the potential solutions.

INCONSISTENCY OF QUALITY IMPROVEMENT

The making of traditional fermented soybean foods usually uses traditional fermentation methods. There are common different techniques used to produce indigenous soy-based foods (figure 1). Asian countries have diverse preparations for fermented soybean products according to indigenous recipes (table 1). Standard Qquality control is not ~~might be difficult to be~~ appropriately applied on the conventional fermentation process so which results in inconsistent outcomes of the fermented soybean products. Consistency of quality for particular fermented soybean food is determined by several factors. For instance, the quality of tempeh (Indonesia fermented soybean cake) might be affected by soybeans, process water, yeast, fermentation time, and fermentation temperature (Novita & Abidin 2020). In daily practice, the process of fermentation is complicated and the product quality mostly depends on several conditions, such as geographical location, environment, weather, season, etc (Liu et al. 2020). As an example, ~~T~~there is a possibility in Indonesia that the small-scale ~~food~~ industry of fermented soybean could ~~not~~vary~~-~~ in meeting the national quality and safety of food standards provided by the government due to environmental factors and raw materials (Anggriawan 2018; Kadar et al. 2021). ~~In Indonesia, it has been found that protein content in commercial products of soy sauce was 1% less than the national standard (2.5%). Furthermore, many institutions cannot~~

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79 **Table 1.** Countries distribution and variety of fermented soybean products ~~(Tamang et al. 2020).~~

~~Country~~	~~Local name~~	~~Organoleptic characters, culinary and additional substrate~~
~~India~~	~~Bekang~~	~~58line, sticky, paste, curry~~
	~~Tungrymbai~~	~~Alkaline, sticky, curry, soup~~
	~~Hawaijar~~	~~Alkaline, sticky~~
~~Japan~~	~~Miso~~	~~Alkaline, paste~~
	~~Natto~~	~~Alkaline, sticky, breakfast~~
~~Indonesia~~	~~Kecap~~	~~Liquid, wheat~~
	~~Ketjap~~	~~Syrup, black~~
	~~Tauco~~	~~Alkaline, paste, use as flavoring agent~~
~~Korea~~	~~Chungkokjang (or jeonkukjang, cheonggukjang~~	~~Alkaline, sticky, soup~~
	~~Doenjang~~	~~Alkaline, paste, soup~~
	~~Gochujang~~	~~Hot-flavored seasoning, red pepper~~
	~~Meju~~	~~Alkaline, paste~~
	~~Kanjang~~	~~Soya sauce, meju, salt, water~~
~~China~~	~~Furu~~	~~Mild acidic, soybean curd~~
	~~Yandou~~	~~Alkaline, sticky, salted, snack~~
~~Taiwan~~	~~Jiang-sun~~	~~side dish~~
~~China, Taiwan~~	~~Douchi~~	~~Alkaline, paste~~
	~~Meitauza~~	~~Liquid~~
~~India, Nepal, Bhutan~~	~~Kinema~~	~~Alkaline, sticky; curry~~
~~Japan, Korea, China~~	~~Shoyu~~	~~Alkaline, liquid, seasoning~~
~~Indonesia (Origin), Netherlands, Japan, USA~~	~~Tempe~~	~~Alkaline, solid, cake~~

Country	Local name	References
India	Bekang	Chettri and Tamang (2014); Singh et al. (2014a, 2014b)
	Tungrymbai	Chettri and Tamang (2015); Singh et al. (2014a, 2014b)
	Hawaijar	Singh et al. (2014a, 2014b)
Japan	Miso	Tamang et al. 2016
	Natto	Liu 2012
Indonesia	Kecap	Alexandraki et al., 2013
	Tauco	Kindossi JM et al, 2012
Korea	Chungkokjang (or jeonkukjang, cheonggukjang	Hong et al. 2012
	Doenjang	24g et al. (2013); Kim et al. (2016a)
	Gochujang	Nam et al. 2012
	Meju	Sanni et al, 1991
	Kanjang	Shin, D. H, 2012
China	Furu	Lin et al. 2016
	Yandou	
Taiwan	Jiang-sun	Chen, Y. S., 2010
China, Taiwan	Douchi	Yang et al. 2019a, 2019b
	Meitauza	24
India, Nepal, Bhutan	Kinema	Chettri et al. (2016); Chettri and Tamang (2015); Singh et al. (2014a, 2014b)
Japan, Korea, China	Shoyu	Sugawara, E. (2010).
Indonesia (Origin), Netherlands, Japan, USA	Tempe	Frias et al. (2017)

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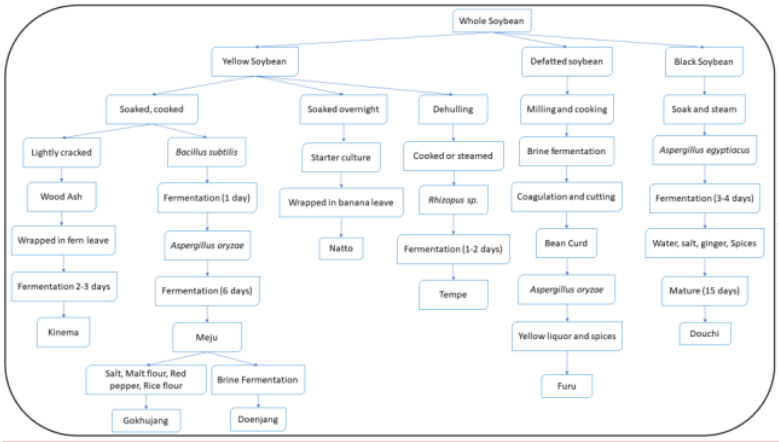

Figure 1. Different methods of soybean fermentation process

REGULATORY IMPLICATION

Although fermented soybean products are considered as safe, there are still health risks associated with inappropriate fermented soybean products, which are produced under inadequate hygienic standards and uncontrolled conditions, especially in household industry settings. The potential risks of adverse events are greater therefore higher hygienic standards need to be considered. To improve hygienic standards and preserve community health, various food safety assurance systems should be applied (Tamang et al. 2020). Because of the significant nutritional value of various fermented soybean foods, many of these products have been studied in order to improve their quality and safety. Urgent monitoring is required to improve the quality of the components and integrate safety management systems for every industrial purpose. The manufacturing process needs to be standardized to produce consistent quality, especially in small-scale industry settings (Anal 2019).

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There are several certification schemes, such as Good Manufacturing Practices (GMP), Good Agricultural Practices (GAP), Good Hygienic Practices (GHP), Hazard Analysis Critical Control Points (HACCP), and International Organization for Standardization (ISO) standards. These certifications should be implemented and supported by government policies in order to reduce public health risks caused by fermented soy products. Having Codex Alimentarius registration for fermented soybean products such as Kimchi, Gochujang and Doenjang will improve the quality standard especially in international trade and commerce (Lee et al. 2012). Food safety and quality audits are also used widely to ensure food safety systems and programs are compliant and effective. Evaluation of management system, assess the condition of premises and products, and certification to certain food safety and quality standards are the common application of the audits (Kotsanopoulos & Arvanitoyannis 2017). However, the objective of food safety and quality audits should be considered as one of constant improvement rather than onetime assessment results or policing exercise (Bradford-Knox 2017).

ANTI-NUTRITIONAL FACTOR

Several processing methods may diminish the anti-nutrient effects, such as soaking, pressure cooking, blanching, germination, fermentation, autoclaving, genetic manipulation, and other methods (Thakur et al. 2019; ten Brink et al. 1990). By using these diverse methods alone or in combinations, it is possible to lessen the content of anti-nutrients in foods (ten Brink et al. 1990). It has been suggested that autoclaving could be a better method to reduce levels of several anti-nutritional factors than other processing methods (Samtiya et al. 2020). However, comprehensive research is still needed to invent removal methods for heat-stable anti-nutritional factors existing in various foods without changing the quality of nutritional value. Heat-stable anti-nutritional factors include phytic acid, tannins, alkaloids, saponins, non-protein amino acids, and heat-labile group are lectins, cynogenic glycosides, protease inhibitors, and toxic amino acids (Thakur et al. 2019). When these substances present at low

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levels, some anti-nutritional factors and their metabolites may have positives health effects but limited knowledge and information on their properties can result in health risks (Gemede & Ratta 2014).

Innovative fermentation methods have been conducted in order to reduce the level of anti-nutritional factors in fermented soybean products such as soybean meal. Bacillus fermentation on soybean meal protein using *Bacillus siamensis* isolate JL8 has shown a significant reduction in major anti-nutritional factors (ANFs) in soybean meal (SBM) namely glycinin, β-conglycinin, and trypsin inhibitor by 86.0%, 70.3%, and 95.01% respectively (Zheng et al. 2017). A similar study using solid-state *Bacillus subtilis* fermentation method was able to reduce levels of beta-conglycinin subunits, glycinin subunits, and trypsin inhibitors by 70%, 50%, 58% respectively in soybean meal after 24 hours (Seo and Cho 2016). Additionally, soybean meal fermentation using the suitable proportion of *Bacillus subtilis*, *Bacillus lactis*, and *Saccharomyces cerevisiae* at 35^{0}C may improve the levels of free amino acids, small peptides and reduced the activity of protease inhibitor (Zhang et al. 2017).

MYCOTOXIN CONTAMINATION

The microorganisms involved in FSPs, especially in traditional spontaneously fermented products, are mostly unknown. However, predominant microorganisms used as in common fermentation have been described (Figure 2). Mycotoxins are secondary metabolites of molds that may harm the health of humans or animals after being consumed and it could contribute also to unwanted effects on crops (Komnenov et al. 2019). If ingested, mycotoxins can cause acute illness or chronic episodes of illness, called mycotoxicosis. The word Mycotoxin is derived from Greek word '*mykes*' means fungus, and Latin word '*toxicum*' means poison or toxin (Kirovska & Velickova 2021). Mycotoxin is produced during fungal growth and can be found in the hyphae and spores of organisms. Several mycotoxins such as aflatoxins, ochratoxins, deoxynivalenol (DON), trichothecenes, zearalenone, citrinin were reported to be present in fermented food products (Omotayo et al. 2019; Sivamaruthi et al. 2019). Some trichothecene mycotoxins, such as DON and T-2 toxins (a trichothecene produced

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by Fusarium spp) can directly impair mucosal tissues through disruption of the intestinal epithelial barrier and further enable translocation of intestinal commensal microbiota, and pathogens. The result could be the elevation of microorganism infection and inflammation (Nazhand et al. 2020). Aflatoxin (AF) is a common example of mycotoxins synthesized *by Aspergillus flavus*, *A. parasiticus* and *A. nomius*. Aflatoxins are chemically derived from difuranocoumarins with bifuran-based coumarin nuclei groups and lactone rings (Aflatoxin Gs) or pentanone rings (Aflatoxin Bs and Aflatoxin Ms). During the biosynthesis of AF in plants by *A. flavus* and *A. parasiticus*, the main substrate of hexanoyl is converted to polyketide using a polyketide synthase and two fatty acid synthases (Nazhand et al. 2020).

It has been reported that 97.5% of tested samples of 40 domestic and imported (from Japan) soy sauces sold in China were contaminated with DON. The mean incidence rate of DON contamination in domestic soy sauces was 97.1% with a concentration range from 4.5 to 1245.6 µg/l, whereas those imported from Japan were 100% in a range of 30.5 –– 238.3 µg/l (Zhao et al. 2013). Meju prepared without additives may result in isolation of *Aspergillus ruber* which ability to release aflatoxin B_1 and the ochratoxin A (Shukla et al. 2017). *Aspergillus oryzae* and *Aspergillus sojae* are commonly used in the soybean fermentation process such as soy sauce, and miso. These strains are closely associated with the aflatoxigenic species *A. flavus* and *A. parasiticus*. Although these fermented soybean products have rarely been shown to produce aflatoxin, they may contain homologs of several aflatoxin biosynthesis pathway genes (Shukla et al. 2017). Doenjang prepared through inoculation with a natural starter is commonly contaminated with aflatoxin. The fungal community present during traditional production is found to be the aflatoxigenic *Aspergillus flavus* (Zain 2011).

MYCOTOXIN MITIGATION

Official regulation and policy play an essential role in the mitigation of mycotoxin levels in foods among many countries. According to FAO data, at least 99 countries regulate mycotoxins content

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for food and/or feed in 2003. The number of countries shows an increase of about 30 percent compared to 1995. The total population in these countries represents about 87% of the total world population ("Worldwide Regulations for Mycotoxins in Food and Feed in 2003" n.d.). On top of that, perhaps special approach for the reduction of mycotoxin level in fermented soybean product need to be explored. As an example, fermentation of Meju using plant extracts (*Nelumbo nucifera* leaves, *Ginkgo biloba* leaves, and *Allium sativum* cloves) may significantly influence fungal microflora, leading to its quality improvement. This outcome could be due to the diminishing effects of the extracts against toxin-producing fungal pathogens (Shukla et al. 2017).

BIOGENIC AMINES

Biogenic amines (Bas) are low molecular weight, non-volatile nitrogenous bases with an aliphatic, aromatic, or heterocyclic structure, which have been found in fermented foods, such as fish products, cheese, wine, beer, miso, chunjang, jajang, kimchi, sufu etc. (Komprda et al. 2007; Pachlová et al. 2012; Renes et al. 2014; Alvarez & Moreno-Arribas 2014; Bai et al. 2013; Lee et al. 2019; Shukla et al. 2010; Guan et al. 2013; Byun & Mah 2012). The name of a biogenic amine is ascribed to the name of the amino acid from which it is derived. For instance, histamine is derived from the decarboxylation of histidine, and tyramine is formed from tyrosine through the same reaction (Santos 1996). The formation of biogenic amines in foods is mainly due to the presence of bacteria that are able to perform decarboxylation to certain amino acids (Renes et al. 2014; Bover-Cid et al. 2003; Buňková et al. 2013).

The bacteria with amino acid-decarboxylase activity are *Pseudomonas*, *Clostridium*, *Bacillus*, *Photobacterium*, *Enterobacteriaceae* family (*Escherichia*, *Klebsiella*, *Citrobacter*, *Proteus*, *Shigella*, and *Salmonella*), *Micrococcaceae* family (*Staphylococcus*, and *Micrococcus*), *Enterococcus*, *Lactobacillus*, *Carnobacterium*, *Pediococcus*, *Lactococcus*, and *Leuconostoc* (Santos 1996; Stadnik and J. Dolatowski 2010).

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In low amounts, the intake of BA in the human diet is usually not harmful to health because it can be detoxified by amine oxidase enzymes present in the intestine. These enzymes namely monoamine oxidase (MAO), diamine oxidase (DAO), and histamine N-methyltransferase (HNMT) can metabolize dietary BA in healthy people (Fogel et al. 2007). However, BA can turn into toxic metabolites that can threaten human health when the amount in the diet is too high or when the detoxification ability is inhibited or impaired in humans (Anderson 2008; Ruiz-Capillas & Herrero 2019). Since biogenic amines accumulation might occur if there are uncontrolled microbial enzymatic reactions (Halász et al. 1994), therefore the presence of BA in food is always undesirable because if absorbed at high concentration, it can cause headache, respiratory distress, palpitation, hypo or hypertension, and allergic reactions (Restuccia et al. 2015).

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BIOGENIC AMINE MITIGATION

The formation of BA in fermented soybean products is a complex phenomenon that depends on several factors, such as BA-producing strain or species, salt concentration, and high temperatures (Bai et al. 2013; Chun et al. 2020). Different concentrations of salt may affect the formation of BA. This happens due to high salt levels can inhibit the growth of microorganisms that produce biogenic amino acids, so that the production of decarboxylase enzymes decreases (Chun et al. 2020; Chin & Koehler 1986). It has been shown that thermal breakdown of BA can occur during high-temperature treatment such as cooking. After 10 minutes of frying at 200°C, there is approximately a 40% reduction in the levels of tryptamine and b-phenylethylamine. While other Bas namely cadaverine, histamine, tyramine, spermidine, and spermine show decreases ranging from about 10% to 20% (Bai et al. 2013).

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Up to date, most efforts on regulatory standards for monitoring biogenic amines are more focused on fish and seafood products than fermented soybean foods (Park, Lee & Mah 2019). The suggested

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toxic limit of BA content in fermented soybean products is 1000 mg/kg (Santos 1996) and 30 mg/kg for β-phenylethylamine, 100 mg/kg for histamine, and 100 mg/kg for tyramine (ten Brink et al. 1990). Attempts have been made to reduce the formation of BA in foods such as handling and processing under sanitary conditions, using some amine-negative starter cultures, adding some probiotic bacterial strains alone or in combination with the starter cultures, high-pressure processing, or low-dose gamma irradiation (Oh et al. 2014; Kim et al. 2005a; Mendes et al. 2005; Zhang et al. 2013).

In order to reduce BA concentration in fermented soybean foods, the use of a selected starter culture containing bacteria with less decarboxylase activity is one of the common ways to reduce the development of BA in soybean fermented foods (Alvarez & Moreno-Arribas 2014). The application of *Bacillus subtilis* and *Bacillus amyloliquefaciens* strains are able to reduce histamine levels in vitro by 27 – 46% and 70%, and tyramine contents by 42 – 59% and 71% respectively (Kim et al. 2012). Besides that, the use of *Lactobacillus plantarum* as a starter culture could decrease histamine and total BA content by 58 – 100% and 27%, respectively (Lee et al. 2016; Kung et al. 2017). Besides the application of BA low producing microorganisms for fermentation, the use of additives has been proposed as an alternative method for this purpose. The addition of ethanol to the dressing mixture during soybean fermentation has shown BA content reduction. It might be due to ethanol's ability to inhibit the degradation of water-soluble protein during the ripening stage (Qiu et al. 2018). Another additive such as nicotinic acid may reduce tyrosine decarboxylase activity of *Enterococcus faecium* isolated from cheonggukjang. It suggests that nicotinic acid could be used as tyrosine decarboxylase inhibitor to reduce tyramine content in vitro and in situ (Kang et al. 2018). Additionally, the application of gamma irradiation may not only reduce the usage of salt but also lessen biogenic amine levels during soybean fermentation (Kim et al. 2005). Though studies have described several methods to decrease BA content in vitro and in situ, practical application is still crucial to ensure the production of safe fermented food products (Park et al. 2019).

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HIGH SALT CONTENT

Fermented soybean products might use different methods and some of them may require a certain amount of salt. In general, the salt content is above 18% in soy sauce, 10-15% in douchi, and over 10% in dajiang (Liu et al. 2020). Sodium Chloride ~~is able to~~ control water activity, affect microbial growth and fermentation speed, make the fermented soybean products more savory and extend their shelf life (Liu et al. 2020). Salt is an essential seasoning used for making traditional fermented soy paste such as doenjang (Korea), miso (Japan), dajiang (China), and thua nao (Thailand) as well as ganjang, a soy sauce made with fermented soybean in Korea (Shim et al. 2016; Chun et al. 2020). As an example, a traditional Korean doenjang is made by fermentation of doenjang-meju bricks soaked in high solar salt concentrations (approximately 16 -18%) for one to two months (Jeon et al. 2016). Different concentrations of salt (NaCl) and temperature may influence microbial development and organoleptic quality fermented soybean products (Shim et al. 2016). Salt can inhibit the enzyme maturation process in the hydrolysis of proteins and lipids. The lower salt content in sufu (fermented tofu) can result in a decrease in hardness, elasticity, and the degree of degradation of proteins and lipids. Reducing the salt content can speed up the cooking time of the sufu, but it will also cause the sufu to spoil during the ripening stage with less salt content equal to 50 g kg^{-1} (Han et al. 2003).

Salt addition may reduce essential bioactive components that contribute to antioxidant properties during soybean fermentation, such as isoflavones. The amount of total isoflavones during the process sufu making can lose 68.7% of total isoflavones from soybeans due to leaching from materials. The change in isoflavones content is mainly during the preparation of tofu and salting of pehtze. Furthermore, Nacl concentration can inhibit isoflavones hydrolysis by beta-glucosidase activity during the fermentation (Li-Jun et al. 2004). Similarly, higher concentrations of NaCl in douchi (Chinese fermented black soybeans) production process may decrease isoflavone level and inhibit enzyme activity. It has been shown that total isoflavones content in douchi fermentation process reduced by 61% from raw soybeans during pre-fermentation (43%) and post-fermentation (18%)

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when the sodium content was 10% (Wang et al. 2007). Salt also can inhibit β glucosidase activity so that the conversion of isoflavone glucosides to isoflavone aglycones decreased. As a result, there is concern that high salt intake is associated with increased consumption of fermented products soybeans due to high salt is one of the major risk factors for hypertension (Komnenov et al. 2019). Therefore, it is necessary to make efforts to maintain the physicochemical properties and sensory quality of fermented soybean products by reducing the addition of salt, which appears as a problem in the field.

Despite this, the increase of government oversight and control in response to salt reduction, such as setting up the maximum amount of salt per-serving target, it is also necessary to engage with producers to reduce salt use in fermented soybean products. Salt reduction in fermentation has been the subject of studies. One common strategy is to identify the lowest salt concentration under which the growth of the fermenting microorganisms, as well as the flavor and texture of the fermented soybean products, will not be adversely affected. Several novel methods have been developed to produce low salt, or no salt fermented soybean products, such as natto, tempe, and kinema (Wang et al. 2007).

Selection and use of high-quality soybean cultivars

Food-grade soybeans are the raw materials for soy food products, with or without fermentation including tofu, soymilk, miso, natto, soy sprouts, and tempeh. Most food-grade cultivars share several common traits. They are non-GMO, have a high seed quality lacking mottling, cracking, etc. and, because most soy food products require a soaking step, thus rapid water uptake is essential (Anderson et al. 2019). Besides these traits, the advance of soybean breeding and cropping system provides not only better chemical composition but also yields preservation through resistance improvement toward weed, pathogen, insect pest, and abiotic stress (Anderson et al. 2019). Selection and use of cadmium (Cd) safe soybean cultivars for fermentation may avoid the undesirable metal accumulation in the

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human body from Cd contaminated soil (Zhi et al. 2020; 2015). A particular cultivar of soybean might be more suitable for specific fermented soybean products, for example, Saedanbaek cultivar provides better quality standards than other cultivars (Jinpung, Daepung 2, Pyeongwon, Cheonga and Saeolkong) for the fermentation process of the soy paste (Shin et al. 2019). This cultivar has shown an ability to produce higher amylase and protease activities, amount of viscous substance, and amino-type nitrogen contents (Shin et al. 2019).

Conclusions

Fermented soybean products (FSPs) have been the attention of scientific studies and consumers due to their nutritional values, bioactive components, and flavor profiles and texture. Even though FSPs are considered as safe foods, along with the development of society, people have become more aware of food-borne illness possibilities. Urgent attention is required to improve the safety and quality of fermented soybean products to prevent unwanted public health problems in the future. Anti-nutritional factors, pathogenic microorganisms and mycotoxins, the production of biogenic amines, the use of high concentration of salt during the fermentation process, and other safety hazards are still significant issues in fermented soybean production. In order to promote nutritional quality and safe fermented soybean foods, the following aspects are essential and should be taken into consideration. First, food regulation policy and standards need to be implemented, especially in industrial fermentation. Second, the application of pure, or excellent suitable strains under a controlled environment will produce a better conventional soybean fermentation process.

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Acknowledgments

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