



A LITERATURE REVIEW ON EFFECTS AND USES OF AROMATIC COMPOUNDS IN SOYBEAN

AUTHOR NAME

1. **Dr .Velhal Amol.**
Ph.D. (Registered)

Ph.D. Registered at Bharati Vidyapeeth's (Deemed to be university) College of Ayurved, Pune.

Email

velhalamol@gmail.com

Dr. Kirti Bhati

Associate professor
Guide for Ph.D.

Bharati Vidyapeeth's (Deemed to be university) College of Ayurved, Pune.

Abstract

Soybeans (*Glycine max*) are traditionally used as nutritious foods all over the world because of high protein and oil content. Soybean is the world's most important seed legume, as it contributes almost 25% of global edible oil, and about two-thirds of the world's protein requirement. Soybean's utilization is limited in some part the world because of characteristic soy flavor. This unpleasant flavor can be attributed to the presence of various chemicals such as

phenols, aldehydes, ketones, furans, alcohols, and amines. These flavor compounds usually interact with protein and lead to the formation of new off flavors. It may reduce the digestibility and nutritive value of soybeans. It is considered as off-flavor formation in foods is generally associated with lipid oxidation. According to some fats and oils also are responsible for many desirable and undesirable flavors. This article illustrates the volatile compounds isoflavones present in soybean, their role and impact on nutritional value.

Key words

Fats, off flavors, nutritional value oils, soybean

Introduction

Soybean (*Glycine max*) contains almost 35–50% of protein depending on its origin .it is a major source of protein in the human diet and equally useful for animal nutrition. Soybean protein also contains well-balanced amino acid and is a good source of many essential amino acids. Along with these soybean is a good source of carbohydrate conjugates, fatty acids (soybean oil), phytoestrogens, and inorganic materials (minerals). Their nutritional value is enriched by a large quantity of unsaturated fatty acids, B vitamins, and minerals, such as nitrogen, potassium, magnesium, iron, calcium, and phosphorus¹. Soybeans are also a good source of Isoflavone. Epidemiological and clinical investigations of postmenopausal ladies have proposed that isoflavones diminish their danger of osteoporosis and cardiovascular illnesses while reducing vasomotor symptoms². Soybean commonly available in India is one of the most nutritious pulses and practically feasible for cultivation. It has all macronutrients for better nutrition, protein, fat, carbohydrates, calcium, iron, vitamin B1, and phytoestrogens which are helpful to alleviate the menopausal problems³. Soy protein is also of the highest quality. Under guidelines adopted by the Food and Drug Administration and the World Health Organization for evaluating protein quality for children and adults, soy protein isolate receives a score of 1, which is the highest possible score. This means that the quality of soy protein is equal to that of meat and milk proteins. Also soybean is available in many varieties. Soy products of wide varieties have been prepared such as roasted soybean, boiled soybean, soymilk, soy mayonnaise, miso, soy cheese, soy yogurt, tempeh, soy sauce, tamari, Textured Vegetable Protein (TVP), or Textured Soy Protein (TSP) and tofu⁴.

Soybean oil used as cooking oil. Generally cooking oils sold as “vegetable oil” contains soybean oil. Most of the fat in soybeans is unsaturated. Polyunsaturated (primarily linoleic acid), monounsaturated (oleic acid) and saturated (primarily palmitic acid) fatty acids comprise about 63 percent, 23 percent, and 14 percent, respectively, of the total fat content of soybeans⁵. The polyunsaturated fat content of soybeans is of interest because it includes alpha-linolenic acid (7 percent of the total fat content), an essential omega-3 fatty acid. Soybeans are one of the few good plant sources of both essential fatty acids⁵.

Various aromatic compounds in soybean

These volatile compounds are made of terpenes derived from fatty acids and aromatic compounds. These volatile compounds act as signals for other organisms and for the plant itself. The main functions of these compounds are to attract pollinators, seed dispersers. They also defend the plants by repelling insects or detaining colonization of pathogenic bacteria and fungi⁶. Soybean is particularly rich in various volatiles, including alcohols, acids, esters, aldehydes, ketones, phenols, furan(one)s, pyrazines, pyrones, and sulfur-containing compounds. Many of these have been linked to the main odor qualities of soybean, namely malty, caramel-like, cooked potato-like, floral, alcoholic, sour, smoky, seasoning-like, and fruity⁷.

List of Volatile Compounds Reported in Soybean⁷

1. Acids

- a. 2-methylpropanoic acid
- b. 2-methylbutanoic acid
- c. 3-methylbutanoic acid
- d. benzoic acid
- e. 2-phenylacetic acid
- f. butanoic acid
- g. acetic acid
- h. 3-methylpentanoic acid
- i. 4-methylpentanoic acid
- j. pentanoic acid
- k. hexanoic acid
- l. nonanoic acid

- m. decanoic acid
- n. phenylacetic acid

2. Alcohols

- a. ethanol
- b. 2-methyl-1-propanol
- c. 2-phenylethanol
- d. 3-methyl-1-butanol
- e. 2-methyl-1-butanol
- f. butanediol

3. Aldehydes

- a. phenylacetaldehyde
- b. benzaldehyde
- c. 2-methylbutanal
- d. 3-methylbutanal
- e. 2-methylpropanal
- f. octanal
- g. nonanal
- h. trans-4,5-epoxy-(E)-2-decenal
- i. 4-hydroxy-3-methoxybenzaldehyde

4. Esters

- a. methyl benzoate
- b. ethyl benzoate
- c. ethyl 2-methylpropanoate
- d. 54 ethyl
- e. ethyl propanoate
- f. isoamyl benzoate
- g. ethyl hexanoate
- h. ethyl octanoate
- i. methyl 2-methylpropanoate
- j. ethyl phenylacetate
- k. phenylethyl acetate
- l. ethyl 2-hydroxypropanoate

5. Furan(ones)

- a. 3-methyl-2(5H)-furanone
- b. 4-decanolide
- c. 3-phenylfuran
- d. 5-decanolide
- e. 3-hydroxy-4,5-dimethyl-2(5H)-furanone (sotolone)
- f. 5-dimethylfuran
- g. 1 2-pentylfuran



6. Ketones

- a. (E)- β -damascenone
- b. 2,3-butanedione
- c. 2-butanone
- d. 6-dimethyl-4-heptanone sweet
- e. 3-hydroxy-2-butanone
- f. 1-octen-3-one

7. Phenols

- a. 4-ethylguaiacol
- b. guaiacol
- c. 4-vinylguaiacol
- d. 4-vinylsyringol
- e. syringol
- f. 4-ethylphenol

8. Pyrazines

- a. 2,3,5-trimethylpyrazine
- b. 2-isobutyl-3-methoxypyrazine
- c. 2-isobutyl-3-
- d. 2-isopropyl-3-methoxypyrazine
- e. 2-ethenyl-6-methylpyrazine
- f. 2-methylpyrazine
- g. 2,5-
- h. 2,6-dimethylpyrazine
- i. 2,5-dimethyl-3-ethylpyrazine
- j. 2,3-diethyl-5-methylpyrazine
- k. 2-ethyl-3,5-
- l. 2-ethyl-3-methylpyrazine
- m. 2-isoamyl-6-methylpyrazine

9. Others

- a. 3-methylindole
- b. 2-methyl-4-pyranone (maltol)
- c. 2'-aminoacetophenone
- d. 3-acetyl-1-
- e. styrene
- f. naphthalene
- g. dodecane
- h. hexadecane
- i. limonene



Effects of volatile compounds

Isoflavones are subgroup of flavonoids is highly potent antioxidants. Consumption of soy products has many health benefits, including protection against breast cancer, prostate cancer, menopausal symptoms, heart disease and osteoporosis. Isoflavones are produced from a branch of the general phenylpropanoid pathway biosynthesis. This pathway begins from phenylalanine. It produces flavenoid compounds in legumes and is stored as glucosyl- and malonyl-glucose conjugates⁸. The major isoflavones in soybean are genistein, daidzein, and glycitein. They are available as 50% genistein, 40% daidzein, and 10% glycitein of total isoflavone profiles. The chemical structure of isoflavones is closely resembled to that of the primary female sex hormone, estrogen. Thus, isoflavones are called as “phytoestrogens”. The role of phytoestrogens present in plant is to protect from stress and to act as part of a plant’s defense mechanism. Isoflavones content in soy foods is variable among brands and preparations⁹. Among the phytoestrogens, isoflavones and lignans are commonly used to relieve menopausal symptoms, as they are abundant in fruits, vegetables, legumes, and soy¹⁰.

Vasomotor symptoms of menopause, including hot flashes, night sweats, and insomnia (as a consequence), are the essential symptoms of postmenopausal estrogen deficiency¹¹. Various study showed that soy intake reduced the incidence of hot flashes. During clinical research, a randomized double-blind study in menopausal women found that the administration of 30 mg of genistein for 12 weeks reduced hot flashes by 51% (9.4–4.7/day), whereas, the placebo group experienced only a 27% reduction (9.9–7.1/day)¹².

Studies have also pointed out that the ability of women to produce equol may be the major determinant of whether or not isoflavones can effectively reduce VMS. A systematic review and meta-analysis of RCTs assessed the efficacy of soy isoflavones and equol for alleviating menopausal symptoms (especially vasomotor symptoms) in postmenopausal women who were either equol producers or nonproducers¹³. The result of this meta-analysis revealed a significant benefit of equol for decreasing hot flash scores. This study concluded that supplementing equol to equol nonproducers significantly lowered the incidence and/or severity of hot flashes in menopausal women¹³.

Soy is used for high cholesterol, high blood pressure and preventing diseases of the heart, blood vessels. It is likewise utilized for type 2 diabetes, asthma, lung function, all kind of cancers (lung cancer, endometrial cancer, prostate cancer and thyroid cancer) and additionally preventing weak bone(osteoporosis) moderating the progression of kidney diseases. Other utilize incorporates treating constipation and diarrhea, and in addition decreasing protein in the urine of individuals with kidney disease, improving memory and treating muscle soreness caused by exercise. For women soy is used to relieve breast pain, preventing breast cancer, preventing hot flashes for breast cancer, menopausal symptoms and premenstrual syndrome (PMS)¹⁴.

Other effects of Isoflavones

Symptoms/Disease	Effects of isoflavens
Vasomotor	Reduction of hot flashes, night sweats, and sleep disturbances frequency; as well as depression symptoms and memory loss ¹⁵
Cardiovascular	Reduction of myocardial necrosis, macrophage and serum levels of TNF- α , severity of atherosclerosis, and myocardial infarctions incidence ¹⁶
Obesity	Reduction of serum concentration of total cholesterol, LDL, triglycerides, and HDL ¹⁷
Diabetes	Reduction of fasting glucose concentration, insulin resistance, and improves glycemic metabolism ¹⁸

Cancer	Reduces the incidence of breast, hepatocellular, lung, gastric, and ovarian cancer ¹⁹
Stress responses	Improves 5-HT metabolism, stabilizes MAO activity, and improves turnover ratio of 5-HIAA/5-HT ²⁰

Causes for formation of off flavors

Soybean contains suspended non-glyceride materials (fatty acids, phosphatides, sterols, metals, hydrocarbons, pigments, and protein fragments). These compounds are considered undesirable because they contribute offensive flavors and other undesirable reactions in the presence of oxygen and/or heat²¹. Various volatile compounds usually serve as indicators of developmental maturity and as biochemical markers to evaluate seed quality. Several compound classes identified were alcohols, aldehydes, esters and lactones, ketones, and terpenoids. Many reports are available on the key volatiles of soybean²². The development of objectionable off odor detection and classification methodology for use in grain grading has stimulated research on volatile components of soybeans and grains²³.

Mechanisms for formation of flavors during lipid oxidation

Flavor deterioration in vegetable oils is very common especially in soybean oil because it is the dominant source of edible oil. The oxidation of unsaturated fatty acids, such as oleate linoleate and linolenate (which are the main fatty acids in vegetable oils) when oxidized produces odor and is due to generation of carbonyl compounds such as aldehydes and ketones. Some researchers have found that flavor compounds may come from the oxidation of minor fatty acids in the oil, such as furanoid fatty acids²⁴. This oxidation process is much complicated that many of the oxidation products are not well identified.

Generally, the flavor carbonyl compounds are derived not only from the decomposition of hydroperoxides formed by the reaction of unsaturated fatty acids with oxygen, but also from the decomposition of secondary oxidation products, such as hydroperoxides, unsaturated aldehydes and ketones, dimers or other polymers of hydroperoxides, and the reaction between unsaturated fatty acids and hydroperoxides²⁵.

The formation of hydroperoxides is due to autoxidation (free radical mechanism) and photosensitized oxidation by participation of light and sensitizers.

Enzymatic oxidation of linoleic acid and linolenic acid by lipoxygenase genes (Lox) is reported as a major cause of the beany flavor²⁶, and in soybeans there are three separate genes, Lox1, Lox2 and Lox3 controlling this trait²⁶. Hexanal is commonly associated with the grassy flavor; hexanol; 1-octen-3-ol; 1-octen-3-one; trans,trans-2,4-decadienal; and trans,trans-2,4-nonadienal are other aromatic compounds linked with the beany taste in soy meal products²³.

Effect of fermentation on aromatic compounds

There are essentially two fermentation processes: traditional fermentation and acid hydrolysis. Traditional fermentation uses starter cultures of microorganisms which secrete enzymes capable of breaking down the proteins, lipids, and starches into peptides, free amino acids, volatiles, and saccharides²⁷.

Fermentation process carried out in seeds inoculated with different microorganisms produced significant changes in flavonoids and phenolic acids contents. A significant increase in the content of phenolic acids was observed in the samples fermented with the different microorganisms with respect to soybean without fermentation and fermented naturally²⁸. Fermentation process produced also important changes in flavonoids compounds, with a significant formation in isoflavone aglycone contents such as daidzein, glycitein and genistein as a consequence of glucosidase activity of microorganism in this process²⁸. Food fermentation

during processing or gut digestion breaks glycoside bond by β -glucosidase enzymes of starter microorganisms used in food transformations or by microbial strains of gut microbiota after ingestion²⁹. Breaking of glycoside bond leaves isoflavones in aglycone form.

Conclusions and future perspectives

Soybean (*Glycine max*) is the world's most important seed legume and it contributes 25% of global edible oil. It has attracted the attention due to its nutritional value. This value is due to presence of proteins, amino acids, fat, carbohydrates, calcium, iron, vitamin B1, and phytoestrogens which are helpful to alleviate the menopausal problem and also cardiovascular, metabolic good effects. This food is popular because flavor, aroma, and overall acceptability by population all over the world. One of the factors that limit soybean's utilization as a major source of protein for humans is its typical, characteristic soy flavor. This off flavor is due to the presence of various chemicals like phenols, aldehydes, ketones, furans, alcohols, and amines. Along with this, these flavor compounds interact with protein and cause the formation of new off flavors. More comprehensive research is required to understand the causes for formation of off flavors, mechanisms behind formation of flavors during lipid oxidation, mechanisms of action of volatile compounds.

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