

# [Causes and minimization of soybean flavour via enzymes](https://assignbuster.com/causes-and-minimization-of-soybean-flavour-via-enzymes/)

Lipids, proteins, carbohydrates, as well as vitamins and minerals are main food ingredients that are responsible for flavour in vegetables. These compounds may give rise to volatile and non volatile compounds that give vegetable its characteristic odour and taste (Sessa, 1979). Soybean is very popular and unique in its ability to be cholesterol free and lactose free, and also because it provides good source of nutrients at low-cost such as proteins, minerals, vitamins and phytochemicals (biological active components derived from plants) and also is a source of oil and therefore it is classified as an oilseed and has a reputation of being natural and good for health (Martin et al, 2010). Soybean originated from Asia, was first cultivated in china and is most common in Asian countries and is grown by farmers since centuries. Soybean is a good source for providing useful protein especially in countries where people are protein deficient, or lack of proteins from animal source, or for those people that are lactose tolerant and cannot consume cow’s milk for them soymilk is available, which is made from soybean and is healthy and rich in protein. Soybean is used to produce many food products such as soymilk powders, flour, oil, soybean curd, chocolate, ice-cream, etc (Martin et al, 2010; Stephan et al, 2000). Although in many western countries acceptance of soybean has not been much successful due to its strong grassy/beany flavour which is unpleasant in taste and is unfavourable according to most consumers. Therefore, much research has been done to improve soybean flavour. According to many studies done on soybean flavour, lipid oxidation (lipoxygenase) an iron containing enzyme which is common in plants and animals, which undergoes Fe2+ to Fe 3+ transitions during per oxidation of fat catalyses the peroxidation of unsaturated fats to hydroperoxides is said to be responsible for the off flavour which breaks down during hydration, which will be further discussed in this review.

Causes of beany Flavour

During cultivating soybean, it is found that it is beneficial to environment in terms of nitrogen and other minerals that benefit the soil by increasing carbon, nitrogen, phosphorous contents in soil.

Unpleasant flavour such as beany /grassy flavour of soybean are generated from the lipids through

lipoxygenase during the process of roasting, fermentation and germination, the lipoxygenase breaks down the oil into a number of chemicals including hexanal, and methanethiol and these chemicals result in off-flavours which are described as beany and grassy primarily in soybeans ( Suratman et al, 2004; Wszelaki et al, 2005). Lipoxygenase in soybean seeds is present in the form of three isozymes ( Lox-I, Lox-II and Lox-III) (Kumar, et al, 2003). Soybean is an iron containg enzymes which catalyzes the oxidation of polyunsaturated fatty acids with cis, cis-1, 4-pentadiene units to produce conjugated unsaturated fatty acid peroxides which are rensposible for the off flavour in soybeans as well as bitter taste (Li et al, 2008; Wang et al, 2008). It comprises of enzymes that are commonly found in soybean, can arise by either hydrolysis of fatty esters or oxidative fat corrosion. Naturally occurring enzymes such as lipid acyl-hydrolases, directly hydrolyze the fatty ester bonds of triglycerides and phospholipids, producing free fatty acids.

Lei and Boatright, 2005, revealed the importance of methanethiol to the characteristic odour of soybean which could give rise to a volatile sulphur compound; dimethul trisulfide is responsible for the off odour. Although the means for the effect of lipoxygenase on the formation of methanethiol is not well known, but is thought to be due to release of the free radicals formed during oxidation of polyunsaturated fatty acids. Methionine residues in soy protein products are aggregated by such free radicals, resulting in the formation of methionine sulfoxide which generates methanethiol as a final product as proposed by Lei et al 2005. Therefore, the data from current studies suggest that lipoxygenase not only catalyzes the oxidation of polyunsaturated fatty acids, resulting in the formation of volatile aldehydes, ketones, and alcohols, but also promotes formation of methanethiol (Lozano et al, 2007). Flavours developed depend on the composition of the fat with short chain fatty acids to C10 having particularly disagreeable odours flavours and those above C1O possessing waxy or, at alkaline pH, soapy flavours. Hydrolytic fat corrosion is not much important in terms of flavour formation when compared with flavours from oxidative deterioration of free fatty acids. Strong soybean-like flavours

have been found in model systems consisting of hydroperoxides generated by the oxidative action of soy lipoxygenase on pure linoleic and linolenic acid. Volatile Compounds produced contribute to the

grassy and beany flavours, while non volatile compounds cause bitter and astringency.

In addition, scientists have found that lipid hydroperoxides produced by Oxidation readily form in soybean seeds when compared with other vegetables. Once formed, hydroperoxides undergo decomposition to both volatile and non volatile compounds. Many volatile Compounds generated either by the action of enzymes or by autoxidation of polyunsaturated lipid. A volatile synthetic compound, 2(l-pentenyl) furan also was found to contribute to the beany and grassy notes of soybean oil. It was hypothesized to arise from autoxidation of linolenic acid. According to Zhou et al, 2000, 2-pentyl pyridine (2-pp) has the largest flavour value of any other flavour volatiles found in soybean products. While volatile compound contribute to beany flavour, non-volatile oxygenated fatty acids impart a bitter taste to soybeans and dried peas. For example, trihydroxy fatty acids generated by the action of soy lipoxygenases on linoleic acid is responsible for the bitter tastes but due to its low concentration it is unlikely to be the main cause off odour (Stephan et al 2000) .

According to many studies peroxides, lipoxygenase, and phospholipids are the main cause of off odour in soybean and many studies show that pH and temperature may also have influence on the flavour impact causing undesirable taste. According to Iassonova, removing lipoxygenase (LOX) isozymes can reduces the amounts of volatile off-flavor compounds in soybeans and soy products drastically, but are not completely eliminated. The present work presents evidence that lipoxygenase-null (LOX-null) soybeans contain a LOX-like enzyme that is responsible for the offflavors in LOX-null soybeans. Volatiles production in triple LOX-null soybeans was terminated by heat treatment, which suggests an enzymatic cause to the off-flavors. The source is LOX-like in that the volatile compounds produced are similar to LOX-generated products of polyunsaturated fatty acids. Oxygen was consumed when a LOX-null protein solution was incubated with crude soybean oil suggesting that the enzyme catalyzed oxygen consuming reactions. The generation of flavour compounds was inhibited by the typical LOX inhibitors propyl gallate and nordihydroguaiaretic acid (NDGA). The enzyme appears to be more active with phosphatidylcholine than with other lipid substrates. The cause of the off-flavors in LOX-null beans appears to have enzyme-like characteristics (Iassonova et al, 2009).

Strategies adapted to reduce beany flavour

Although soy is rich in its nutritional value, it has not been much popular due to its beany unpleasant flavour; therefore many methods have been considered in order to get rid of this lipid derived beany off flavour in soybean which is due to lipoxygenase activity. Soybean proteins can be readily be modified by chemical, physical and enzymatic treatments changes the functional properties of the protein such as leading to flavour change. Methods such as heat treatment, pH adjustment, hydrolysis, enzyme treatment, ingredients addition, thermal modification, and breeding of soybean with low beany flavours have been used to eliminate/ reduce unpleasant beany flavour of soybean (Heywood et al, 2002; Suratman et al, 2004). According to Heywood et al, 2002, value enhanced soybeans (genetic modified/breed) have transformed fatty acid/ protein composition which means volatile compounds are removed that cause unpleasant beany flavour. According to Iassonova et al, 2009; removing lipoxygenase (LOX) isozymes can reduces the amounts of volatile off-flavor compounds in soybeans and soy products drastically, but are not completely eliminated.

Temperature also has significant effect on soybean protein where significant decrease in unpleasant flavour compound was observed at lower temperature around 5. 5 C (lower than room temperature). In many studies it was investigated that at higher temperatures the methanethiol increased and vice versa (Heywood et al, 2002). Also heating increases the digestibility of soy protein. Similar results were reported by Rehman et al, 2007, according to him soymilk prepared by heating soybean grains at least 15min at 100 C soaking in water at pH 8, (soybean water extract) improved the flavour and taste to some extent but did not completely eliminate the unfavourable flavour, it only had less beany flavour and more protein solubility and also improved colour consistency. Similarly Machado et al, 2008 reported that the anti-nutrients in soybean such as Kunitz (protease inhibitor that reduces the nutrient level of soybean) can be inactivated by heat treatments (wet) or biochemical treatments or either by selecting soybean varieties (could be modified/ genetically grown) that lack these protease inhibitors along with heat treatment such as wet heat rather than dry heat. Soybean was heat treated for 15 minutes ( as excess heat could completely denature the protein i. e. decrease the solubility and nutrition value) and as a result the trypsin inhibitors (which was seen to be dependent on moisture level) were inactivated without affecting the quality of soy protein the in terms of nutrition value.

Thermal treatment the most common old method used to modify soy bean flavour without affecting the nutritional value. This treatment is used to eliminate lipoxygenase activity in soybean which produces volatile compounds responsible for off odour. Enzyme modification are conducted to eliminate undesired flavours (beany) caused by hexanal. Alpha-tocopherol and isoflavones, both naturally occur in soybeans. Are antioxidants which inhibit enzymic oxidation of linoleate with lipoxygenases . Method’s are developed to free naturally occurring antioxidants of enzyme inhibitors. Cysteins under aerobic conditions interacts with the catalytic site of lipoxygenase and induces irreversible inactivation of the enzyme. Cysteine reacting with linoleic acid prevents formation of volatile flavour compounds. In line with Li et al, 2008, and Wang et al, 2008, although the thermal treatment inactivates effectively soybean lipoxygenase (LOX), it denatures soybean proteins, results in amino acid degradation and other deteriorative reactions. Although there are concerns over the affects of flavours, texture, colours, vitamins and nutrients by thermal treatment, therefore, inactivation of soybean LOX by non-thermal treatment is aimed in order to avoid quality loss of soymilk by thermal processing and new techniques are introduced such as high pressure techniques for better quality and taste. Pulsed electric fields (PEF) a non-thermal food preservation method and become increasingly a promising option to thermal pasteurization. In comparison with traditional thermal pasteurization, PEF dramatically lead to inactivation of LOX activity and denature of enzymes in soymilk PEF not only can kill microorganisms and inactivate enzymes, but maintains taste, colour, texture, vitamins, and nutrients, of foods.

Gas chromatography-mass spectrometry was used to determine the content of methanethiol in soybean which occurred in every sample of soybean tested (Lei et al, 2005) which gives out unpleasant odour. It also was observed that if pH levels were increased the amount of methanehtiol also increased due to breakdown of methionine. Cyclodextrin, which masks beany flavour molecules by reducing or changes the food flavour overall have been used to eliminate the molecules responsible for the off flavours in soybean. Hexanal is reported to be the main sources of beany flavour have been used to inactivate soybean lipoxygenase activity but it is found that it lowers the protein solubility. Another method is soaking soybean in ethyl alcohol and PH adjustment. Off-flavour is only observed when the soybean cells are borkendown/ or during cooking where many chemicals (e. g. linoleic acid; ketones, aldehydes, and alcohol) are released which give off odour (Rehman et al, 2007). According to Stephan et al, 2000 saturated free fatty acids (FFAs) did not produce any bitterness in the concentrations investigated, and were able to influence the bitter taste of emulsions essentially even if they are present in concentrations that are only slightly above their thresholds.

Fig. 1. Improved soybean products (Bay, 2006)

Various methods have been employed to inhibit lipoxygenase. Enzyme inactivation by blanching whole soybeans before grinding of soaked soybeans prevents formation of oxidized flavour in the production of bland-flavoured soy milk. Heat inactivation of lipoxygenase by extrusion cooking yields full-fat flour with improved odour, flavour, and stability. Further low pH inhibits lipoxygenase in soybeans and other legumes. Thereby minimizing the formation of volatile compounds for example flavourless tasting slurries free of lipoxygenase- induced off-flavours and odours were produced by grinding and fractionating raw soybeans under pH 3. 8 for enzyme inactivation with saturated monohydric alcohols.

Flavour of soy flour should be improved with alcohol or heat treatments. Alteration of flavour causing aldehydes to alcohols by means of an enzyme alcohol dehydrogenase could reduce flavour because alcohols generally have higher flavour thresholds than corresponding aldehydes. . Alcohols produced by this reaction can act as enzyme inhibitors in the meals, or they can be more readily extracted from meals unlike aldehydes because alcohols do not bind to proteins . Present processes for preparing soyflour, concentrate, and isolates generally involve solvent extraction, aqueous extraction, drying, and toasting. Products with improved flavours through these procedures are commercially available. One current method is used to achieve soybean with acceptable flavour, better quality, and reducing any undesirable characteristics. (fig. 1.). In this method soybean is mixed in an heated aqueous salt solution to form a mixture, heating leads to deactivation of enzymes that are responsible for beany flavour. This improved misture is further processed (drying, roasting, powdering, and flavouring) so can be used in a variety of food products.

Conclusion

Although soybean milk is recognized as a nutritious beverage, it contains much lower calcium than cow’s milk. To eradicate the off flavour, scientists throughout the world have been in an attempt to find soybean’s that lacked lipoxygenase enzymes thought processes such as mutation, hybridization and selection they were able to find few that few of the enzymes. These soybeans are now being used in soymilk production and other food products and no longer have the off flavour (beany flavour).

Therefore, according to Rehman et al, 2007 soybean in water at pH8 showed to have less beany flavour and more protein solubility, similarly according to Wang et al 2008 high pressure was found be effective in slightly reducing off flavour by deactivating lipoxygenase in soy products such as milk and gave improved taste and flavour , these results were also in line with the finding with Li et al, 2008 who studied the inactivation of soybean lipoxygenase due to thermal treatment but is shown to affect the quality of food and similarly results reported by Wang et al, 2008. Although there are concerns about reduction in protein content or health affect when soybean is modified in order to eliminate the unacceptable odour, since consumers concern has always been on quality, appearance, taste, smell, and texture. According to Lei and Boatright, 2005 little is known about factors that influence occurrence of methanethiol in soy products.