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FUNCTIONAL FOODS: GARLIC

FONKSİYONEL BESİNLER: SARIMSAK

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ÖZET

Sarımsağın (Allium sativum) anti-mikrobiyal, anti-fungal ve anti-helmintik özellikleri tarih boyunca iyi bilinmektedir. Bu derleme, sarımsağın biyoaktif bileşenlerinin hazırlanması ve tüketilmesiyle şu anda ilişkili çeşitli sağlık yararlarını açıklamakta ve tartışmaktadır. Sarımsak, geleneksel tıpta binlerce yıldır yaygın olarak kullanılan popüler bir fonksiyonel besindir. Zamanla, sarımsak ekstraktındaki çeşitli organosülfür bileşikleri, sağlık üzerindeki yararlı etkileri nedeniyle giderek daha önemli hale geldi. Son yıllarda yapılan klinik çalışmalardan ve klinik öncesi denemelerden elde edilen kanıtlar, sarımsağın kanser önleyici, aterosklerotik önleyici, tansiyon düşürücü, diyabet önleyici ve hipolipidemik etkilerini desteklemektedir. Son yıllarda yapılan klinik çalışmalardan ve klinik öncesi denemelerden elde edilen kanıtlar, sarımsağın kanser önleyici, aterosklerotik önleyici, tansiyon düşürücü, diyabet önleyici ve hipolipidemik etkilerini desteklemektedir. Sonuç olarak, sarımsak tüketimi ile ilişkili sağlık yararları, çeşitli allisin, ajoen, vinil-ditiin ve alliinden metabolize edilen diğer uçucu organosülfür bileşiklerini içerir. Bu nedenle sarımsağın çeşitli aktif metabolitlerinin çok hedefli moleküler aktiviteleri ve ciddi yan etkilerinin olmaması nedeniyle hastalıkların tedavisinde ve önlenmesinde faydalı olabileceği bildirilmiştir. Bu derlemenin amacı, sarımsak hazırlama yöntemlerine bağlı olarak sarımsakta organosülfür bileşiklerinin değişimi ve oluşumu ile ilgili mekanizmaları özetlemektir.

Anahtar Kelimeler: Fonksiyonel, Fonksiyonel gıda, Sarımsak.

ABSTRACT

The anti-microbial, anti-fungal and anti-helmintic properties of garlic (Allium sativum) have been well known throughout history. This review describes and discusses the various health benefits currently associated with the preparation and consumption of the bioactive components of garlic.Garlic is a popular functional food that has been widely used in traditional medicine for thousands of years. Over time, the various organosulfur compounds in garlic extract have become increasingly important for their beneficial effects on health. Evidence from clinical studies and pre-clinical trials in recent years supports the anti-cancer, anti-atherosclerotic, anti-hypertensive, anti-diabetic and hypolipidemic effects of garlic.Examples of bioactive compounds with these positive functional properties in garlic are diallyl trisulfite, allicin, allyl mercaptan diallyl disulfide and diallyl sulfide. In conclusion, the health benefits associated with garlic consumption include various allicin, ajoene vinyl-dithiin, and other volatile organosulfur compounds metabolized from alliin. Therefore, it has been reported that various active metabolites of garlic may be useful in the treatment and prevention of diseases due to their multi-targeted molecular activities and the absence of serious side effects. The aim of this review is to summarize the mechanisms related to the exchange and formation of organosulfur compounds in garlic depending on the garlic preparation methods.

Keywords: Functional, Functional food, Garlic.

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INTRODUCTION

Known as the Liliaceae family, garlic (Allium sativum L.) is a bulbous plant widely used in cooking and also for medicinal purposes due to its rich flavor and abundant sulfur-based ingredients. It is thought to originate from the Latin word "olere" meaning "to smell". However, despite its pungent smell, garlic is still consumed all over the world due to its unique aroma. Allium sativum L. has been used for 5000 years since ancient times. We understand from the written tablets that garlic has been used medicinally since ancient times. In ancient times, garlic was often used as a remedy for intestinal disorders, gas, intestinal worms, respiratory tract infections, skin diseases, wounds, signs of aging, and many other ailments (1).

In fact, garlic can be a good example of functional foods. In the literature (PubMed), the positive effects of garlic as a functional food on health have been determined by many scientific articles. Garlic, as a functional food, is usually consumed by cooking or processing. When we look at the content of bioactive compounds as a functional food, garlic is quite complex. Raw garlic bulbs contain a large amount of water (68%), less carbohydrates (about 28%), about 2% protein, 1.2% amino acids and 1.5% fiber, fatty acids, small amounts of phenols and trace elements. In addition, raw garlic contains more than 33 (about 2%) sulfur-containing compounds (2).
However, organosulfur compounds, phenolic compounds and fructans are its three main early components. Various garlic extraction techniques can be used to process garlic, such as soaking in lemon, vinegar or oil, roasting, steaming or drying. Even the simplest processes, such as peeling the garlic, cause changes in the content of the garlic and the formation of new products in the garlic content (2-4). As a result of the powerful reactive properties of garlic, it contains large amounts of sulfur-based substances that are easily converted into various volatile compounds during processing. In addition, the volatile profiles of processed garlic are affected by processing conditions such as temperature, pH and solvent. For example, thiosulfinates and their degradation products contribute to the pungent odor of garlic, making it difficult to consume (5).

Volatile Components of Raw Garlic

The most important component in garlic are organosulphur compounds (OSCs). Sulfur-containing OSCs in garlic compounds are broadly divided into two groups: they are oil-soluble and water-soluble OSCs. In fact, the fat-soluble OSCs found in garlic are sulfur compounds such as alliin, allicin, and ajoene. Fresh garlic contains alliin [S–3-(2-propenylsulfinyl)-L-alanine-], an odorless cysteine derivative. Fresh garlic cloves contain isoallin, which is mainly composed of alliin (S-allyl L-cysteine sulfoxide), followed by methiin (S-methylcysteine) sulfoxide) and γ-glutamyl cysteine (6). When garlic is crushed, chewed, or cut, the enzyme alliinase is released and alliin is converted to allicin (allyl 2-propenthiosulfinate). Therefore, intact garlic cloves do not contain allicin; Both alliin and the enzyme are found in different parts of the garlic clove. But when fresh garlic is crushed, alliin can convert alliin into allicin (S-allyl 2-propene-1-sulfinothioate), which represents the characteristic odor of crushed fresh garlic. In fact, allicin as the active ingredient is the most abundant thiosulfinate formed through allinase reactions (6, 7). A clove of garlic contains 8g/kg of alliin, an important component of OSCs (2). Fortunately, alliin and other cysteine sulfoxides are found in different compartments of the garlic cell. However, when garlic is peeled and crushed, the enzyme allinase is released in the garlic cell and can catalyze these molecules.

Alliinase enzyme (approximately 10%), which makes up the protein part of garlic, is sensitive to acids and stomach acid. In addition, alliinase enzyme and Alliin substrate can form enzyme-substrate complex in the presence of optimum temperature (33 °C), mild acid (pH: 6.5) and water. Therefore, enteric-coated tablets can be used in the preparation of garlic supplements (8).

Allicin, the most abundant thiosulfinate, is sparingly soluble in water and is responsible for a pungent and unpleasant taste, but is very unstable and can be easily converted into numerous products classified as oil-soluble. This degradation takes place within hours at room temperature and within minutes during cooking.

The products that can be formed during the cooking process in oily media are: dithiins (formed by the dimerization of thioacrolein formed by the β-elimination of allicin), followed by ajoene, allyl methyl trisulfite (AMTS), diallyl sulfide (DAS), dialyl. Contains other sulfur compounds, including diallyl trisulfide (DATS) (7-9). Conversely, when Garlic is extracted in aqueous solvent, the metabolites allyl mercaptan (AM) are converted into γ-glutamyl-S-alk(en)yl-L-cysteines, S-allylcysteine (SAC), S-allylmercaptocysteine (SAMC), methyl sulfide. (AMS) and allyl. OSCs that are actually formed in aqueous media are water-soluble organosulfur compounds with less odor, more active and less characteristic taste than oil-soluble OSCs. However, water-soluble OSCs are the most important compounds in functional foods, although they make up a small portion of garlic (10, 11). As a result, aldehydes formed when garlic is heated are the predominant compounds in black garlic, while esters and phenols are key flavor compounds in aged garlic extract. These small differences in chemical reactions during the aging process in aqueous media may cause differences in flavor of the two types of garlic, depending on the difference in the products formed (12).

Among the various commercially available garlic processing products, black garlic (BG) is well known and most studied as a functional food. BG is an ancient form of garlic obtained from raw garlic through the Millard reaction under high temperature (60–90 °C) and humidity (70–90%) for a period of time. The offensive and pungent smell of fresh garlic turns into a chewy texture and sweet taste as it ages. The aging process not only changes the nutrients and sensory properties of BG, but also improves its bioactivity (12-14).

The volatile compounds in raw and heated garlic cloves obtained by various extraction methods differ. In the study of Abe et al., a total of 85 sulfur-containing compounds and 40 non-sulfur compounds were reported in garlic. (5). Thiosulfinates such as allicin are reactive molecules and consist of dialyl, methyl allyl and diethyl mono-, di-, tri-, tetra-, penta- and hexasulfides, vinyldithiins, and (E)- and (Z)-ajoene(15,16). Analytical methods significantly affect the composition and number of detected compounds. However, Allicin, which is one of the active substances, is converted into active organosulfur compounds in water at room temperature over a long period of time. Conversely, when BG used in commercial production is heated or at high temperature, it can quickly cause the flavor of fresh garlic to change faster than expected (15-17).

The nature of volatile compounds in garlic cloves during heating

This section focuses on how the flavor of fresh garlic is changed or transformed through processing, particularly heating. There are few reports of analysis of volatile compounds in cooked garlic samples. Researchers have demonstrated profiles of organosulfur compounds, including allicin, E or Z-ajoene, dithiins, diallyl sulfide, diallyl disulfide, and diallyl trisulfide, in solvent extraction of precooked (chopped, sliced and whole cloves) and cooked (boiled) cloves (15-19).The results showed that allicin content could be determined in precooked samples, while cooking significantly affected the levels of diallyl disulfide and diallyl trisulfide. These two compounds exhibited the highest levels with increasing processing temperature (boiling and stir-frying).Especially the aroma of raw garlic and its precursors are destroyed by these heating processes. As a result, the aroma of heat-treated garlic is:

i) acrylic sulfur-containing compounds such as thiol and sulfur;

ii) cyclic sulfur containing compounds such as thiophenes and vinyldithiins;

iii) nitrogen-containing compounds containing one and two nitrogen atoms, pyridine and pyrazine in the benzene ring;

iv) oxygen-containing compounds such as aldehydes and alcohols.

Diallyl disulfide and diallyl trisulfide were found to be the predominant compounds in the baked and microwaved garlic samples. Diallyl disulfide was also found to be the predominant compound in samples of fried, deep-fried, and microwave-fried garlic; however, the diallyl trisulfite content was very low. In addition, the levels of vinyldithiins, allyl alcohols, and volatile compounds containing oxygen and nitrogen were higher in the fried samples than in the baked samples. It has been reported that vinyldithiins are converted from allicin to a non-polar solvent, and therefore, the levels of these compounds can be expected to increase in oil-cooked samples (20-22).

During heating of garlic, sulfur-containing compounds are essentially decomposed and/or rearranged into volatile nitrogen-containing compounds such as alk(en)yl buulfinates and pyridines and pyrazines. These compounds are never found in fresh cloves and are formed as a result of the Maillard reaction that occurs during high temperature heat treatment in fried or baked garlic (21, 22).

Comparison of volatile components between black garlic and aged garlic extract (AGE)

The aging process provides a number of benefits to improve functional properties. Garlic is no exception to this process; Black garlic is produced by heat-treating fresh garlic at 60–80°C under controlled humidity for several months without additives. Ancient garlic extract (AGE) and other types of ancient garlic are also available in the markets, prepared by soaking sliced cloves in a solution of ethanol or by extraction of crushed cloves that are several months old at ambient temperature. Various bioactivities of aged garlic prepared with these two different conditions have been explained in many scientific reports.

The composition of AGE, which is prepared by keeping the volatile compounds in black garlic (5 weeks fermentation) and sliced garlic cloves in aqueous ethanol solution under high humidity (10 months fermentation) or extracting, is very different (5,23-26).

Although the volatile components of aged processed garlic consist mainly of sulfur-containing compounds, non-sulfur compounds have also been associated with flavors with different compositions and components depending on the type of aging process. For sulfur-containing compounds, the flavor components in AGE show a similar trend as the volatile profile of black garlic. Allyl methyl sulfide dominates in black garlic (18.2%), followed by allyl methyl trisulfite (1.5%), diallyl sulfide. Thus, various organosulfur compounds are formed in its content (1, 4).On the contrary, diallyl sulfide (6.29 mg/l) dominates the AGE content to be produced. In AGE, diallyl disulfide (1.88 mg/ml), diallyl trisulfide (1.39 mg/l) and various organosulfide compounds are also produced at a lower rate. These multi-ethnic sulfides are formed by the decomposition of thiosulfinates during the aging of fresh garlic. On the other hand, the flavor components of AGE for sulphur-free odorants differed significantly compared to black garlic.

Aldehydes, such as furfural (17.3%), 2-methylene-4-pentenal (14.9% and benzenacetaldehyde (12%) are the predominant compounds in black garlic, but they are not the key flavor compounds in AGE (25, 27). The fact that furfural compounds are not dominant in AGE compared to black garlic preparation may reduce the importance of furfurals for AGE.

Indeed, Phenols, esters, and nitrogen-containing compounds are identified as key flavor compounds in AGE. These compounds were produced within months and exceeded their respective concentrations detectable by the human nose. Whereas, three fruity-smelling esters (ethyl acetate, 7.00 mg/l; ethyl 2-butenoate, 0.07 mg/l and ethyl butanoate, 0.03 mg/l) were not detected in black garlic (5). However, these compounds are key in AGE defined as flavor compounds. These esters are likely to have been produced by esterification of ethanol used as solvent during the aging process. Undetectable nitrogen-containing compounds in black garlic (trimethyl pyrazine, 0.10 mg/l; trimethyloxazole, 0.07 mg/l and 2, 3-dimethylpyrazine, 0.02 mg/l) were determined as the main flavor components. Depending on age, these fragrant compounds are probably produced by the Maillard reaction during the aging process (28-30).

In fact, the water-soluble sulfurous compound OSCs are considered the main bioactive ingredient in cancer prevention, although they make up a smaller portion of garlic. S-Allylcysteine (SAC) and S-allylmercaptocysteine (SAMC), the metabolites of allyl mercaptan (AM) and allyl methyl sulfide (AMS), are water-soluble OSCs and less odorous than oil-soluble OSCs (31, 32).

Many studies in the medical literature have shown that garlic has important biological effects in preventing cancer. Especially increasing its effectiveness as a functional food has allowed the research of garlic bioactive substances against cancer.

For example, the anticancer effects of garlic can be summarized as suppression of mutagenesis, antioxidant effect, regulation of enzyme activities of cell organelles, inhibition of protein folding. It also inhibits proliferation, apoptosis resistance, and detrimental behavior of particularly engineered cancer cells, such as avoidance of immune surveillance. SAC and SAMC, which are the most important bioactive molecules of garlic, are powerful radical scavengers. Besides this feature, SAC has anti-cancer properties. In many studies, it has been reported that garlic is a highly effective antioxidant as well as blocking the effects of extracellular mutagens (33-35).

Especially its aqueous components (e.g. SAC) have a positive effect on enzymes, for example, they can increase the activity of glutathione reductase in the cell. Garlic has also been shown to stimulate carcinogen detoxifying enzymes such as glutathione S-transferases and cytochrome P450s. Moreover, ajoene, one of the components of garlic, has been shown to cause the accumulation of misfolded protein aggregates in cancer cells and activate the production of unfolded protein (36,37). In addition, reduced proliferation of cancer cells in processed garlic can be partially achieved by increased endoplasmic reticulum stress and meanwhile, garlic extract can induce apoptosis of cancer cells through the caspase signaling pathway (38). Thus, functional food garlic extract may also play a role in inducing apoptosis in cancer cells with its anti-proliferative effects (39).

Immunotherapy of garlic extract may be more effective than chemotherapy, especially for bladder cancer (40). The increased activities of immune cells against cancer may directly reflect the stimulation of the immune response by garlic extract. Although clinical studies have provided encouraging results for cancer patients, clinically the truly active compounds with the anticancer effect of garlic extract have not been fully discovered. It is important to reduce the risk of stomach and colorectal cancer with the intake of garlic extract. But more importantly, the potential antitumor effect of these garlic components warrants further investigation into the specific mechanism of their underlying antitumor activity (41).

As a result, epidemiological and laboratory studies may suggest that garlic consumption may be effective against cancer types such as stomach, colon, breast, cervical liver, and lung.Processed extraction has been shown to metabolize garlic into N-aceryl-S-allyl cysteine, allyl mercaptan, diallyl disulfide, diallyl sulfide, diallyl sulfoxide, diallyl sulfone, and allyl methyl sulfide.

We can summarize the anti-carcinogenic effect of garlic by scavenging radicals, increasing glutathione levels, increasing the activities of enzymes such as glutathione S-transferase, catalase, inhibiting cytochrome p450, endoplasmic stress, and preventing chromosomal damage through a number of mechanisms such as DNA repair mechanisms. However, future research may provide clear evidence of the dosage and type of garlic, ie whether it should be taken fresh, cooked or stale. Therefore, odorless functional foods that increase and endoplasmic stress, and preventing chromosomal damage through a number of mechanisms such as DNA repair mechanisms. However, future research may provide clear evidence of the dosage and type of garlic, ie whether it should be taken fresh, cooked or stale. Therefore, odorless functional foods that increase and preserve the anti-carcinogenic activity of garlic should be investigated.

Today, the earliest scientific studies showing the effectiveness of garlic extract against atherosclerosis date back to 70 years ago. Since then, thousands of studies have been published to isolate the active ingredients and evaluate the effects and safety of garlic. In fact, garlic extract is one of the most researched herbal remedies today and one of the most used complementary therapies against heart disease (42, 43). Currently, garlic extract is a functional food whose anti-atherosclerotic potential remains to be fully evaluated. It is clear that garlic extract is relevant to the treatment and prevention of atherosclerosis and related diseases.

In general, garlic extract regulates the lipid profile in humans, has an antihypertensive effect by reducing blood pressure, suppresses platelet aggregation, can lower plasma fibrinogen level and increase fibrinolytic activity. Garlic extract may thus exert clinically relevant cardioprotective and anti-atherosclerotic effects (44-50). In particular, it is important to evaluate the current level of evidence for the different protective effects of garlic extract and to understand the underlying mechanisms. In the future, it is necessary to regulate the clinical practice of garlic-based preparations.

Higher contents of water-soluble antioxidant compounds (S-allyl cysteine, S-allyl-mercaptocysteine), 5-hydroxymethylfurfural, organosulfur compounds, polyphenol, volatile compounds and other Millard reaction products can be obtained from garlic extract after processing compared to fresh garlic. Showed that as a functional food, garlic extract and its bioactive

compounds have a wide range of biological activities and pharmacological properties that show better efficacy and protection in preventing different types of diseases (e.g. migraine)(51,52).In summary, garlic extract may positively affects cancer, atherosclerosis, hypertension and diabetes, Alzheimer's disease, which are very common diseases today, and may help to reduce the risk of myocardial infarction and ischemic stroke(53-55).

Garlic is a prominent topic for future research for its potential as an adjuvant to conventional pharmacotherapy for these common health conditions. Specifically, the key points regarding the mechanisms underlying the anti-carcinogenic, anti-hypertensive, anti-hyperlipidemic and hypoglycemic effects of garlic should be further investigated. Garlic has been used for hundreds of years as a natural, inexpensive and common health remedy. Garlic will become more important as a functional food as new molecular pathways are identified in the prevention and treatment of diseases.

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