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An overview of how to produce, benefits and treatment with black garlic

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Abstract

Black garlic is a functional nutrient produced from fresh garlic and is made by fermenting whole garlic or peeled pulp in a chamber whose temperature is between (60-90 ° C) and humidity (70-90). 2) It is set and prepared in a period of 30 to 90 days. As a result of this process, the smell of garlic disappears and it acquires a soft, jelly-like texture and a taste similar to figs. This makes the normal garlic caramelized. One of the most important things that happens to garlic during this process is that it loses its spicy taste because some of the ingredients in this substance are neutralized The healing properties of black garlic are not less than ordinary garlic and even work better in some cases, which is why the price of this type of garlic is very high. Black garlic has a lot of antioxidant compounds such as polyphenols, flavonoids, tetrahydro-β-carboline derivatives and organosulfur compounds compared to fresh garlic. Note that fermentation not only changes the nutritional components and sensory properties, but also increases the activity of black garlic. Growing evidence showing the therapeutic effects of black garlic, including anti-cancer, anti-obesity, immune system, hypolipidemia, antioxidant, liver cell protector and nerve protector, has been reported over the past few decades. Among garlic processing products, black garlic is one of the most well-known functional foods available in the global market.

Keywords: Fermentation, treatment, white garlic, black garlic

1.History of black garlic

Black garlic has an ancient history, and there are several stories about its origin, all of which are probably true. Garlic growers had to find creative ways to maintain their harvest and increase their shelf life. If the garlic stays in a warm and humid environment for several weeks, the garlic cloves will turn black. But this black appearance of garlic does not mean that it is rotten. This simple product was called black garlic, in which farmers, by placing garlic in this special environment, prepared the conditions for Millard's reaction. A British garlic farmer claimed in 2009 that he had used a 4,000-year-old Korean recipe for black garlic. Evidence shows that black garlic has been used for culinary and medicinal purposes in Asia for centuries. Of course, it is not entirely clear how long black garlic has been in Asia. Some claim that the century(1).

1.1. Processing of black garlic

This type of garlic is not easy to prepare and sometimes you have to expose it to heat and humidity for up to 40 days. This makes the normal garlic caramelized. One of the most important things that happens to garlic during this process is that it loses its spicy taste because some of the ingredients in this substance are neutralized. The healing properties of black garlic are not less than ordinary garlic and even work better in some cases, which is why the price of this type of garlic is very high. As mentioned, in the 40-day process of preparing black garlic, it causes extensive changes in the structure of garlic. That is why black garlic can be used to treat some diseases and make medicines. You can use this substance in various ways such as fermented, oil or raw. Nutritionists have conducted various experiments on this substance and found that the process of heating garlic increases the concentration of allicin. Black garlic is a functional nutrient produced from fresh garlic and is made by fermenting whole garlic or peeled pulp in a container with a temperature between (60-90 ° C) and a humidity (70-90 ° C). 2) It is prepared and prepared in a period of 30 to 90 days [2, 3]. Black garlic has a lot of antioxidant compounds such as polyphenols, flavonoids, tetrahydro-β-carboline derivatives and organosulfur compounds compared to fresh garlic [4]. Note that fermentation not only changes the nutritional components and sensory properties, but also increases the activity of black garlic. Growing evidence showing the therapeutic effects of garlic, including anti-cancer, anti-obesity, immune-boosting, hypolipidemic, antioxidant, hepatocellular and neuroprotective, has been reported over the past few decades [3].Among garlic processing products, black garlic is one of the most well-known functional foods available in the global market. Compared to raw garlic, black garlic has the usual black color, sweet taste and chewy and odorless texture. People in Asian countries such as Thailand, South Korea and Japan have been producing and using black garlic as a traditional food for centuries, but it has entered the global market in recent decades. In summary, black garlic is produced by fermenting whole onions. Fresh garlic is produced at high humidity and temperature, which in turn causes garlic to be blackened by a series of non-enzymatic reactions, including the Millard reaction, phenolic oxidation, and caramelization. When garlic is fermented, not only does the physiological properties of garlic change, but also the concentration of biologically active compounds improves. As a result, black garlic has an elastic and chewy texture as well as a sweet, odorless aroma of garlic. . Due to its delicious taste and abundance of biologically active compounds, black garlic has become one of the most famous and prominent products in nutrient and functional foods with the significant growth of consumer demand in recent years. In addition, black garlic has attracted consumer attention in improving the production process as well as innovating new black garlic processing products. Recently, some processed garlic products such as garlic garlic molasses, puree, paste, extract and supplement pills have been introduced in Vietnam and the world market. Among garlic processing products, black garlic is one of the most well-known functional foods available in the global market. Compared to raw garlic, black garlic has the usual black color, sweet taste and chewy and odorless texture. In the thermal process of producing black garlic from fresh garlic, changes are made in the physical and chemical properties of garlic. Due to the genetic differences of garlic, the type of field operations and environmental conditions such as growing location, climate and growing season of the crop, as well as the type of processing method, changes in the content of black garlic compounds produced are different [5].

Figure 1. White garlic and black garlic plant

Figure 2. Processed black garlic

Figure 3. White garlic and black garlic pulp

1.2. Changing compounds in black garlic

Most of these changes occur during the Millard reaction and cause some unstable compounds in garlic, such as allicin, to disappear and not be present in black garlic, and changes in some other compounds to be very large and effective. For example, changes in the organic composition of sulfur make black garlic no longer have the pungent odor of raw garlic and its consumption does not cause digestive allergies. Changes in carbohydrates cause the formation of monosaccharides and disaccharides 30 to 80 times more than garlic, resulting in a pleasant sweet taste of black garlic. Also, by changing the binary, ternary and quaternary structures of proteins, the amount of essential and non-essential amino acids in black garlic increases by 2.5 to 2.8 times and oscillalcysteine is produced as the most important amino acid with abundant antioxidant properties in this product. Alkaloid and polyphenolic compounds, which have high antioxidant activities, increase 7 to 11 times in black garlic and help the body's cells excrete toxins such as hydrogen peroxide [3, 4, 5].

1.3. Moisture changes in black garlic

During the thermal process and the water evaporation process that takes place on the garlic, the humidity decreases continuously (from 62 to 68% to 45 to 54%) [6, 7]. 1. Moisture in the range of 45 to 54% is suitable for creating a desirable and soft texture in black garlic. 2. The higher temperature used in processing leads to a faster decrease in humidity. 3. Higher relative humidity is likely to cause more moisture to remain in the processed product. 4. According to experiments, the amount of garlic water decreases during the thermal process. 5. In the temperature range of 72 to 78 degrees Celsius, the moisture changes in black garlic are 0.4 to 0.7 percent.

1.4. Changes in carbohydrates in black garlic

Garlic and black garlic are both high in carbohydrates. However, the shape of carbohydrates changes significantly during the process of turning garlic into black garlic. Carbohydrates make up 22 to 26 percent of the weight of garlic or 77 percent of the weight of dried garlic, most of which are polysaccharides and small amounts of oligosaccharides and monosaccharides. During the garlic-to-garlic heat treatment, fructanes are gradually catalyzed to monosaccharides (mainly glucose and fructose), disaccharides, and oligosaccharides, through heat-induced degradation and enzymes enriched by garlic fructan exhydrolase. The degradation of polysaccharides is mainly due to heat treatment and not enzymatic hydrolysis, and the distribution of molecular weight and the rate of degradation of polysaccharides are closely related to the thermal process during processing. During the production process of black garlic, in general, carbohydrates increase one to two times, sucrose increases 1.3 times to 1.6 times, fructose increases 6 and 108 times, and glucose increases 2 to 13 times in black garlic compared to garlic. [14].

1.5. Black garlic processing methods

Production methods of black garlic are completely different according to the variety of garlic or shallots and their growing areas, and also the devices and technologies available to producers to regulate the temperature, time, pressure and humidity during production and the quality of the final product. During the construction of black garlic processing machine and fermentation of different varieties of garlic and shallots produced in Iran, as well as various imported products, a single method cannot be considered for all types of garlic. Black garlic is produced from white garlic in an environment with temperature and humidity control, for more than 30 days and without any additional additives. The processing and production period of black garlic can vary according to temperature, time, pressure and humidity, and shorter periods are performed at higher temperatures and pressures. Black garlic is generally prepared in the temperature range of 40-90 ° C and relative humidity of 90-60%. Different periods of temperature and humidity cause changes in the concentration of active elements in garlic. In general, black garlic is produced after multi-stage heat treatment processes [4].

1.6. Therapeutic effects of black garlic-white garlic

Fermenting garlic and turning it into black garlic not only changes its nutritional components and sensory properties, but also increases the biological activity of black garlic. Growing evidence for the various therapeutic effects of black garlic, including: Fight against cancer growth - Strengthen heart health - Maintain brain function and strengthen memory - Stabilize blood sugar - Reduce blood lipids - Increase immunity - Anti-obesity effects - Anti-inflammatory effects - Anti-allergy effects - Prevent and improve liver damage and protect the kidneys Has reported over the past few decades. Garlic has several health benefits such as: antiseptic, antioxidant, antibiotic, anti-fat, antidiabetic, anticoagulant, antimicrobial, anti-constipation, anti-parasitic, diuretic and hepatoprotective effects [3].

1.6.1.The effect of black garlic on kidney health

The kidney is one of the most important organs in the body and one of its main functions is to expel waste products produced by metabolism or ingested foods. Controlling the volume and composition of body fluids is also a function of the kidneys. The major part of maintaining the balance between the amount of intake and the amount of excretion in the case of water and almost all of the body's electrolytes is the responsibility of the kidneys. The kidneys do their most important job of purifying the plasma, depending on the needs of the body. The kidneys cleanse the body by excreting unwanted substances in the urine and return the required substances to the blood. Sometimes kidney failure or the presence of external toxins can lead to kidney toxicity. Colistin is an antibiotic used to treat infections caused by gram-negative bacteria, but its use is limited because it causes kidney toxicity. In other words, colistin increases the level of nitrogen urea and creatinine in the blood serum. According to studies, black garlic extract prevents the increase of these substances in urea and blood. Garlic also lowers the levels of oxidative stress biomarkers such as 8-hydroxy deoxyguanosine and malondialdehyde and increases the levels of enzymes such as superoxide dismutase and catalase, which inhibit kidney inflammation and play an antioxidant role. This is why black garlic protects the kidneys from the toxicity caused by colistin and prevents kidney tissue damage [3].

1.6.2. Anti-cancer effect of black garlic

Cancer, which is considered to be one of the leading causes of death worldwide, is a disease associated with the uncontrolled or abnormal growth of cells or tissues in the human body. With a growing body of evidence reported to counteract the effects of black garlic in recent decades, some researchers have suggested that black garlic could be used as a food product to prevent and treat stomach cancer and leukemia. In addition, black garlic has an anti-invasive effect and prevents tumor metastasis in the human stomach [3].

1.6.2.1. Protective effect of S-allyl cysteine enriched black garlic on esophageal reflux in rats via NF-Kb signal pathway

The aim of this study was to determine whether black garlic (BG), which is effective with pectinase treatment, was effective. With high hydrostatic pressure processing, the protective effects in the experimental model of acute esophageal reflux RE BG were administered orally at a dose of 100 mg / kg body weight 2 hours before RE induction, and its effects were compared with raw garlic (RG). Pathological changes of esophagus were analyzed using gross and histological examinations. Antioxidant and inflammatory protein levels were determined and also the histological change caused by RE was specifically suppressed by BG so that RE catalase reduction was significantly increased by BG supplementation. However, superoxide dismutase showed a tendency to increase in the esophagus. In general, the healing effects of BG were superior to those of RG. These data suggest that treatment of BG esophagus ameliorates by regulating NF-κB mediated inflammation. As a result, BG reverses the disorder and reduces the antioxidant enzyme caused by oxidative stress and stomach upset. Inactivation of NF-κB by BG supplementation also led to a decrease in inflammatory cytokines. These findings suggest that improved inflammation and increased antioxidant enzymes, which may have seen a potential therapeutic approach for esophageal mucosa, were analyzed [8].

1.6.3. Black garlic and its antioxidant properties

Black garlic contains many antioxidant compounds, including polyphenols, alkaloids, flavonoids, S-allyl cysteine, and antioxidant intermediates derived from the Millard reaction. Numerous studies show that black garlic activates not only free radicals in the laboratory but also antioxidant enzymes [3].

1.6.3.1 Investigation of epigallocatechin gallate impregnation to inhibit 5-hydroxymethylfurfural formation and its effect on the antioxidant ability of black garlic

5-Hydroxymethylfural (5-HMF) is considered as a neo-formed (NFC) that may adversely affect human health. Among heat-treated foods, the content of 5-HMF in black garlic was relatively high. However, many studies have shown that 5-HMF has antioxidant ability. Therefore, in this study, with the aim of discovering the use of epigallocatechin gallate (EGCG) to reduce 5-HMF, we investigate whether it also affects the antioxidant ability of garlic. Reducing the formation of 5-HMF in black garlic and increasing the safety of black garlic consumption were the objectives of this study. On day 30 of aging, the 5-HMF content of garlic with EGCG impregnation for 12 hours was 0.11 ± 2.37 mg / g dry weight, which reduced 5-HMF formation by almost 50% compared to the control sample. This showed that EGCG could be induced with 5-HMF to reduce 5-HMF formation during the production of black garlic from white. Moreover, it also increased as the soaking time which also had greater antioxidant ability of garlic. EGCG impregnation is useful because the method of reducing the formation of 5-HMF in black garlic without affecting the bioactivity of black garlic is similar to its antioxidant ability. Through this study, we found that the EGCG impregnation method could effectively form 5-HMF formation during the reduction of black garlic production. The 5-HMF content in black garlic with EGCG impregnation can be reduced by nearly 55% compared to the reduction of black garlic without EGCG impregnation. In addition, this method can not only reduce the product of Maillard reaction, such as 5-HMF, even without affecting the color, but also increase the antioxidant ability of black garlic. In the future, it is worthwhile to use another thermal method of food processing, expanding the application and increasing the value of EGCG in food processing. It is also expected that this technology could be used in the black garlic industry and even related industries to improve food safety and bioactivity [9].

1.6.4 Black garlic and its anti-inflammatory effect

Inflammation is the process by which our immune system responds positively to damage, infection, and toxins. Inflammation not only plays a vital role in wound healing but also plays an important role in protecting the human body from foreign invaders, including viruses and bacteria [3].

1.6.5 Hepatoprotective effect of black garlic

The liver is a vital organ in which detoxification, protein biosynthesis, and gastrointestinal biochemical production take place. However, the liver is vulnerable to drugs, chemicals, alcohol, solvents, infections, and dietary supplements. Black garlic has been shown to be effective in protecting the liver from side effects including hepatoxicity. Black garlic supplementation at a dose of 200 mg / kg body weight improves DNA damage and changes in blood biochemical parameters (bilirubin, alanine transaminase (ALT), aspartate transaminase (AST)) and liver antioxidant enzyme (CAD) levels (SOD, GSH-Px) increased compared to the cyclofusamide-treated group [3].

1.6.5.1. Evaluation of physicochemical and gastrointestinal properties of melanoidin from black garlic and antioxidant activities in laboratory

As important compounds in black garlic, the physicochemical and bioactive properties of melanoidin (MLD) were investigated in this study. The results showed that MLD has strong metal chelating capacity and radical inhibitory activity which is positively correlated with molecular weight (MW). In laboratory simulated digestion, UV absorption, degree of browning, and MW MLD distribution remained the same. This proved that MLD from black garlic can be indigestible. Such as: dietary fiber with a slight loss of volatile compounds and polysaccharides. Significantly reduced MLD bioactivators were significantly treated with α or hydrochloric acid, while they were stable and more than 60% retention was seen after the addition of pepsin and pancreatin. This study provides basic evidence for further research and the widespread use of MLD in black garlic in the production of functional foods or food additives based on the analysis of the composition and basic physicochemical properties of MLD samples obtained from black garlic. Macromolecular matter with 26 volatile species and 15.72% of the compounds were other essential components. MLD had high ion metal cooling activity and antioxidant ability, which was positively correlated with MW in the same process. In addition, physical properties including UV absorption and browning degree were also discussed with increasing MW. During the simulated MLD digestion in the laboratory, many volatile compounds were removed and several polysaccharides were degraded while the UV absorption, browning and MW distribution remained the same. The activity of metal chelate ions and the antioxidant power of MLD were significantly reduced by treatment with alpha-amylase or hydrochloric acid, while they could still maintain more than 60%. After digestion simulated in the laboratory. This study showed that the physicochemical and digestive properties and bioactivity of black garlic can be expressed by MLD, which can have great potential for use such as: dietary fiber for diabetes or obesity [10].

1.6.5.2. Effect of High Hydrostatic Pressure Conditions on the Composition, Rifology, Rheology, Thermal Behavior, Color, and Stability of Black Garlic Melanoidins

The effects of different conditions of high hydrostatic pressure (HHP) on the composition of rifology, rheology, heat behavior, color and stability of high molecular weight melanoidins of black garlic were investigated. Because HHP promoted the Maillard reaction, HHP treatments reduced aldehyde content from 46.76% to 11.92% but increased ketone and heterocyte contents by 4.46% to 6.66% and 9.32% to 11.55%. HHP therapies produced five compounds Was not present in the control sample, including 5-methyl-2 (3H) -furanon, 3-methyl-2-cyclopentinone, 2, 3-dihydrofuran, 2-ethylfuran, and 2-vinylfuran. HHP-treated melanoidin levels were rough and wrinkled, and from large particles compared to controls. In addition, HHP reduced the viscosity of the melanoidin solution at a loading rate of 1–10 s − 1. Also, HP improves thermal stability and stability under ultraviolet light melanoidin black garlic. Overall, HP treatment increased the composition and structure of black garlic melanoidin and improved stability. HHP treatment significantly altered the composition, rheology, rheology, thermal behavior, color, and stability of black garlic melanoidins. Compared with controls, HHP treatment decreased aldehyde contents while increasing the proportion of melanoidin ketones and heterocytics. The topology of melanoidin levels became rougher and wrinkles as the pressure increased with increasing thermal and ultraviolet stability. HHP treatment of 200–500 MPa also reduced the apparent viscosity of melanoidins at a contribution rate of 1–10 s − 1, and improved the color density, polymer color, and brown index of the extracted melanoidins. Overall, pressure levels below 400 MPa appear to have been shown to be effective in promoting Maillard, BI, and ultraviolet stability of garlic garlic melanoidin. These results contribute to further discoveries about the effects of HHP therapy on the composition, structure and function of melanoidin for potential use as natural foods in the food industry [11].

1.7.Aromatic compounds of black garlic

Scientists have identified a total of 52 active aromatic compounds in black garlic, which are classified into seven groups, including alcohols, aldehydes, ketones, sulfur-containing compounds, heterocyclic compounds, organic acids and other compounds. There are 24 aromatic compounds with a mild aroma in black garlic, including eight sulfur compounds, six heterocyclic compounds, two carbonyl compounds, two alcohol compounds, three acids and three other unknown aromatic compounds. These compounds include: Sulfur-containing compounds (8 compounds): allyl methyl trisulfide, 2-vinyl-4H-1,3-dithiine, diallyl disulfide, diallyl trisulfide, 3-vinyl-1,2-dT acycloheix 4-In, diallyl sulfide, 3H-1,2-dithiol and dimethyl sulfoxide have been identified. Among these compounds are diallyl disulfide, 3-vinyl-1, 2-dT-acyclohexy-4-in, and diallyl sulfide. Heterocyclic compounds (6 compounds): Phenol, 2 2 (H5) furanone, 1- (2-furanyl) -ethanone, 2-acetyl-1-pyrroline, 5-heptyl dihydro 2 (H3) -furanone and butyrolactone. Carbonyl compounds (2 compounds): 3 (methyl thio) proponaldehyde and 1-hydroxy-2-butanone (not present in garlic) Alcoholic compounds (2 compounds): 2, 6 (EZ) - nonadin-ol, and allyl alcohol (3 compounds): Acetic acid, 3-methylbutanoic acid and propanoic acid and 3 other unknown compounds. Among these 24 active aromatic compounds, 10 of its compounds are known as the main compounds responsible for fragrance and perfume. These compounds include acetic acid, allyl methyl trisulfide, faranol, diallyl disulfide, diallyl trisulfide, (E, Z) -2, 6-nonadin-ol, 3-methyl butanoic acid, 5-heptyl dihydro-2 (H3) - furanone, diallyl sulfide and propanoic acid [5].

1.8. Organic acids of black garlic

Some organic acids such as citric acid, malic acid, lactic acid and fumaric acid are present in garlic extract, but in black garlic extract, fumaric acid, acetic acid and formic acid, 3-hydroxypropionic acid is lost and absent. Succinic acid is also formed in black garlic through complex chemical reactions, including fermentation. Increasing the amount of organic acids not only makes the taste sweet and sour (in addition to reducing sugars) but also facilitates the hydrolysis of proteins and polysaccharides in black garlic cloves. The increase in acidity after heat treatment of garlic is due to the consumption of large amounts of alkaline groups, such as the amino group in amino acids, during reactions such as the Millard reaction as well as the formation of short-chain carboxylic acids. Scientists know the basic mechanisms of carboxylic acid production mainly from hexoses (mainly fructose and glucose) in garlic. Changes in pH are very effective in changing organic acids during the fermentation process. In one experiment, researchers changed the pH before and after heat treatment from 42.6 (in garlic) to 5 or 3.5 (in black garlic obtained by heat treatment at 40 or 85 ° C for 45 days) reported.

1.9. Characteristics of different items of garlic

Fresh garlic (chopped) contains the highest amount of allicin. Aguin in fresh garlic is anti-platelet and is effective in preventing atherosclerosis, coronary artery thrombosis and cerebral stroke [4]. Garlic powder dissolved in soybean oil has more agave (significant in patients with coronary artery obstruction). Garlic pulverization reduces 40% of alien [3, 4]. In dried garlic, some alien remains stable, which is converted to allicin by contact with water and moisture absorption. Old garlic is free of allicin and has only anti-cancer effects [4, 5].

1.10. Benefits of black garlic

All the known health benefits of garlic, along with the countless benefits of the fermentation process, are found in black garlic. The benefits of consuming black garlic include the following [4]:

Cholesterol - Black garlic helps lower bad cholesterol (LDL).

Antioxidants - Black garlic is rich in powerful antioxidant compounds.

Cleansing - Black garlic, due to its rich antioxidant and amino acid composition, helps cleanse the liver to remove heavy metals from the body.

Digestion - Enzymes and probiotic organisms in black garlic help digest food.

Immunity - Black garlic strengthens the immune system with B vitamins such as B6, vitamin C and manganese.

S. allyl cysteine - This compound, which is derived from allicin and is found in large amounts in black garlic, has many benefits such as: anti-cancer, anti-inflammatory, anti-fungal, antibiotic.

Fighting Cancer - Black garlic has been shown to reduce the rate of stomach and colon cancer.

1.11. Stabilize blood sugar with black garlic

Diabetes is one of the most common metabolic diseases. The hallmark of it in adults is a fasting blood sugar above 120 mg / dL, and other symptoms include overeating and binge drinking. Diabetes is caused by a decrease in the body's production of insulin or a decrease in the effect of insulin on the metabolism of sugars (insulin causes sugar to be used, or the body's most important source of energy, which is produced in the pancreas). High blood sugar can have negative effects on health. In the short term, it has symptoms such as frequent urination and fatigue, and even in the long term, it can lead to kidney dysfunction, skin infections, and an increased risk of heart disease. According to research conducted at the University of Denkok in Korea, black garlic extract was not only effective in lowering blood cholesterol and triglyceride levels in rats fed a high-fat diet, but was also able to lower blood sugar levels. Meanwhile, other researchers say that high levels of antioxidants in black garlic are also helpful in preventing the complications of diabetes. Further studies in mice also show that black garlic extract has beneficial metabolic effects in the field of obesity or diabetes. Researchers in Spain have found that administration of black garlic extract alters the metabolism and arteries of a high-fat, high-fat diet. This is achieved through changes in the expression of proteins and neuropitides, including inflammation, fat metabolism, and regulation of food intake [12].

1.12. Protein compounds of black garlic

In general, fresh garlic has 1.5 to 1.2 percent protein in fresh weight and many free amino acids depending on the variety and growing environment of garlic. Glutamine, asparagine and glutamic acid are the most abundant amino acids in garlic, which contain some essential amino acids, lysine, tryptophan and valine [13]. Deformation of proteins is possible when fresh garlic is processed into black garlic at high temperatures, and some free amino acids participate in the Millard reaction. The amino acid properties are particularly different from those of fresh garlic and fresh garlic. Changes in the total amount of 18 free essential amino acids are variable and are accompanied by an increase in the amount of a number of amino acids (including leucine, isoleucine, phenylalanine, aspartic acid, alanine, cysteine and valine) and a decrease in the content of some other amino acids. The amount of S-allyl cysteine measured in fresh garlic using HPLC fluorescence was 52.21 µg / g and using ultraviolet HPLC was 73.22 µg / g fresh weight [15]. And depending on the actual amount of heat process, it may increase significantly and reach four to six times the amount in fresh garlic. Another biologically important amino acid, aminobutyric acid (GABA), is a non-protein amino acid whose content decreases during the production of garlic, possibly due to amino acid damage and involvement in non-enzymatic brown reactions [16].

1.13. Black garlic lipid compounds

The amount of extracted lipids varies from 0.53 - 0.31% in fresh garlic to 0.6% in dried garlic [17]. In addition, as a nutritious and energetic source, the lipids in fresh garlic and black garlic also play an important role in their sensory properties. According to reports, lipids extracted from fresh garlic using chloroform-methanol contain 62.6% of neutral lipids, 14% of glycolipids and 23.4% of phospholipids [18]. Among these lipids, linoleic fatty acid, palmitic acid, linolenic acid and oleic acid are found as the most abundant fatty acids (by gas chromatography) [19]. During the process of producing black garlic, lipid deformation has been attributed to oxidation and their participation in chemical reactions. However, reports on fat content have been contradictory or even controversial. For example, Choi et al. (2008) showed that the amount of crude fat after processing fresh garlic into black garlic increased significantly (from 0.18 to 58.0%) [20], while Lou (2017) reported the levels of crude fats in fresh garlic and related to black garlic as 0.33 and 0.16 percent, respectively [21]. These differences were most likely due to differences in the type of garlic, processing methods (including heat and fermentation stages), extraction methods, analysis, as well as changes in the moisture content of fresh garlic and black garlic. Hydrolytic and oxidative changes in garlic fats are possible, especially in the process of processing fresh garlic into black garlic, such as: high temperature (60 to 90 ° C) and high humidity (70 to 90%). As a result, complex fatty acids are produced from compounds such as alcohol, aldehydes, ketones, and lactones. These products, along with the fatty acids that are initially produced, participate in a wide range of complex chemical reactions including hydrolysis, oxidation, and Millard reaction [22]. All of this explains why the lipid content of processed black garlic was lower than that of fresh garlic.

1.14. Strengthen the immune system with black garlic

The immune system plays a key role in your overall health. The immune system works by protecting the body against disease and infection and can even help prevent chronic disease. Immune system cells (called white blood cells) flow through the blood throughout the body and are found in various organs, including the bone marrow, thymus gland, lymph nodes and spleen. The antioxidants in black garlic boost your immunity by fighting free radicals, reducing inflammation and preventing oxidative damage to the body's cells. A 2012 laboratory study examined the difference between black and raw garlic and their effects on immune function. Black garlic not only showed the strongest anti-cancer and antioxidant properties, but also had a stronger effect on stimulating the immune system. These immune-boosting benefits can have far-reaching health effects in several ways, and may help treat everything from allergies to autoimmune disorders and acute infections, as well as fighting viruses such as Covid [26].

2.What is allicin?

Allicin, first discovered in 1991 by Cotirio et al., Is one of the most important organosulfur compounds derived from garlic and, compared to other effective garlic compounds, has attracted more attention from scientists and researchers and has attracted more studies and discussions. Dedicated to himself. Allicin causes a pungent garlic flavor and a highly volatile compound that decomposes under heat and alkaline conditions. Interestingly, allicin is not found in fresh garlic cloves. After garlic is crushed by chewing or during the cooking process, the enzyme allinase in it comes in contact with the amino acid alien and is rapidly converted to allylsulfonic acid, which is then converted to allicin. The thinner the garlic cloves and the smaller the cloves, the more allicin is produced and the greater the medicinal effect of the final product. The severe instability of allicin has led us to always be skeptical of its role in the health effects of garlic. The process of fermentation in garlic affects the amount of allicin and reduces it. In fact, this highly unstable thiosulfate is rapidly converted to various types of sulfurous organic compounds during processing. In other words, during the fermentation process, allicin is broken down to produce new compounds such as acallycysteine and S. allyl mercaptocysteine. Ordinary garlic lacks these compounds. Allysocysteine can have many health benefits. Many attribute the beneficial effects of black garlic to this compound [23].

3. Comparison of phenolic acids and flavonoids in black garlic in different stages of heat treatment

Phenolic acid and the flavonoid components of garlic were examined under different heat treatment steps. Black garlic was produced in a programmed chamber with stepwise heating, according to the following steps. Step 1: 90 C and 100% RH for 34 hours; Step 2: 60 C and 60% RH for 6 hours; Step 3: 75 C and 70% RH for 48 hours; Step 4: 70 C and 60% RH for 60 hours; Step 5: 65 C and 50% RH for 192 hours. The results of the present study showed that heat treatment affects the amounts of phenolic acid and flavonoids. The total phenolic content (TPC) and total flavonoid content (TFC) of garlic in different stages of heat treatment were higher than the stages of fresh garlic. Regarding ripe black garlic using step 1 (BG1), black garlic ripe using step 2 (BG2), black garlic ripe using step 3 (BG3), and black garlic ripe using samples Stage 5 (BG5) levels of TPC used were exhibited higher than TFCs, whereas TFC was higher in fresh garlic (FG) and black ripe garlic using samples in Stage 4 (BG4) than TPCs. Hydroxycinemic acid derivatives are the major phenolic acids of garlic that were found at different stages of processing. Among the four major flavonoid subtypes in garlic, flavanols were found in the highest concentrations, followed by flavanones and flavonoids, except in the FG sample [24].

4. Changes in nutritional composition, bioactivity and antioxidant capacity during processing of black garlic

The aim of this study was to investigate the ideal processing of conditions for black and white garlic based on changes in nutritional components, bioactivity and antioxidant capacity. Fresh garlic was processed under constant conditions of temperature (65, 75 and 85 C) and relative humidity (70, 75, 80 and 85%) for 16 days. The content of nutrients was significantly affected by humidity and temperature, and 85% humidity and 75 C were appropriate. The polyphenol content was with increasing temperature and decreasing in humidity. Reducing sugars and total sugars, total acids and 5-HMF at 75 C were higher than 65 and 85 C. Decreased sugar and protein content decreased on day 8. Maintaining a temperature of 75 C and a relative humidity of 85% for 8 days were ideal for black garlic to maintain abundant antioxidant capacity. As a result, the proper humidity was higher for antioxidant capacity and 85% better taste. Most indicators peaked or began to decline on day 8, so we chose

8 days as the processing time. An average temperature of 75 C was more suitable for preserving nutrients and flavor. Therefore, 75 C conditions, 85% humidity and 8 days of processing were recommended for better taste and increased antioxidant capacity and nutrient retention [6].

5. Effect of packaging materials and storage temperature on moisture status, mechanical and thermal properties of black garlic

We examined the effects of polyethylene terephthalate (PETB) bottle packaging materials, Kraft paper bags (KPB) and aluminum laminated polyethylene bag (ALPB) and storage temperature (4 and 20 ° C) in chemical composition. Moisture status and mechanical and thermal properties of black garlic were investigated after 90 days of storage. As a result, we found that ALPB maintained the highest levels of 5-hydroxymethylfurfural, total sugar, and reduced sugars at the same temperature. While PETB retained the textural properties of garlic. Water reduction and migration were serious defects in KPB and PETB at 20 ° C. The initial decomposition temperature was the highest for KPB, while the glass transition temperature was the highest for ALPB. Samples stored in the ALPB could easily be differentiated from other methods using a partial least-square-methogenous-discriminatory analysis model and this high predictive power was increased by 98.9%. Low temperatures and ALPB effectively maintained the integrity of black garlic. We found that packaging materials and storage temperatures of different levels affect the storage quality of black garlic. Storage at 4 ° C resulted in the preservation of most significant nutrient chemicals. Water loss will be less and garlic will be more stable. Packaging materials in ALPB will lead to better water retention than others and will lead to higher total sugar and reduced sugar content and increased browning temperature in glass transfer. PETB preserves the textural properties and Kraft paper will produce the highest level of degradation. Therefore, different packaging materials provided different protective effects on storage and they can be selected according to different needs. The HCA and PCA results showed that the ALPB packaging used at both 4 and 20 ° C was significantly different from the other four packaged groups. NMR peaks A22 and A21 (water activity), 5-HMF, total glucose, glucose reduction and hardness were considered as sensitive markers to evaluate the storage properties of black garlic [2].

6. Physicochemical changes and sensory properties in black garlic

Black garlic is produced using heat treatment of freshly controlled garlic bulbs. High temperature conditions and high relative humidity for long periods without any additional treatment time or additives. During this thermal process, changes in the chemical and physicochemical composition of BG were produced in very different amounts, and were mainly influenced by volatile sulfur compounds, free amino acids, polyphenols and carbohydrates. By analyzing these changes, studies on the mechanism of BG explanation have been performed. Recent scientific findings have shown that the Maillard MR reaction is responsible for BG metamorphosis, leaving behind the hypothesis of spontaneous fermentation. Therefore, the trend in BG research is related to the usefulness of MR compounds as quality indicators for controlling the non-enzymatic process of BG as well as evidence of the important role of humidity and temperature conditions required for industrial production of BG. Although BG has been known in Asia since ancient times, it is now emerging worldwide due to its unique organ properties and bioactive properties. The questionable origin of BG and the lack of a single method to explain it have increased to the lack of a quality index that makes it difficult to achieve a standard BG product. Inactivated alinase is reduced by heat and the concentration of aline and allicin. Due to the changes in polyphenols, during the production of BG, the total phenolic content increases, so that BG contains a higher level of polyphenols than the fresh product. This study focuses on chemical and physicochemical changes, paying special attention to the non-enzymatic browning reaction as one of the main changes to obtain BG. These reactions play a very important role in BG processing and determining the properties of this product in a similar way. Other authors have described the BG process as 'aging periods' under heat treatment. In addition, current research on the formation of Amador and Heinz compounds has shown that the conversion of BG is mainly due to non-enzymatic brown reactions, MR, rather than spontaneous fermentation produced by microorganisms The findings presented in this work demonstrate the usefulness of MR compounds such as 2-FM-AA acids and HMF as quality indicators for non-enzymatic control of the BG process as well as evidence of the important role of humidity and temperature conditions required for industrial Bg production [5].

7. Maillard reaction intensity and product quality achievement by high pressure pretreatment during black garlic processing

The processing efficiency of black garlic improved with the intensity of Millard reaction after high pressure pretreatment. The relationship between component changes and Maillard reaction was analyzed. Three stages of processing became general: 1) In the pretreatment stage, degradation of the cell structure promoted an enzymatic reaction with high pressure. 2) From 0 to 3, the enzymatic reaction was promoted at 45 ° C in the affected cells and 3) after day 3, heating caused the components to change directly. High-pressure pretreatment damaged the intracellular environment and produced reducing sugars for the Maillard reaction that accumulated during the initial processing step, which directly resulted in acceleration of the reducing sugar equilibrium point (RSBP). Application of high pressure pretreatment shortened the production time of black garlic from 24 to 15. Sensory evaluation was performed and the quality of black garlic produced in this innovative way to meet commercial requirements was examined. This research showed that HHP and HPCD can improve the efficiency of black garlic processing with Maillard reaction intensity. There were three stages of garlic processing: 1) In the pretreatment phase, cell structure promoted the enzymatic reaction. 2) From 0 to 3 d, the enzymatic reaction was promoted at 45 ° C in the affected cells and 3) after day 3, heating caused the components to change directly. The destruction of cell structure by high-pressure pretreatment under the influence of the intracellular environment, especially the severity of fructan degradation, was investigated, and large amounts of substrates for the Maillard reaction were rapidly accumulated in the initial processing stage, directly leading to RSBP acceleration during Heat treatment of garlic became black and white. This study also proved that the quality of black garlic after the Maillard reaction determined the commercially available quality of black garlic. The RSBP proposed in this study brought a new idea to control the Maillard reaction in black garlic processing. It has a strong technology to upgrade costs and also provide a new technology for the industry of producing black and white garlic [25].

8. The effect of heat treatment on the degradation of polysaccharides during the processing of garlic

The reduction in sugar content increases several times during the processing of black garlic. This study was performed to detect hypoglycemia. The molecular weight (Mw) distribution of saccharides and the degradation of heat-treated kinetic polysaccharides were also evaluated. Degradation of polysaccharides by heat treatment, by enzymatic hydrolysis to make all saccharides in black garlic less than 2 kDa. Thermal temperature affected the dynamic distribution of Mw saccharides. High temperature degradation of high MW polysaccharides to low Mw oligosaccharides and monosaccharides was kinetically degraded. Compared to all thermal processes did not obey the first-order reaction. These results could be a reference to further reveal the formation quality of the mechanism of presentation of black garlic saccharides in black garlic with that in fresh garlic due to the difference in polysaccharide degradation. Degradation of polysaccharides is not mainly through heat treatment and enzyme hydrolysis. Kinetic degradation does not obey the first-degree reaction of all thermal processes. It should be noted that more studies should be done to investigate the factors affecting the polymerization of polysaccharides [12].

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