Volume : 3 | Issue : 10 | October 2014 • ISSN No 2277 - 8179

Research Paper

Drying Of Garlic (Allium Sativum L.) to Minimize Pht Loss - A Review

Agriculture

KEYWORDS : Garlic, Sun drying, value added products, PHT loss and drying techniques

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ABSTRACT

Drying is a critical step in the processing of dehydrated products because of the high energy requirement of the process (due to low thermal efficiency of dryers. Increased consumer awareness of food quality as well as the desire to produce a high quality have emphasized the necessity of optimization. Various methods are employed for drying of garlic which have their merits and demerits. Sun drying is suitable for water content reduced from shelf life of products % (db), wind (velocities km/h) for 120 days with over turning once/twice a day and heaping or covering during night and not suitable for large commercial scale. It is a uncontrolled method, non-uniform drying methods. Convection drying is employed for heat and mass transfer coefficient and to study the moistures transport during microwave-convective drying of garlic cloves. It a mechanical process but not feasible operating cost and initial cost. Drying is an industrial preservation method in which water content and water activity of the fruits and vegetables are decreased by heated air to minimized biological, chemical and microbial deterioration. Drying is a process of simultaneous heat and mass transfer. Mathematical modelling help to of drying process help in understanding the physics of drying. At this moisture level, the chances of insects and molds infestation are minimized and thus the commonly can keep well in storage. To obtain the dehydrated product of high quality, the drying process should be such that it allows effective retention of colour appearance, flavour, taste and nutritive value, comparable to fresh vegetables. The technique of drying is probably the oldest method of food preservation practiced by mankind for the extension of food shelf life. The use of artificial drying to preserve agricultural commodities is expanding, creating a need for more rapid drying techniques and methods that reduce the large amount of energy required in drying processes.

Introduction

Garlic (*Allium sativum* L.) is a nutritional herbaceous plant known for its medicinal as well as culinary benefits, which originated from the mountains of Central Asian regions Globally; China is by far the largest producer of garlic, producing over 75% of world tonnage followed by India. (FAOSTAT, 2005).

Garlic is a bulbous perennial vegetable spice. The bulb is composed of pungent bolblets, commonly known as cloves. Garlic is a semi-perishable product. Due to lack of suitable storage and transportation facilities, about 30% of fresh crop is wasted by respiration and microbial spoilage (Anonymous, 1993). Like other biological crops (Duarte *et al.* 2004), garlic. It is mainly used as a condiment in various food preparations such as flavouring mayonnaise and tomato ketchup-sauce, salad dressing, meat sausages, stews spaghetti, chutney, and pickles etc. Garlic cloves with approximately 1.85g water/g dry matter are dried to a safe moisture content of 0.06g water/g dry matter. Currently hot air drying method is used for drying the garlic (Prahesh, Dekshinamurthy, & Shukla, 1994; Dash & Bhatnagar, 1991 and Dawn & Shreenarayanan, 1998). Many food products are dried at least once at some point in their preparation. Drying fruit and vegetable products is an important means of enhancing resistance to degradation due to a decrease in water activity (a_w). Easier processing, lower transport costs as well as quality enhancements can also be achieved (Mazza & Le Maguer, 1980; Sokhansanj & Jayas, 1987). Heated air drying is the most commonly employed commercial technique for drying biological products, and although large quantities of drying information are available in the literature, the process still remains largely an art (Mazza & Le Maguer, 1980). Fruits and vegetables are highly seasonal and available in plenty amounts in particular times of the year. In the peak season, the selling prices are usually at the minimum and this may lead to lower profits or even losses for the grower. Preservation of these fruits and vegetables can prevent the huge wastage and make them available in the off-season at remunerative prices (Parakash, Jha, & Datta, 2004). Garlic is an important agricultural product that is a strong source of phenolic materials, phosphorus, potassium, sulphur, zinc, selenium and vitamins A and C, and lower levels of the elements calcium, sodium, magnesium, manganese, iron and B complex vitamins (Brewester, 1997). It has antiseptic properties and used in a number of medicinal preparations. Various garlic powder pills and garlic oil pills are now commonly available (Sharma and Prasad, 2006). (Afzal and Abe, 2000) reported that air velocity during convective grain drying in thin layers has little influence (would normally increase although may not substantial) on the moisture removal rate. The convective heat transfer coefficients for some crops (green chillies, green peas, white gram, onion flakes, potato slices and cauliflower) under open sun drying were reported by (Anwar and Tiwari, 2001). India produced nearly 4.39 million tonnes of garlic throughout 2006 and 2007 and exported 12,210.79 tonnes of garlic in 2006-07. The export has been 2 -3% of the total production. The export has been 42000 tonnes of dehydrated garlic products (APEDA Export Statement 2002).

DRYING

Food drying is one of the oldest methods of preserving food for later use. Food drying is a very simple, ancient skill. It is one of the most accessible and hence the most widespread processing technology. Sun drying of fruits and vegetables is still practiced largely unchanged from ancient times. Traditional sun drying takes place by storing the product under direct sunlight. Sun drying is only possible in areas where, in an average year, the weather allows foods to be dried immediately after harvest. The main advantages of sun drying are low capital and operating costs and the fact that little expertise is required. The main disadvantages of this method are as follows: contamination, theft or damage by birds, rats or insects; slow or intermittent drying and no protection from rain or dew that wets the product, encourages mould growth and may result in a relatively high final moisture content; low and variable quality of products due to over - or under-drying; large areas of land needed for the shallow layers of food; laborious since the crop must be turned, moved if it rains; direct exposure to sunlight reduces the quality (colour and vitamin content) of some fruits and vegetables. Moreover, since sun drying depends on uncontrolled factors, production of uniform and standard products is not expected. The quality of sun dried foods can be improved by reducing the size of pieces to achieve faster drying and by drying on raised platforms, covered with cloth or netting to protect against insects and animals. In open sun drying, there is a considerable loss due to various reasons such as rodents, birds, insects and micro-organisms. The unexpected rain or storm further worsens the situation. Further, over drying, insufficient drying, contamination by foreign material like dust dirt, insects, and micro-organism as well discolouring by UV radiation are characteristic for open sun drying. In general, open sun drying does not fulfill the quality standards and therefore it cannot be sold in the international market (Sharma *et al.* 2009). Drying is a critical step in the processing of dehydrated products because of the high energy requirement of the process (due to low thermal efficiency of dryers. Increased consumer awareness of food quality as well as the desire to produce a high quality have emphasized the necessity of optimization. Dryer design, simulation and optimization are complex processes still based on experimental data (Keey, 1980). The use of artificial drying to preserve agricultural commodities is expanding, creating a need for more rapid drying techniques and methods that reduce the large amount of energy required in drying processes. New and innovative techniques that increase drying rates and enhance dried garlic quality are receiving considerable attention (Mongpraneet *et al.* 2002). Drying is dependent on the two fundamental process-Heats and Mass transfer, heat has to be transferred into the fresh products which are then followed by the removal of moisture from the products Eke *et al.* (1995).

Drying also reduces shrinkage during subsequent handling, reduces the occurrence of sprouting, and allows the crop to ripen before fresh consumption or long-term storage (Opara and Geyer, 1999). Due to the current trends towards higher cost of fossil fuels and uncertainty regarding future cost and availability, use of solar energy in food processing will probably increase and become more economically feasible in the near future. Solar dryers have some advantages over sun drying when correctly designed. They give faster drying rates by heating the air to 10-30^{0}C above ambient, which causes the air to move faster through the dryer, reduces its humidity and deters insects. The faster drying reduces the risk of spoilage, improves quality of the product and gives a higher throughput, so reducing the drying area that is needed. However, care is needed when drying fruits to prevent too rapid drying, which will prevent complete drying and would result in case hardening and subsequent mould growth. Solar dryers also protect foods form dust, insects, birds and animals. They can be constructed from locally available materials at a relatively low capital cost and there are no fuel costs. Thus, they can be useful in areas where fuel or electricity are expensive, land for sun drying is in short supply or expensive, sunshine is plentiful but the air humidity is high. Moreover, they may be useful as a means of heating air for artificial dryers to reduce fuel costs (Fellows, 1997). Drying is probably the oldest and the most important method of food preservation practiced by humans. This process improves the food stability, since it reduces considerably the water and microbiological activity of the material and minimizes physical and chemical changes during its storage.

Effect of drying Characteristics on quality of garlic

The purpose of the present study was to test and to evaluate the effect of different levels of infrared radiation intensity and air velocity on drying characteristics and quality changes of thin layer garlic slices under convection and combined heating modes. The major quality problems faced during garlic drying loss of flavour, discolouration and poor rehydration characteristics of the dried garlics. Garlic flavour and colour are generally perceived as important quality attributes. In drying, diffusivity is used to indicate the flow of moisture from the material. In the filling rate period of drying moisture removed is controlled mainly by molecular diffusion. Diffusivity is influenced by shrinkage, case hardening during drying, moisture content and temperature of the material (Singh *et al.* 2008). The allicin content of the garlic drying during was determined using the modified Lawson's method (Lawson *et al.* 1995). (Sharma and Prasad, 2001) studied the colour change of fresh garlic in a hot air dryer at 70 ^{0}C and rather large number of mercaptans, disulfides, trisulfides and thiophenes (Lindsay, 1996). Li and Xu, (2007) however, reported 90.2 percent retension of thiosulphates with microwave-vacuum and freeze drying. More than 50% of the water is taken out with the help of hypertonic solutions. After that, the fruit pieces are very soft and are still subjected to spoilage by a variety of microorganisms. The water content needs to be lowered further to gain microbiological stability without cool storage. Osmotic dehydration (OD) and pretreatment prior to drying was found advantageous for improving the product quality and for decreasing energy consumption (Mandala *et al.*; 2005; Moreno *et al.* 2004).

Today's consumer expectation for better quality, safety and nutritional value drives research and improvement of drying technologies. The heat and mass transfer coefficients are important parameters in the simulation of drying rates, since the temperature difference between the air and food product varies with these coefficients. Jain and Tiwari, (2003). Evaluated the convective heat-transfer coefficient for some of the crops (green peas, green chillies, white gram, onion, onions and potatoes) under solar drying condition and developed a mathematical model to predict the drying parameters. Jain and Tiwari, (2004). Further studies the dependence of convective heat-transfer coefficient on the drying time during complete solar drying process of green peas and cauliflower. The present work was focused on estimating the convective heat and mass transfer coefficients and to study the moisture transport during microwave-convective drying of garlic cloves.

The study was mainly concerned with the development of a mathematical model of a thin layer drying for garlic using an indirect forced convection solar dryer under conditions typical of Minufiya, Egypt. Studies of some pretreatments affecting the changes in the various chemical and physical constituents of garlic during the drying process were considered. Quality attributes of dried product were evaluated. One of the most important ways to reduce the adverse influence of drying on food quality or to ensure basis quality properties on food quality or to ensure basis quality properties of the final product is to carefully design the process and implement it consistently (Lewicki, 2006). The moisture removal during drying processes is greatly affected by the drying air conditions as well as the characteristic dimension of material, whereas all other process factors have a practically negligible influence (Kiranondis *et. al.* 1997). Several quality standards for dried garlics were developed over time; the official standards of the American Dehydrated Onion and Garlic Association (ADOGA) are considered the primary standard.

Methods of drying

Hot air drying

Hot-air drying of garlic slices in a common fixed bed method is unfortunately not suitable due to a significant decrease in the quality of dried product related to the fresh one. Applying high temperature (about 60°C) in a fixed bed drying causes an increase in drying period, energy consumption, color degradation and mass transfer. Hot-air drying samples were dried at 50^{0}C using a hot-air drying oven (DMC-122SP, Daeil Engr. Co., Korea) for 48 h to a final moisture content of approximately 5-7%, moisture-free basis (MFB), which was determined by the gravimetric method at 105^{0}C, till the weight reached a constant value. A major disadvantage associated with hot air drying is that it takes long time even at high temperature, which results in degradation of the dried product quality. Compared with hot air drying, combined microwave-hot air could reduce the drying time of biological materials without damaging the quality attributes of the finished products (Ren & Chen, 1998). The food materials reportedly have been dried using microwave-convective technique include corn (Gunasekaram, 1990), grapes (Tulasidas, Raghavan, & Norris, 1993), carrots (Prabhanjan, Raghavan, Ramaswamy, & Oaghavan, 1995) apples and mushrooms (Funebo & Ohlsson, 1998), and various medicinal plants (Ren & Chen, 1998). However, no work has been reported on the drying of garlic. The evolution of a microwave-hot air drying process to produce high-quality dried garlic in a relatively short time could make a significant contribution to the garlic processing industry. Therefore, the main objective of was to explore the possibility of using combined microwave-convective drying technique for processing of garlic and assessment of the quality of finished product. Many studies have recently provided strong evidence that most of these biological functions of garlic are attributed to allicin (Li & Xu, 2007; Krest *et al.* 2000; Mousa, 2001). (Li & Xu, (2007) reported that no compound outside the thiosulphate, of which allicin is about 60-80% has been found that accounts for a significant portion of the pharmaceutical activities of crushed garlic at levels representing normal human consumption (2-5 g/d). And these biological effects of thiosulphates can be related to their strong SH-modifying and antioxidant properties (Rabinkov *et al.* 1998; Prasad *et al.* 1996). Garlic products have been popular and marketed in recent years as health food for human in many western countries. The relatively high moisture content of fresh garlic (about 70%, w.b) shows that it is unfit for long term storage without sprouting or rotting. Consequently, the majority of the garlic supplements sold today is dried garlic powder tablets that are standardized on allicin (Sovova 2000; Lawson *et al.* 2001). The allicin and other volatile compounds in garlic have to be preserved during processing in order to ensure its medicinal and culinary benefits. Pretreatment is an essential step in the processing of food materials (Senadeera *et al.* 2000). Various methods of pretreatment, which reduce drying time includes chemical pretreatment, blanching, and osmotic dehydration (Ade- Omowaye *et al.* 2000; Piga *et al.* 2004; Tharrington *et al.* 2005, Tunde-Akintunde, 2010). Many workers reported that pretreatment can speed up drying rate, improve the quality of dried product, prevent browning, and help retain volatile compounds (Jayaraman & Gupta, 2006; Singh *et al.* 2008;). Researchers such as (Xiao *et al.* 2009; Davoodi *et al.* 2007; Gazanfer & Sefa, 2006, and Doymaz, 2004) showed that chemical pretreatment could significantly accelerate the drying process and remarkably improve the quality of dried products such as sweet potatoes, mushrooms, red pepper, and plums. The effect of microwave and combined microwave and vacuum drying methods on the allicin content of garlic slices have been investigated by many researchers including (Li & Xu, 2007, Ciu *et al.* 2003, Sharma and Prasad, 2001).

Solar and open sun drying

Recent efforts to improve on sun drying have led to solar drying. Solar drying also uses the sun as the heat source. A foil surface inside the dehydrator helps to increase the temperature. Ventilation speeds up the drying time. Shorter drying times reduce the risks of food spoilage or mold growth. It is a complex operation involving heat and mass transfer which may cause changes in product quality. Physical changes that may occur include shrinkage, puffing and crystallization. In some cases, desirable or undesirable chemical or biochemical reactions may occur leading to changes in colour, texture, odors or other properties of the food product. Drying can either be an alternative to canning and freezing or complement these methods. Drying occurs by vaporization of the liquid by supplying heat to the wet feedstock. Heat may be supplied by conduction (contact or indirect dryers), by convection (direct dryers), by radiation or volumetrically by placing the wet material in a microwave or radio frequency electromagnetic field. Over 85% of industrial dryers are of convective type with hot air or direct combustion gases as the drying medium (Chirife, 1983; Mujumdar, 2000).

Solar drying is often differentiated from "sun drying" by the use of equipment to collect the sun's radiation in order to harness the irradiative energy for drying applications. Sun drying is a common farming and agricultural process in many countries, particularly where the outdoor temperature reaches 30°C or higher. In many parts of South East Asia, spices and herbs are routinely dried. However, weather conditions often preclude the use of sun drying because of spoilage due to rehydration during unexpected rainy days. Furthermore, any direct exposure to the sun during high temperature days might cause case hardening, where a hard shell develops on the outside of the agricultural products, trapping moisture inside. Therefore, the employment of solar dryer taps on the freely available sun energy while ensuring good product quality via judicious control of the irradiative heat. Solar energy has been used throughout the world to dry products. Such is the diversity of solar dryers that commonly solar-dried products include grains, fruits, meat, vegetables and fish. A typical solar dryer improves upon the traditional open-air sun system in five important ways (Sharma *et al.* 2009).

Freeze drying

The amount of energy necessary to eliminate water from the material dried in both processes, i.e. in convection- and freeze-drying, usually accounts for 50% of the total energy expenditure connected with the drying process (Ratti 2001, Koyuncu *et al.* 2004, 2007). The fixed energy costs result from the necessity of supporting the work of particular dryer sub-assemblies, as well as from external energy losses (Lis *et al.* 2003). Usually, these costs do not depend on the conditions in which the drying process is conducted, but are merely contingent on the drying time (Kribs *et al.* 1999, Ivanova *et al.* 2001, Krulis *et al.* 2005, Sharma *et al.* 2006). Due to the process-specific mechanisms, freeze drying is viewed as one of the most energy-consuming food preservation methods. The energy expenditure on freeze drying is several times higher, compared with convection drying (Flink, 1977, Lorentzen 1980, Kumagai *et al.* 1991). However, the overall analysis of the costs related to these two processes, as well as the considerably higher quality of dried garlic, point in favour of freeze drying (Adams 1991, Depata *et al.* 2001, Benali *et al.*, 2006).

Fluidized bed drying

Thin layer drying properties of high moisture garlic sheets under semi fluidized and fluidized bed conditions with high initial moisture content (about 154.26% d.b.) were studied. Air temperatures of 50, 60, 70 and 80°C were applied to garlic samples. Among the applied models, Page model was the best to predict the thin layer drying behavior of garlic sheets. It is proved that the quality of dried food products are strongly affected by applied drying methods and various physical, chemical and biological changes may be created in the food material (Krokida *et al.* 2000). In other words, some properties of foodstuffs such as color, structure, aroma compounds and nutritional substance were changed or deteriorated. These changes may tend to reduce the product quality (Pezzutti, Crapiste, 1997). In recent years, fluidized bed drying was investigated and utilized as a new method for obtaining dried foodstuffs with high quality (Poomsa-Ad *et al.* 2002; Cubillos, Reyes, 2003; Amiri Chayjan *et al.* 2009; Gazor, 2009). Fluidized bed drying is rapid and more uniform compared with fixed bed drying (Soponronnarit *et al.* 1997). Fluidized bed drying was employed for drying of some agricultural grain products such as: broad beans (Hashemi *et al.* 2009). Suspending of grain particles in air flow is known as fluidization. At the beginning of air passing through grain bed, a fixed bed will be created. With gradually increasing in air flow rate, a bed of fluffy material is obtained, namely minimum fluidized bed (semi fluidized bed); afterward with another increase in air flow rate, bubbling fluidized bed and transportation phenomenon would be observed. At the semi fluidized bed, maximum value of pressure drop is obtained and particles weight is equal to frictional force between bed particles (Kunii, Levenspiel 1991; Soponronnarit *et al.* 1997). Although many investigations were carried out on drying indices for various crops and agricultural products, no study reported about drying of fresh garlic sheets in semi fluidized and fluidized bed dryer. Also drying properties of garlic sheets in fluidized bed drying are not available. The main goals of this study were to find a mathematical model for predicting the drying behavior of high moisture garlic sheets and to compute the effective moisture diffusivity, activation energy and specific energy consumption of high moisture garlic sheets during falling rate of semi fluidized and fluidized bed thin layer drying method and their relation to input parameters such as air temperature and velocity.

Dried garlic products

Garlic powder

In India due to lack of suitable storage, transport and processing facilities, heavy losses are incurred both in terms of quality and quantity due to respiration, transpiration and microbiological spoilage. Through garlic is produced abundantly and consumed as such, little efforts have so far been made to produce dehydrated garlic and garlic powder.

Garlic paste

Sica Sol (1969) described a method for marking garlic paste with the same flavour as fresh garlic. The cleaned bulbs are broken into cloves, peeled and boiled carefully to obtain a homogeneous paste. To ensure a pleasing appearance and good shelf life an addition of 0.1% SO_2, 15% NaCl and 0.05% ascorbic acid is recommended. Ahmed *et al.* (2001) prepared garlic paste with a TSS and pH value of 33% and 4.1 respectively, from fresh garlic by addition of 10% NaCl (w/w) and citric acid. Appearance of green pigment was noticed in the product during preparation. Paste was thermally processed at 70.80 or 90^0C respectively for 15 minutes. Greening of paste decreased with increase in temperature. The product was found to be shelf stable at 25^0C for a period of at least 6 months.

Garlic extract

Several patents have been registered to prepare garlic juice or extract. Lazarev and lvanova (1969) patented the method of obtaining 2-component extract of garlic. According to the process the garlic is cooled and ground for aqueous extraction to yield enzyme extract called the first component. The residue is then extracted with liquid CO_2 to give enzyme-free extract called second component. The two components are mixed together prior to being added to food products. Avagimov *et al.* (1982) patented a method in which garlic was mixed with a dehydrating agent, viz. dried spices or dry waste material from extraction of spices, in a spice to garlic ratio of 1:1, and the mixture was then ground and extracted with liquid CO_2. This method claimed to increase the yield, enriched with biologically active substances. (Morinaga, 1983) patented a method for producing deodorized liquid garlic extract. The method involves merely mixing any edible oil into the garlic juice squeezed from the garlic bulbs, and holding the juice for a predetermined period in a vessel under a specific condition until has liquid garlic extract was completely precipitated. The resultant garlic extract had no unpleasant odour and acrid taste. Chopping garlic and aging it in alcohol for almost two years made aged odourless garlic extract. The extract contained thioallyl compounds.

Kimixuka *et al.* (1988) patented a flavour enhancing seasoning containing deodorized garlic extract and process. Blanching garlic, and extracting the blanched product with water prepared the seasoning. The extract produced was deodorized and concentrated, to provide seasoning additives that dramatically improved flavour fullness, depth and duration. The extract could be advantageously combined with flavour intensifiers such as monosodium glutamate.

Garlic oil

Garlic oil is derived by steaming crushed garlic and capturing the resultant oil released. The yield of garlic oil is around 0.46-057% on moisture free basis, and it makes it quite expensive. The specific gravity and refractive index of garlic oil at 25^0C is 1.091-1.098 and 1.5740-1.5820 respectively. Several workers have studied the odorous constituents of garlic oil (Brodnitz *et al.* 1971, Saghir *et al.* 1964). The compounds reported ate listed in Table 1.

Table 1. Volatile compounds obtained from garlic

Dimethyl sulphide	Diallyl disulphide	Diallyl trisulphide
Diallyl sulphide	Allyl propyl disulphide	Methyl allyl trisulphide
Methyl allylsulphide	Methyl allyl disulphide	Methyl propyl trisulphide
Dimethyl disulphide	Methyl propyl disulphide	Diallyl thiosulphinate
Dipropyl disulphide	Dimethyl trisulphide	Methanol
Sulphur dioxide	2-Propen-1-ol	p-Cymene

Source: (Brodnitz *et al.* (1971)

The major component of distilled oil of garlic is diallyl disulphide. Vegetable oil is usually added to the garlic oil to make capsules of garlic oil. It has a strong smell of garlic and is also used as a food-flavouring agent. (Hibi, (1997) patented the method of processing garlic and preparing ajoene-containing edible oil products. 100 parts (by wt.) water and 100 parts garlic bulbs are mashed together. The mashed mixture, or juice extracted from the mixture, is brought into contact with edible oil and the pH of this mixture is adjusted to neutral or between pH 6 and 8. The resulting mixture is incubated between 0 and 50^0C in order to from Z-ajoene in the oil.

Macerate of garlic

It is a product formed when garlic is chopped or macerated with salad oils or other edible oils. Macerate of garlic is a rich source of naturally formed garlic derived compounds having the scientific names ajoene, methyl ajoene, and dithiins. These products are stable enough to be stored at room temperature for more than a year (Habi, 1997).

Pickled garlic

Whole, sliced, cubed garlic is pickled in vinegar or brine or vegetable oil or their combinations. Picking garlic in vinegar leads to formation of S-allyl cysteine. Kim *et al.* (1994) studied chemical characteristics and storage stability of garlic pickled in brine (5% NaCl) acidified with a lactic acid-acetic acid mixture. The concentration of each acid (0.74%, w/v) in the brine gave a pH of 4.0 after equilibrium between garlic cloves and brine. Blanching (conventional or by microwave) prior to packaging was very important for the preparation of high-quality pickled garlic. It resulted in elimination of the pungent flavour by deactivation of the enzyme allinase, elimination of green coloration or formation of gas, and reduction of firmness.

Dehydrated garlic

The removal of water from garlic results in a substantial reduction in bulk, enabling savings in storage space and reducing the weight to be transported. Garlic is dried to mainly produce slices, cubes chunks and powder. Powered garlic attempts to mirror the chemical profile of fresh garlic in a stabilised from. Garlic is peeled, sliced, sliced and dried before pulverising. In this process a little allicin is formed where thus cloves are sliced, but most of the cells are unbroken when dried and the alliin and allinase remain separate. Dried garlic has many uses in restaurants, hotels, and in other eating establishments and in the home. Also it is used in the flavouring of tomato products, canned soups, meat products such as sausage, hamburger, and salami, as well as in certain salad dressings. As a medicine it is used to form tablets. Studies on the stability of allicin, allyl sulphides and antibacterial activity, retention of colour and flavour, satisfactory re-hydration characteristics and drying rates during dehydration has been extensively studied. Screening of varieties from the viewpoint of dehydration has also been done. (Bear *et al.*, 1994) evaluated five improved lines of garlic i.e. 3 white types (G-49, G-15 and 56-4) and 2 pink types (LCS-2 and G-11) for their physicochemical characteristics. The pink var. LCS-2 had the largest bulb size (3.7±0.7 cm), max. total soluble solids (37.5 degree Brix), and highest reducing (2.72%) and total sugar (29.9%) content. It was also found to be highly pungent as determined by its pyruvate content (22.9 micromole/g) which was the highest of the varieties evaluated. On the basis of these characteristics, var. LCS-2 was considered the best for dehydrated garlic and garlic powder. (Singh and Gupta, 1998) analysed bulbs of fifteen varites of garlic for quality parameters for dehydration purposes. Studies revealed that garlic collection G-189 recorded significantly highest TSS (43.42%), dry matter (44.245), drying ratio (2.261:1), pyruvic acid content (28.3 micro mole/g) and re-hydration ratio (1:5.06). The performance was at par with collection G-176 (43.07%, 43.90%, 2.28:1 & 27.38 micro mole/g and 1:4.85) and collection G-268 (42.80%, 43.60%, 2.29:1, 26.99 micron mol/g & 1:4.64) respectively. G-189 garlic collection was found to be the most suitable for dehydration purpose on account of better recovery and colour of dehydrated product.

CONCLUSIONS

Various methods are employed for drying of garlic which have their merits and demerits. Sun drying is suitable for water content reduced from shelf life of products % (db), wind velocities km/h) for 120 days with over turning once/twice a day and heaping or covering during night and not suitable for large commercial scale. It is a uncontrolled method, non-uniform drying methods. Convection drying is employed for heat and mass transfer coefficient and to study the moistures transport during microwave-convective drying of garlic cloves. It a mechanical process but not feasible operating cost and initial cost. Drying is an industrial preservation method in which water content and water activity of the fruits and vegetables are decreased by heated air to minimized biological, chemical and microbial deterioration. Drying is a process of simultaneous heat and mass transfer. Mathematical modelling help to of drying process help in understanding the physics of drying. At this moisture level, the chances of insects and molds infestation are minimized and thus the commonly can keep well in storage. To obtain the dehydrated product of high quality, the drying process should be such that it allows effective retention of colour appearance, flavour, taste and nutritive value, comparable to fresh vegetables. The technique of drying is probably the oldest method of food preservation practiced by mankind for the extension of food shelf life. The use of artificial drying to preserve agricultural commodities is expanding, creating a need for more rapid drying techniques and methods that reduce the large amount of energy required in drying processes. In case of garlic is a antioxidant product used for several medicinal purposes. New and innovation techniques that increase drying rates and enhance dried garlic quality are receiving considerable attention.

ACKNOWLEDGEMENT

The author expresses his sincere thanks to Indian Council of Agricultural Research and Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut for providing financial assistance to conduct the experiment. The authors express his sincere thanks to Dr. M.P. Singh (Associate Professor), K.V.K., Balia at N.D.U.A. & T., Kumarganj, Faizabad (U.P.)

Volume : 3 | Issue : 10 | October 2014 • ISSN No 2277 - 8179

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