

VALUE-ADDED PRODUCTS OF GARLIC AND THEIR POTENTIAL HEALTH BENEFITS - A REVIEW

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Abstract– Garlic and its different value-added products are widely employed in food and pharmaceutical industries in a variety of forms due to its distinct flavour. It is processed into dehydrated garlic flakes, garlic slices or rings, garlic grits, garlic tablets, garlic pickles, garlic powder, digestive churns, paste, garlic oil, salts which are mostly demanded at national as well as international market due to its nutritional composition, health benefits and medicinal properties. The presence of various biologically active compounds in garlic has attracted the attention of modern medicine because of its effects in maintaining good health it reduces cholesterol, boosts the immune system, prevents from various ailments such as cancer, cardiovascular diseases, metabolic disorders, blood pressure, and diabetes, through its anti-inflammatory, antioxidant, and lipid-lowering properties. Value addition of garlic in the form of various processed products will significantly increase the export of garlic and its value-added products and will also play an important role to augment the expanding garlic-based processing industries in India.

INTRODUCTION

Allium sativum is known as garlic and belongs to the family Alliaceae. The genus *Allium* consists of over 800 plant species, including onions, leeks, and chives. Garlic is an annual herb with thin, flat leaves (Roy and Pal, 2000) and is widely cultivated for its edible bulb, which consists of many small cloves. The name garlic is probably derived from the old English word “gar”, which refers to clove. It originated in Central Asia and then spread to the Mediterranean region. The taxonomy of the genus *Allium* is complex, with many species sharing similar morphological characteristics and overlapping geographical distributions. Species *A. sativum* is divided into two subspecies. *A. sativum* subsp. *sativum*, including most cultivars of garlic, and *A. sativum* subspecies *ophioscorodon* includes wild and cultivated hard neck garlic varieties.

It is also grown for medicinal purposes in the pharmaceutical industry. It is the most important commercial spice plant, used for seasoning and gives flavour in vegetable and meat dishes. It has digestive and anti-rheumatic properties. It has been used since ancient times in Ayurvedic formulas to heal muscle ache, dizziness, heating of lungs and

intestinal ulcers, etc. It is consumed as a flavouring ingredient in vegetarian and non-vegetarian dishes and pickles. Delicious cucumbers, chutneys, and curry powders are made from garlic. It is also used to mask the smell and taste of cured meat and fish. In many countries, powdered or granulated dried garlic is used instead of fresh onion. The main advantage of preparing value-added products from garlic is increased shelf life, while reducing transportation costs and earning more foreign currency (Bondre *et al.*, 2017).

According to the United Nations Food and Agriculture Organization (FAO, 2022), the world’s largest garlic producer is China, followed by India. In 2020, China produced over 20 million tons of garlic, while India produced about 3.19 million tons.

Table 1. Country wise production and % share

Location	Production (million tons)	% share
World	28.204	100
China	20.45	72.53
India	3.19	11.31
Bangladesh	0.50	1.78
Egypt	0.34	1.23

Source: FAOSTAT, 2022

In India, garlic is harvested in March-April and stored all year round. Due to the daily fluctuating environmental conditions in our region, it is very difficult to maintain the quality and quantity of garlic during the storage period. Consumers therefore need to make it available in a variety of forms, including dried cloves, garlic paste, minimally processed garlic, and dried powder (Rai *et al.*, 2006).

Production of Garlic in India

Garlic is widely cultivated in India and is an important crop for both domestic consumption and exports. Madhya Pradesh, Rajasthan, Gujarat, Uttar Pradesh and Maharashtra are the major garlic producing states in India (NHB, 2021-2022).

Garlic production in India has increased in recent years due to the high demand for garlic in both domestic and international markets. According to a report by the Agriculture and Processed Food Export Development Authority (APEDA, 2014), fresh and processed garlic export from India have increased in recent years. In 2020-2021, total garlic exports from India were estimated at around 61,354 tonnes worth US\$52.07 million.

Medicinal and Nutritional Value

Garlic has been used for its medicinal and nutritional properties due to the presence of various secondary metabolites. It contains vitamins including vitamin C, vitamin B6, and thiamine. Vitamin C is an antioxidant involved in immune system function and collagen synthesis, and vitamin B6 is involved in neurotransmitter synthesis and erythropoiesis (USDA, 2020). Thiamine is important for energy metabolism and proper functioning of the nervous system (Lu *et al.*, 2018).

Garlic has been shown to have beneficial effects on cardiovascular health by lowering blood pressure and cholesterol level. Allicin, in particular, has been shown to have strong antioxidant activity and prevent the development of cardiovascular disease (Hansson *et al.*, 2017). Supplement risk for heart disease significantly lowers blood pressure in hypertensive patients (Ried *et al.*, 2008). Garlic supplementation reduced total and LDL cholesterol in adults with high cholesterol (Reinhart *et al.*, 2008). Garlic contains antioxidants, including allicin, allin, and quercetin. These compounds possess anti-inflammatory and anti-cancer properties (Bayan *et al.*, 2014). It has been shown to have anti-cancerous properties, especially in preventing stomach and

Table 2. State wise Production of Garlic in India (2021-22)

Sr. No.	State	Production (000 Tonnes)	Share (%)
1	Madhya Pradesh	2,016.13	62.85
2	Rajasthan	539.18	16.81
3	Uttar Pradesh	210.90	6.57
4	Gujarat	105.65	3.29
5	Punjab	85.20	2.66
6	Assam	64.45	2.01
7	Odisha	43.49	1.36
8	Haryana	39.86	1.24
9	West Bengal	36.98	1.15
10	Maharashtra	22.79	0.71
11	Karnataka	13.37	0.42
12	Uttarakhand	8.08	0.25
13	Tamil Nadu	6.68	0.21
14	Himachal Pradesh	5.14	0.16
15	Chhattisgarh	2.77	0.09
16	Nagaland	2.66	0.08
17	Bihar	2.63	0.08
18	Kerala	0.64	0.02
19	Jammu & Kashmir	0.57	0.02
20	Meghalaya	0.48	0.01
21	Telangana	0.23	0.01
22	Mizoram	0.01	0.00
	Total	3,207.89	

Source: National Horticulture Board (NHB, 2021-22)

colon cancers. Regular consumption of garlic has been shown to reduce the risk of stomach and colon cancers. (Fleischauer *et al.*, 2000). Eating large amounts of garlic has also been shown to reduce the risk of colon cancer (Zhou *et al.*, 2013).

Garlic helps to strengthen the immune system and increases the number of immune cells in the blood (Nantz *et al.*, 2012). It is an excellent source of several minerals, including manganese, calcium, and copper. Manganese is involved in several metabolic processes and is important for bone health, while calcium is important for bone health and muscle function. Copper is important for the production of red blood cells and connective tissue (USDA, 2020).

It is also a great source of dietary fiber, with one clove of garlic provides about 1% of recommended daily fiber intake (USDA, 2020). Fiber is important for digestive health and helps lower cholesterol levels. It contains only 4 calories, no fat and small amount of other nutrients such as potassium, phosphorus, and selenium.

Processing of Garlic

Garlic processing includes various steps to

transform raw garlic into different forms suitable for consumption and use in different industries. The main processing techniques include dehydration, pickling, freezing and blackening. Other forms of garlic processing include grinding, pureeing, and roasting, commonly used in the food industry to make garlic pastes, sauces, and spice blends.

Dehydration is one of the most common processing techniques to dry garlic cloves for removing moisture, resulting in a long-lasting product that can be used in a variety of culinary applications.

Pickling

Garlic is soaked in vinegar or salt water, resulting in a tangy, slightly sweet product that can be used in salads, sandwiches, and other dishes. Dehydration has been found to significantly reduce water-soluble and heat-sensitive compounds in garlic such as allicin, which has antibacterial and anti-inflammatory properties (Choi *et al.*, 2013). It retains a significant amount of antioxidant activity that is beneficial to health (Ninfali *et al.*, 2005).

Freezing

Freezing garlic cloves preserves their nutritional and medicinal properties for an extended period of time. Frozen garlic has been found to improve its nutritional and medicinal properties as compared to dehydration and long-term storage (Ninfali *et al.*, 2005). It also helps to preserve its flavor and aroma, making it suitable for a variety of culinary uses (Ahmad *et al.*, 2015).

Crushing

It involves crushing garlic cloves with a knife blade or the flat side of a garlic press, releasing the garlic's essential oils and enzymatic compounds. This method is common in recipes where raw or lightly cooked garlic is preferred. Additionally, crushing garlic may increase the bioavailability of allicin, which has potential health benefits (Borlinghaus *et al.*, 2014).

Pureeing

It involves blending or grinding garlic cloves into a smooth paste or sauce. It is often used in garlic puree has a smooth texture and can be used as a spread or dip. However, mashing increases exposure to oxygen and heat, which can reduce the effectiveness of allicin (Song *et al.*, 2017).

Roasting

It involves roasting whole cloves of garlic in an oven until they are soft and caramelized. It can be used in a variety of dishes such as dressings, sauces etc. Additionally, roasted garlic increases antioxidant activity, which helps in reducing inflammation and improving immune function (Mancuso and Santangelo, 2018).

Processed Products

Different processed products are prepared from garlic which have additional medicinal benefits, some of which are mentioned below.

Black Garlic

Black garlic is fermented garlic, a popular processed product due to its unique flavor and potential health benefits (Lee, 2014). It is made by heating a whole garlic bulb at 60-90°C and 70-90% relative humidity. This process causes a chemical reaction called the Millard reaction that gives garlic cloves a darker color and changes their flavor and texture. It has a sweet, tangy flavor, and a slightly chewy, soft and rubbery texture reminiscent of dried fruit. Unlike fresh garlic, black garlic is low in allicin. However, it has increased polyphenol content, antioxidants and other beneficial compounds such as S-allyl cysteine (Kang *et al.*, 2007).

Black garlic lowers cholesterol and improves blood vessel function. It reduces natural killer cells and helps to strengthen the immune system by increasing the activity of immune cells and reduces inflammation (Lee *et al.*, 2021).

Garlic Powder

Garlic powder is commonly used as a spice in cooking. It is made by dehydrating fresh garlic cloves and grinding them into a fine powder. It is a convenient alternative to fresh garlic because it is easy to use and has a long shelf life. The cloves are

Table 3. Comparison of export data of seven years

Year	Quantity(tonnes)
2015	7477.07
2016	21534.41
2017	33736.1
2018	8840.27
2019	8088.83
2020	4680.05
2021	4568.31

Source: FAOSTAT, 2022

dried at a temperature of 320C with 65-70% relative humidity for 6-7 months.

Garlic bulbs are harvested from the field and cleaned of dirt and debris. The bulbs are dried in a variety of ways including sun drying, oven drying and dehydration. This process draws water out of the garlic, allowing it to be stored for a long time without spoiling. Dried garlic cloves are ground into a fine powder using a grinder or mortar and pestle. Garlic powder is sieved to remove large or uneven particles and packed for sale. The moisture content of dry garlic is reduced to <5%. Garlic powder is a multipurpose spice used in a variety of dishes such as soups, stews, and marinades. It is also a common ingredient in many processed foods such as snack foods, spices and seasonings. A potential benefit of using garlic powder is that it provides the nutritional and health benefits of fresh garlic in a more convenient and easier-to-use format (Choi *et al.*, 2014).

Dehydrated garlic slices

Dehydrated garlic exhibits yellow to dark yellow colour because of sugar caramelizing reaction after exposure to high temperature and the moisture content of dehydrated garlic is reduced to <12% maintaining a dehydration ratio of 6:1 (IIFPT, 2020).

Garlic oil

Garlic oil is obtained by steaming the crushed garlic and capturing the oil released from the cloves. The yield of garlic oil is around 0.46-057% on moisture free basis, which makes it quite expensive. Garlic oil can be used in a variety of dishes, including seasonings, marinades, and dressings. It is also available as a dietary supplement and is marketed as

a natural remedy for a variety of health conditions. (Tapsell *et al.*, 2006).

Garlic bulbs are harvested and washed to remove dirt and debris. Washed garlic bulbs are crushed or sliced to expose maximum surface area to facilitate the extraction process. Garlic oil can be extracted by steam distillation or solvent extraction. In steam distillation, crushed or sliced garlic is subjected to steam distillation to obtain a mixture of essential oils and water. Solvent extraction uses a solvent *i.e.*, hexane to extract the essential oil from crushed or sliced garlic. The essential oil and water mixture obtained by steam distillation is separated by cooling and condensation. The oil is then separated from the water. In solvent extraction, the solvent is removed by an evaporation process or vacuum distillation to obtain garlic oil. The garlic oil is then filtered and purified to remove impurities and unwanted compounds. To ensure the quality and freshness of garlic oil, the final product is packed in airtight containers to maintain storage conditions.

Garlic Extract

Garlic extract is a concentrated form of garlic obtained from raw garlic cloves using a variety of extraction techniques. It is a popular dietary supplement due to its high levels of sulphur-containing compounds such as allicin. Garlic extract is widely used in dietary supplements, pharmaceuticals, and foods, as a natural flavoring agent, and for the health benefits (Borlinghaus *et al.*, 2014).

High-quality garlic cloves are selected and thoroughly cleaned to remove dirt, debris and other impurities. Washed garlic bulbs are crushed or sliced to reveal maximum surface area and facilitate

Table 4. Export of Garlic (dried) from India to top ten countries in last three years

S. No.	Country	2019-20		2020-21		2021-22	
		Qty	Rs. Lakhs	Qty	Rs. Lakhs	Qty	Rs. Lakhs
1	Australia	51.2	195.0	98.5	303.6	48.9	227.2
2	Nepal	42	21.7	257.3	138.8	30.8	191.3
3	Taiwan	19	20.2	62.2	79.1	67.1	82.2
4	America	16.6	12.5	1.9	3.67	30.9	75.6
5	Mexico	95	100.3	92	108.0	54	71.9
6	Vietnam	3.62	4.85	1.5	2.07	62.7	48.7
7	Argentina	15	16.6	40	43.9	25	30.4
8	Germany	0	0	0	0	14.8	24.7
9	U A E	14.4	6.3	36.5	23.9	35.6	19.6
10	U K	0	0	4	5.7	7.4	11.2

Source: https://agriexchange.apeda.gov.in/index/Product_description.aspx?ctrycode=&hscode=07032000&valuegrowth=2

the extraction process. Various extraction techniques are used such as water extraction, ethanol extraction and carbon dioxide extraction. Water extraction involves soaking garlic in boiling water to extract the water-soluble compounds. In ethanol extraction, garlic cloves are mixed with ethanol to extract both water-soluble and fat-soluble compounds. In supercritical carbon dioxide extraction, carbon dioxide is used as a solvent to extract the compounds. The extract is then filtered to remove impurities and concentrated to increase potency. The concentrated extract is dried to remove residual solvent and yield the final product. Dried garlic extract is packaged in airtight containers to preserve freshness and quality.

Garlic Paste

Singh *et al.* (2014) described a technique for imbuing fresh garlic flavour into garlic paste. To get a homogeneous paste, cloves are separated, peeled and boiled. Addition of 0.1% SO₂, 15% NaCl, and 0.05% ascorbic acid gives the paste attractive appearance and longer shelf life.

Exports of Garlic

India exported 463,622.47 tonnes of garlic worth USD 367.98 million from April 2020 to February 2021. Major export destinations of Indian garlic are Bangladesh, United Arab Emirates, Sri Lanka, Malaysia, Nepal, etc.

Growing global demand for processed garlic products is driving garlic exports from India, and India is well positioned to capitalize on this trend due to its large volume of garlic production and the availability of advanced processing techniques. Garlic exports from India are expected to continue growing in the coming years, offering farmers and processors an opportunity to expand their business and contribute to the growth of the Indian economy.

CONCLUSION

Garlic processing is an important aspect of the garlic industry, leading to the development of various value-added products that cater to the diverse taste and needs of the consumers. The most commonly processed garlic product is garlic powder, garlic oil, garlic paste, black garlic, and garlic extract. All these products are processed differently and have unique properties that make them suitable for specific applications. Demand for processed garlic merchandise is growing globally because of the

developing recognition of the various advantages of garlic consumption. India is one of the world's leading producers of garlic products and has become one of the major exporting countries. Industrial growth is driven by the availability of advanced processing techniques and increasing demand for processed garlic products. Garlic has a variety of nutritional and medicinal benefits that have made it a valuable ingredient in many cuisines and medicinal products. Overall, garlic processing will offer farmers and processors a variety of opportunities to expand their business and contribute to the economic growth of the country.

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