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Effect of Xanthan gum and drying temperature on quality characteristics of garlic powder

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Abstract
In present study, garlic was peeled and converted into paste by adding foaming agent *viz*. Xanthan gum. The work comprised of the following treatments: T_1 (Control), T_2 (0.5% Xanthan gum), T_3 (1% Xanthan gum), T_4 (1.5% Xanthan gum). The foamed garlic paste was dried at 50 and 60°C and converted into powder. The foam mat dried garlic powder was packed in polypropylene bags and stored under ambient conditions followed by analysis at a regular interval of 30 days upto three months to ascertain the changes in functional and bioactive properties. In case of both drying temperatures (50 and 60 °C), minimum mean bulk density of 0.372 and 0.362(g/ml) and water activity of 0.492 and 0.481 were observed in T_4 (1.5% Xanthan gum). However, the highest mean rehydration ratio of2.434 and 2.459 were observed in T_4 (1.5% Xanthan gum). The highest mean L* value of 94.21 and 93. 20 were observed in T_4 (1.5% Xanthan gum). Sensory evaluation of foam mat dried garlic powder revealed that T_4 (1. 5% Xanthan gum) recorded the highest mean score for overall acceptability (8.10 and 8.02) when dried at 50 and 60°C, respectively. In general bulk density and water activity increased whereas, calcium content, antioxidant activity and total phenol content decreased during storage. Overall, foam mat dried garlic powder prepared using T_4 (1. 5% Xanthan gum)was adjudged as best for retaining quality attributes, enhanced shelf life and higher overall acceptability scores.

Keywords: Bioactive compounds, foam mat drying, garlic, shelf life, xanthan gum

Introduction
The term spice can be used to describe herbal by-products which adds flavor and aesthetic, aromatic and therapeutic values to various foods, drinks and other items [1]. As food or medicine, the importance of spices cannot be over emphasized. Almost all curries are tasty and popular which are made by combining several spices. They are also used as natural food preservatives. Pharmaceutically, they can also be used as flavor medicines. Garlic (*Allium sativum* L.) is the only spice in the spices kingdom which is rich in all the minerals, vitamins as well as the trace elements. It is rich source of protein and minerals such as calcium, potassium, phosphorous, sulphur and magnesium. It also contains ascorbic acid and has high calorific value. In garlic, *allicin* is present which helps to reduce the cholesterol concentration in human blood. It also helps to reduce serum cholesterol levels. Different compounds in garlic also help to decrease the risk for cardiovascular diseases, have anti-microbial andanti-tumor properties [2]. Since garlic possesses advantageous roles in blood circulation among its physiological effects on the human body, the wealth of scientific literature supports the proposal that garlic consumption have significant effects on decreasing blood pressure, prevention of atherosclerosis, decrease in serum cholesterol and triglyceride, prevention of platelet aggregation, and increasing fibrolytic activity [3]. It is consumed as green as well as dried in the spice form and as an ingredient to flavor the various non-vegetarian, vegetarian dishes and pickles. Garlic powder helps in digestion and absorption of food. In India, though garlic is grown abundantly and is consumed as such but nearly 20 per cent of the crop is wasted due to transportation, respiration and microbiological spoilage during storage of galic bulbs. In order to overcome such limitations, garlic is processed into paste, powder, pickle form etc.

Xanthan gum is an exo-polysaccharide mostly obtained from a plant pathogenic microorganism of the genus *Xanthomonas*, the strain *Xanthomonas campestris* NRRL B-1459 being the mainly used [4]. Xanthan gum is used as thickening agent and emulsifier in various foods like fruit pulp, juice, bakery products, beverages, jellies, desserts, chocolates, margarine, dairy products, yoghurt, frozen foods, sauces and gravies. Xanthan gum is used along with other gums like guaror locust bean gum, to decrease the cost of production.

It provides viscosity, texture, flavor release, appearance and water-control properties as so required by the foods nowadays. Besides these properties, xanthan gum also enhances rheology of the final products by its pseudoplastic behaviour in solutions and as a result of more Newtonian characteristics [5].

Foaming is a process by which liquid or semi solid foods are whipped to form foams. The foam structure plays an essential role in moisture movement during drying and also on subsequent product quality. Foams must also retain the open structure during drying [6]. Foam mat drying is very efficient methods employed for the removal of moisture from the fruit pulps to attain a free flowing powder that have better reconstitution properties.

The process has advantages like less drying time due to the physical structure of foam (honeycomb structure) which results in quick and easy removal of moisture from a food and also decreases the nutritional losses. The foaming process results in a product which has better quality characteristics as compared to non- foamed product.

Numerous factors are responsible to generate stable foam like foaming agents (milk, egg albumin, glycerol monostearate etc.), foam stabilizers (carboxy methyl cellulose, gelatin, xanthan gum etc.), whipping time, method of incorporation of air etc [7].

The objectives of this work was to study the effect of foaming agent (xanthan gum) on drying characteristics of garlic pulp and to evaluate the functional and bioactive properties of foam mat dried garlic powder.

Materials and methods

Procurement of raw materials

The fully matured, disease free garlic selected for the present investigation was procured from the local market of Jammu. The disorted, bruised and diseased garlic cloves were discarded. Foaming agent (Xanthan gum) was purchased from Central Drug House (P) Ltd. New Delhi-110002 India.

Preparation of foam mat dried garlic powder

Preparation of garlic paste

The detailed methodology for the preparation of garlic paste is given in the following flowchart:

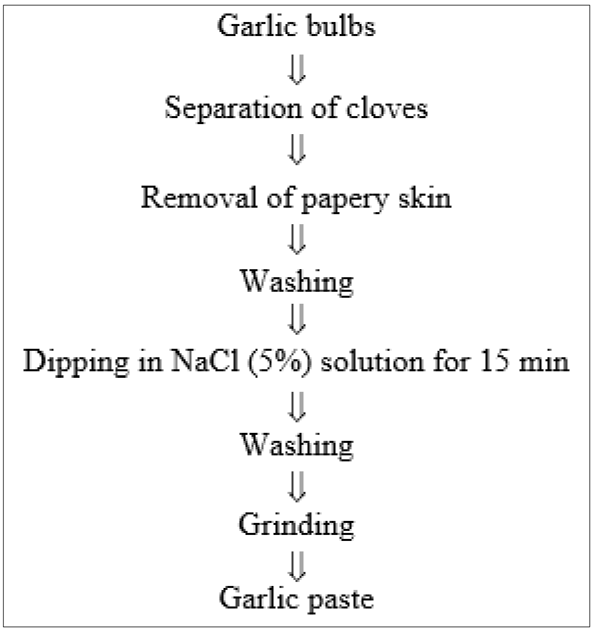

Fig 1: Flow sheet for preparation of garlic paste

Preparation of foaming agent mixture (xanthan gum)

Xanthan gum (XG) was selected as foaming agent and was used within the limits as documented in the Prevention of Food Adulteration Act (1955) of the Government of India. A suspension of xanthan gum was prepared by mixing known weight of xathan gum powder into a measured amount of hot distilled water (100 °C) to get 20 per cent (w/w) xanthan gum suspension. The suspension was blended in a mixer for 1-2 min, at maximum speed, until smooth suspension was formed and then kept at room temperature until ready for use[5]. The suspension was then added to garlic paste at 0.5, 1.0 and 1.5 per cent (w/w).

Production of foam-mat garlic pulp mixture

The required quantity of freshly prepared xanthan gum was added to garlic pulp at different concentrations of 0.5, 1.0 and 1.5 per cent. The mixture was mixed in a mixer at low speed for 1 min to facilitate even distribution of the foaming agent within the paste. The details are given in Figure 2.

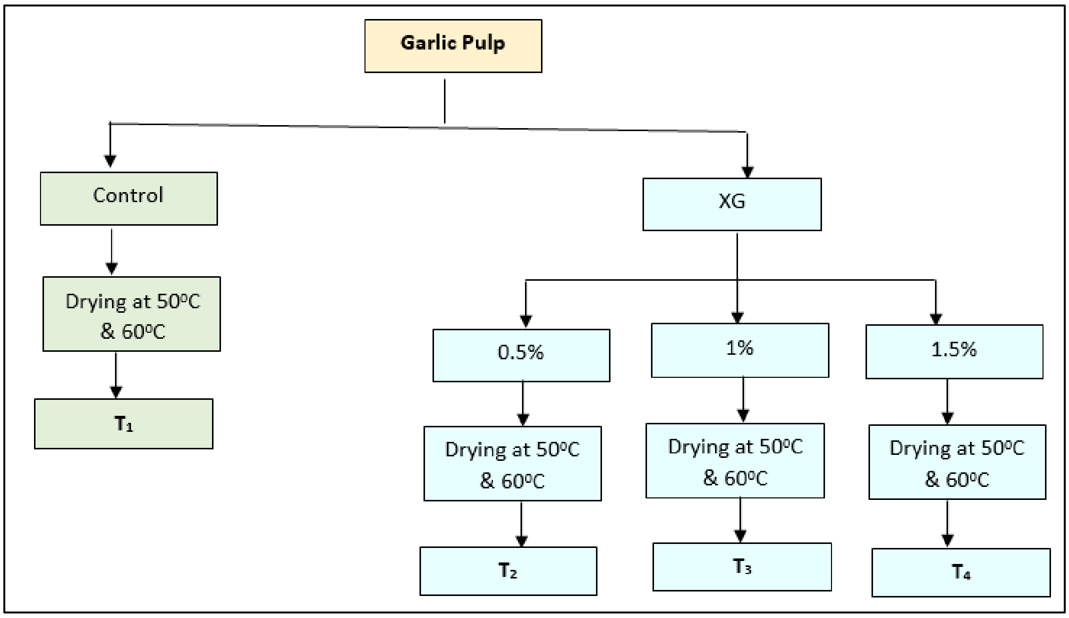

Fig 2: Flow sheet for preparation and drying of foam-mat dried Garlic powder

Drying of foamed garlic pulp

Drying was carried out in a cabinet dryer at dry bulb temperature of 50° and 60 °C and maximum fan speed (200m/s). The dryer was switched on for a period of time until the required temperature inside the cabinet was reached and stabilized. Foamed garlic slurry was spread on food grade stainless steel trays with thickness of 4mm. Drying process started when both temperatures (setting temperature and temperature inside the dryer) shown in thermostat were the same. The foamed slurry was dried and then scrapped after cooling the trays at room temperature. Powder obtained from different temperatures were pulverized using blender for 3 min and the immediately packed in polypropylene bags (150 guage) to prevent diffusion of moist air. The samples were stored at ambient temperature until further analysis. The detailed flow sheet for preparation of foam mat dried garlic powder is shown in Figure 3.

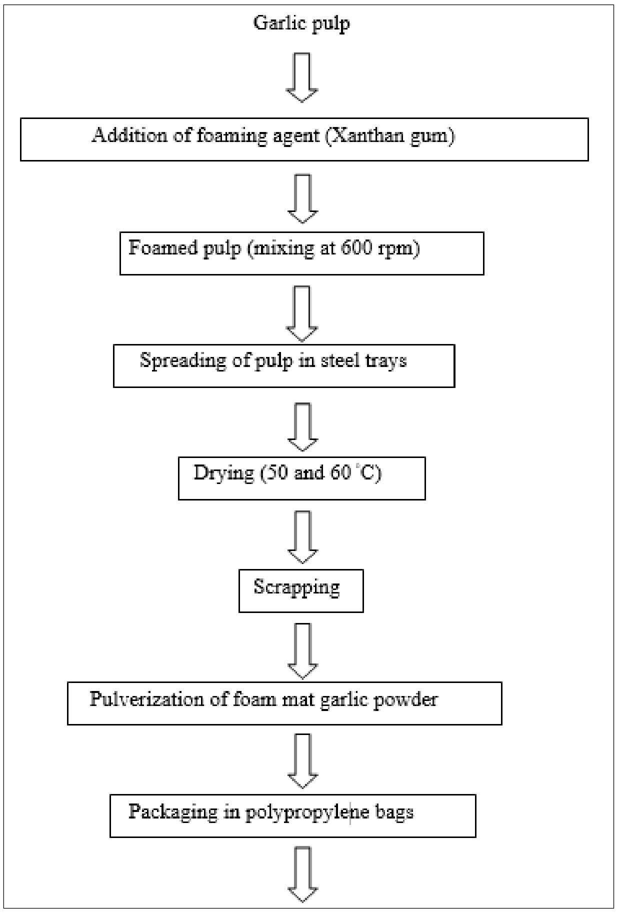

Fig 3: Flow sheet for preparation of garlic powder

Packaging of foam mat dried garlic powder for shelf life studies

The foam mat dried powder was packed in polypropylene (PP) bags and stored for 90 days at temperature of (32±2°C). The stored powder was analyzed for functional & physicochemical properties, antioxidant activity, microbial load and organoleptic properties at interval of 30 days following the standard procedures.

Functional and Bioactive properties

Hunter colour values (L*, a*, b*)

The colour of sample was measured using a Hunter's lab colour analyser (Hunter Lab Color Flex Reston VA, USA). The equipment was calibrated using white and black standard ceramic tiles. In the Hunter's lab colorimeter, the color of a sample is denoted by the three dimensions L*, a* and b*.

Rehydration ratio

Rehydration ratio was determined according to the AOAC method [8]. 5g of garlic powder was soaked for 60 min in 50 ml distilled water, filtered through filter paper and then the filtrates were weighed (two measurements for each sample). The rehydration ratio (R/R) was used to express ability of the dried material to absorb water. It was determined by the following equation:

$$\text{Rehydration ratio} = \frac{W_2}{W_1}$$

Where:
W_2 = weight of drained material, g
W_1 = weight of dried material, g

Water activity

Water activity (a_w) was measured as per AOAC method [8], using a water activity meter series 3TE (Decagon Devices, Inc., Washington, DC, USA) at room temperature (25 °C).

Bulk density

Bulk density of the sample was determined method adopted from Santhalakshmy *et al.* [9]. Bulk density was calculated by the given formula:

$$\text{Bulk density (g/ml)} = \frac{\text{Mass of Powder (g)}}{\text{Volume (ml)}}$$

Calcium content

One ml extract was titrated with standard EDTA (N/50) solution using ammonium perpurate (Mure oxide) as an indicator in the presence of 4 N NaOH solution. The end point is a change in color from orange-red to purple [10].

Antioxidant activity

Free radical scavenging activity was determined by DPPH (diphenylpicryl hydrazyl) method. 500 µl of 0.5 Mm DPPH solution and 2ml of 80 per cent methanol aqueous solution were mixed with 25 µL of methanolic extract of sample, and absorbance was determined under 517 nm blank as 80 per cent methanol and tris buffer) after maintaining at 20^0 C for 30 minutes. The free radical scavenging activity was evaluated by comparing the absorbance of the sample solution with control solution to which distilled water was added instead of sample [11].

$$\text{Radical scavenging activity (\%)} = \frac{\text{Control OD (0 min) - Sample OD (30 min)}}{\text{Control OD (0 min)}} \text{x100}$$

Total phenols

The total phenols extracted in 10-15 times volume of 80 per cent ethanol were estimated on the basis of their reaction with an oxidizing agent phosphomolybdate in Folin –Ciocalteau reagent under alkaline conditions in boiling water bath for one minute. The developed blue colour was measured at 650nm in a spectrophotometer. The standard curve was prepared using different concentrations ($20\text{-}100_{ug/ml}$) of catechol and the results were expressed as mg per cent on fresh weight basis [12].

Sensory evaluation

Sensory evaluation depends upon the responses given by different sense organs. The samples were evaluated on the basis of overall acceptability by semi-trained panel of 7-8 judges by using 9 point hedonic scale assigning scores 9- like extremely to 1- dislike extremely. A score of 5.5 and above was considered acceptable [13].

Statistical analysis

The results obtained were statistically analyzed using completely randomized design (CRD) and factorial CRD for interpretation of results through analysis of variance[14]and the data was taken in 4 replications.

Result and Discussion

Hunter colour values (L*, a*, b*)

Colour values have an important role for the specification of the quality of the dried powder and also influences the consumer acceptability. Changes in external colour of foam mat dried garlic powder were analysed by measuring L* (lightness), a* (redness) and b* (yellowness) values during storage. Among different drying temperatures, 50 °C recorded higher values for L*, a* and b* during storage. This result may be explained by the fact that long drying time and high temperature change the product colour value [15]. The highest mean L* value of 94.21 and 93. 20 were observed in T_4 (1.5% xanthan gum) dried at 50 °C and 60 °C, respectively (as shown table 1). The highest mean a* value of 4.30 and 4.15 and b* value of 30.06 and 29.08 were observed in T_1 (control) at 50 °C and 60 °C (as shown in table2 and table 3). The greening of the foam mat dried garlic powder (decrease in the a* value of dried powder with temperature) results from the accumulation of S-(E-1-propenyl)-1 cysteine sulfoxide[16]. Unni *et al.* [17] during high pressure processing of garlic paste observed that garlic becomes redder when it loses its yellow pigment due to temperature. Figiel [18] who studied the vacuum microwave drying of garlic determined a brighter colour compared to fresh samples. After convective and microwave drying L* value increases and a* and b* value decreases. The colour value of foam mat dried garlic powder decreased significantly with the advancement of storage period. The major reason for the colour change during storage is the formation of polyphenoloxidase compounds in garlic which can cause browning.

Table 1: Effect of foaming agents, drying temperature and storage on L*value of foam mat dried garlic powder

Treatments	Drying temperature (°C)									
	50 °C					60 °C				
	Storage period (days)					Storage period (days)				
	0	30	60	90	Mean	0	30	60	90	Mean
T_1(Control)	77.80	76.56	75.92	75.70	76.50	76.33	75.68	75.04	74.83	75.47
T_2 (0.5% Xanthan gum)	91.58	91.22	91.07	90.76	91.16	90.67	90.33	90.01	89.66	90.17
T_3 (1% Xanthan gum)	92.29	91.96	91.63	91.37	91.81	91.39	91.07	90.76	90.43	90.91
T_4 (1.5% Xanthan gum)	94.67	94.33	94.09	93.73	94.21	93.71	93.32	93.02	92.76	93.20
Mean	89.08	88.51	88.17	87.89		88.02	87.60	87.20	86.92	

Table 2: Effect of foaming agents, drying temperature and storage on a*value of foam mat dried garlic powder

Treatments	Drying temperature (°C)									
	50 °C					60 °C				
	Storage period (days)					Storage period (days)				
	0	30	60	90	Mean	0	30	60	90	Mean
T_1(Control)	4.74	4.45	4.07	3.93	4.30	4.41	4.28	4.09	3.81	4.15
T_2 (0.5% Xanthan gum)	3.56	3.39	3.13	2.97	3.26	3.43	3.25	3.01	2.85	3.14
T_3 (1% Xanthan gum)	3.15	3.03	2.71	2.50	2.85	3.09	2.86	2.57	2.39	2.73
T_4 (1.5% Xanthan gum)	2.80	2.63	2.48	2.16	2.52	2.65	2.44	2.22	2.04	2.34
Mean	3.56	3.37	3.09	2.89		3.39	3.20	2.97	2.77	

Table 3: Effect of foaming agents, drying temperature and storage on b*value of foam mat dried garlic powder

Treatments	Drying temperature (°C)									
	50 °C					60 °C				
	Storage period (days)					Storage period (days)				
	0	30	60	90	Mean	0	30	60	90	Mean
T_1(Control)	30.44	30.13	29.93	29.75	30.06	29.48	29.15	28.94	28.74	29.08
T_2 (0.5% Xanthan gum)	25.42	25.15	24.96	24.75	25.07	23.54	23.15	22.93	22.74	23.09
T_3 (1% Xanthan gum)	23.95	23.54	23.16	22.94	23.40	22.77	22.53	22.30	22.04	22.41
T_4 (1.5% Xanthan gum)	21.54	21.14	20.84	20.54	21.02	19.29	19.01	18.84	18.68	18.96
Mean	25.33	24.99	24.72	24.49		23.77	23.46	23.25	23.05	

Rehydration ratio

Rehydration ratio is an essential parameter as far as the quality of dried product is concerned. The highest mean rehydration ratio of 2.434 and 2.459 were observed in T_4 (1. 5% Xanthan gum) in both drying temperatures 50 °C and 60 °C, respectively. While as, T_1 (control) recorded lowest mean rehydration ratio of 2.404 and 2.444 at 50 °C and 60 °C (as shown in table 4). The increase in rehydration ratio at higher drying temperature is because of the shrinkage and collapse that was present during the hot air drying, resulting in lower transport rate of water, more drying time and tough texture while the porous structure collapsed due to the high rate of water evaporation[19]. Singh and Sharma[20]reported that rehydration ratio of coated samples of carrots was more than the uncoated samples during the entire storage study. This may be due to the fact that the layer of coating formed outside the coated samples did not allow moisture gain into the cuboid whereas the intake of moisture was more due to absence of coating. The decrease in rehydration ratio with increase in storage time was also observed in dried carrots by Prakash *et al.* [21].

Water activity

Water activity measures availability of water responsible for microbial and other deteriorative reactions. At initial stage, the highest mean water activity of 0.589 and 0.575 were observed in powders dried at temperature 50 °C and 60 °C, respectively in T_1 (control) whereas, the lowest mean water activity of 0.492 and 0.481 were observed in T_4 (1.5% Xanthan gum) at 50 °C and 60 °C (as shown in table 5). The reduction in water activity can be attributed to the moisture loss of the product at higher temperature, as on one hand the food structure is more porous at higher temperature accelerating the moisture loss, on other hand, the proteins are unfolded due to denaturation and hence, their water holding capacity is reduced which can result in decrease the water activity of the powder [22].

Similar findings were reported by Franco *et al.* [23] in foam mat dried yacon juice powder at 50, 60 and 70 °C resulting in decrease in water activity from 0.11 to 0.22. During storage of three months, water activity increased significantly. Increase in water activity during storage, may be due to the ingress of moisture from the surroundings through the package.

Bulk density

Bulk density of powder is affected by particle size, chemical compostion and moisture content as well as by storage and processing conditions [24]. At initial stage, maximum mean bulk density of 0.389 at temperature 50 °C and 0.386 at temperature 60 °C were observed in T_1 (control) whereas, lowest bulk density of 0.372 in 50 °C and 0.362 in 60 °C were observed in treatment T_4 (1.5% Xanthan gum) (as shown in table 6). The reduction in density of the dried garlic powder is attributed to the quick moisture removal at higher drying temperature. The higher drying temperature leads to a higher rate of moisture evaporation from the product being dried resulting in lower bulk density and a higher porosity of the dried product [25]. Asokapandian *et al.* [26] also reported reduction in bulk density of foam mat dried muskmelon using soy protein with increase in drying temperature.

Similar kind of results were also observed for drying of tamarind powder using drum drier by Jittanit *et al.* [27]. During storage, bulk density of foam mat dried garlic powder increased. Dayal [28] also reported increase in bulk density of aloe vera powder with increase in storage period depending on the extent of moisture gain of the powder.

Table 4: Effect of foaming agents, drying temperature and storage on rehydration ratio of foam mat dried garlic powder

Treatments	Drying temperature (°C)									
	50 °C					60 °C				
	Storage period (days)					Storage period (days)				
	0	30	60	90	Mean	0	30	60	90	Mean
T_1(Control)	2.413	2.408	2.401	2.392	2.404	2.455	2.449	2.442	2.430	2.444
T_2 (0.5% Xanthan gum)	2.421	2.416	2.407	2.396	2.410	2.452	2.444	2.434	2.425	2.439
T_3 (1% Xanthan gum)	2.430	2.424	2.416	2.408	2.420	2.460	2.454	2.448	2.434	2.449
T_4 (1.5% Xanthan gum)	2.442	2.439	2.434	2.421	2.434	2.471	2.461	2.456	2.449	2.459
Mean	2.426	2.421	2.414	2.404		2.459	2.452	2.445	2.434	

Table 5: Effect of foaming agents, drying temperature and storage on water activity (a_w) of foam mat dried garlic powder

Treatments	Drying temperature (°C)									
	50 °C					60 °C				
	Storage period (days)					Storage period (days)				
	0	30	60	90	Mean	0	30	60	90	Mean
T_1(Control)	0.571	0.584	0.591	0.610	0.589	0.554	0.569	0.581	0.594	0.575
T_2 (0.5% Xanthan gum)	0.492	0.513	0.535	0.559	0.525	0.488	0.509	0.525	0.543	0.516
T_3 (1% Xanthan gum)	0.480	0.491	0.506	0.521	0.500	0.476	0.488	0.496	0.505	0.491
T_4 (1.5% Xanthan gum)	0.476	0.483	0.496	0.511	0.492	0.469	0.477	0.485	0.493	0.481
Mean	0.5047	0.5177	0.532	0.550		0.496	0.510	0.521	0.533	

Table 6: Effect of foaming agents, drying temperature and storage on bulk density (g/ml) of foam mat dried garlic powder

Treatments	Drying temperature (°C)									
	50 °C					60 °C				
	Storage period (days)					Storage period (days)				
	0	30	60	90	Mean	0	30	60	90	Mean
T_1(Control)	0.375	0.386	0.394	0.402	0.389	0.372	0.384	0.391	0.397	0.386
T_2 (0.5% Xanthan gum)	0.373	0.381	0.388	0.395	0.384	0.366	0.377	0.383	0.391	0.379
T_3 (1% Xanthan gum)	0.366	0.375	0.382	0.389	0.378	0.358	0.367	0.374	0.383	0.371
T_4 (1.5% Xanthan gum)	0.360	0.368	0.376	0.382	0.372	0.345	0.356	0.369	0.376	0.362
Mean	0.368	0.377	0.385	0.392		0.360	0.371	0.379	0.386	

Calcium content

The higher mean calcium content of 26.47 mg/100g at temperature 50 °C and 26.28 mg/100g at temperature 60 °C were observed in treatment T_4 (1.5% Xanthan gum) whereas, T_1 (control) recorded the lowest calcium content of 25.99 ant 25.78 at 50 °C and 60 °C (as shown in table 7). The calcium content of foam mat dried garlic powder was observed to be higher at temperature 50 °C than at 60 °C which might be due to heat sensitivity. These result correlate with that of Repo-Carrasco–Valencia *et al.* [29] who also found decrease in calcium content of quinoa seeds upon roasting, Agoreyo *et al.*[30] also observed same results in cocoyam (*Colocasia esculenta*). The calcium content decreased gradually with progression of storage period which might be due to their interaction with other components like protein and carbohydrate. Our findings are in conformity with the findings of Rubin *et al.* [31] who studied the effect of micronutrient addition to cereal grain products.

Table 7: Effect of foaming agents, drying temperature and storage on calcium content (mg/100g) of foam mat dried garlic powder

Treatments	Drying temperature (°C)									
	50 °C					60 °C				
	Storage period (days)					Storage period (days)				
	0	30	60	90	Mean	0	30	60	90	Mean
T_1(Control)	26.30	26.09	25.88	25.69	25.99	26.12	25.89	25.68	25.45	25.78
T_2 (0.5% Xanthan gum)	26.52	26.27	26.05	25.87	26.17	26.30	26.07	25.96	25.75	26.02
T_3 (1% Xanthan gum)	26.61	26.44	26.26	26.10	26.35	26.39	26.22	26.11	25.94	26.16
T_4 (1.5% Xanthan gum)	26.70	26.59	26.43	26.19	26.47	26.52	26.35	26.19	26.08	26.28
Mean	26.53	26.34	26.15	25.96		26.33	26.13	25.98	25.80	

Antioxidant activity

The maximum mean antioxidant activity of 38.09 per cent at temperature 50 °C and 37.97 per cent at temperature 60 °C were observed in T_4 (1.5% Xanthan gum) respectively. Whereas, lowest mean antioxidant activity of 30.59 per cent at temperature 50 °C and 28.45 per cent at temperature 60 °C were observed in T_1 (control) (as shown in table 8). The decrease in antioxidant activity of foam mat dried samples after drying at high temperatures can be related to a reduction in released flavonoids and phenolic content, as they have highly thermo-lability. The findings are in accordance with Unni *et al.* [17] who prepared garlic paste with high pressure processing technique. The phenolic compound acts as a free radical acceptor and a chain breaker by rapidly donating hydrogen and electrons to stabilize free radicals[32]. With the progression of storage period, the mean antioxidant activity decreased from 37.01 to 32.57 per cent at temperature 50 °C and 35.49 to 30.01per cent at temperature 60 °C. This might be due to oxidation or loss of ascorbic acid and total phenolic content during storage which are responsible for antioxidant activity in the powder. Decrease of antioxidant activity is due to ascorbic acid degradation occurring during storage. The decrease in content of antioxidants during storage was also reported by Ashraf [33] in foam mat dried apricot powder.

Table 8: Effect of foaming agents, drying temperature and storage on antioxidant activity (%) of foam mat dried garlic powder

Treatments	Drying temperature (°C)									
	50 °C					60 °C				
	Storage period (days)					Storage period (days)				
	0	**30**	**60**	**90**	**Mean**	**0**	**30**	**60**	**90**	**Mean**
T_1(Control)	32.01	31.38	30.35	28.63	30.59	30.53	29.88	27.33	26.06	28.45
T_2 (0.5% Xanthan gum)	37.01	35.69	34.54	32.72	34.99	35.31	33.96	32.17	30.06	32.87
T_3 (1% Xanthan gum)	38.94	37.83	35.75	33.12	36.37	37.44	36.03	34.78	32.79	35.25
T_4 (1.5% Xanthan gum)	40.09	38.96	37.50	35.84	38.09	38.70	36.91	35.11	31.16	37.97
Mean	37.01	35.96	34.53	32.57		35.49	34.19	32.34	30.01	

Total phenols

Higher phenol content was observed in powders dried at temperature 50 °C than that of dried at temperature 60 °C. The maximum mean phenol content of 54.00 mg/100g at temperature 50 °C and 53.12 mg/100g at temperature 60 °C were observed in T_4 (1.5% Xanthan gum) respectively. While as, lowest mean total phenol content of 46.26 mg/100g at temperature 50 °C and 44.62 mg/100g at temperature 60 °C were observed in T_1 (control) (as shown in table 9). The reduction in total phenol content may be due to high heat sensitive nature of polyphenols. The reduction in total phenolic content during drying could be attributed to the binding of polyphenols with other components (proteins) or due to alterations in the chemical structure of polyphenols. Unni *et al.* [17] also reported significant decrease in total phenol content with temperature which might be due to higher temperature sensitivity of phenolic compounds. The total phenol content decreased gradually with progression of storage period from 55.22 to 46.38 mg/100g at temperature 50 °C and 52.36 to 45.38mg/100g at temperature 60 °C. The decreasing trend in total phenolic content during storage has been revealed by Kumar [34] in osmotically dried plum which can be due to the degradation and oxidation of phenolic compounds during storage.

Table 9: Effect of foaming agents, drying temperature and storage on total phenol (mg/100g) of foam mat dried garlic powder

Treatments	Drying temperature (°C)									
	50 °C					60 °C				
	Storage period (days)					Storage period (days)				
	0	**30**	**60**	**90**	**Mean**	**0**	**30**	**60**	**90**	**Mean**
T_1(Control)	51.72	47.26	44.81	41.27	46.26	48.43	46.13	43.76	40.19	44.62
T_2 (0.5% Xanthan gum)	54.59	50.86	48.79	44.23	49.61	51.82	47.72	45.89	43.15	47.14
T_3 (1% Xanthan gum)	56.74	52.29	49.58	46.75	51.34	53.45	50.98	48.46	47.86	50.18
T_4 (1.5% Xanthan gum)	57.83	54.46	53.28	53.28	54.00	55.76	53.59	52.82	50.33	53.12
Mean	55.22	51.21	49.11	46.38		52.36	49.60	47.73	45.38	

Sensory evaluation

The maximum mean overall acceptability of 8.10 at temperature 50 °C and 8.02 at temperature 60 °C were observed in T_4 (1.5% Xanthan gum), respectively. Whereas, the lowest overall acceptability of 7.87 at temperature 50 °C and 7.81 at temperature 60 °C were observed in T_1 (control). Similar pattern has been reported by Kandasamy *et al.* [35] in foam mat dried papaya powder. Foam mat garlic powder dried at 50 °C have the potential to maintain high level of overall acceptability than powder dried at 60 °C. The decrease in overall acceptability of foam mat dried samples after drying at high temperatures could be related to decrease in sensory attributes. With storage period, the overall acceptability decreased from 8.06 to 7.92 at temperature 50 °C and 7.99 to 7.85 at temperature 60 °C (as shown in table 10). Kaushal *et al.* [36] also reported the decrease in overall acceptability in foam mat dried sea buckthorn leather.

Table 10: Effect of foaming agents, drying temperature and storage on mean overall acceptability score of foam mat dried garlic powder

Treatments	Drying temperature (°C)									
	50 °C					60 °C				
	Storage period (days)					Storage period (days)				
	0	30	60	90	Mean	0	30	60	90	Mean
T_1(Control)	7.93	7.90	7.85	7.82	7.87	7.88	7.82	7.81	7.75	7.81
T_2 (0.5% Xanthan gum)	8.03	7.97	7.93	7.89	7.95	7.95	7.91	7.87	7.83	7.89
T_3 (1% Xanthan gum)	8.11	8.04	7.99	7.95	8.02	8.01	7.96	7.90	7.89	7.94
T_4 (1.5% Xanthan gum)	8.18	8.14	8.09	8.02	8.10	8.12	8.05	7.96	7.94	8.02
Mean	8.06	8.01	7.96	7.92		7.99	7.93	7.88	7.85	

Conclusion

Based on the results, it can be concluded that foam-mat drying of garlic with foaming agent (xanthan gum) increases functional and bioactive properties and decreases drying time. The colour scores improved with the addition of foaming agent and there was decrease in the water activity of the developed powder. Foam mat drying of garlic powder using Xanthan Gum followed by packaging in polypropylene bags resulted in better retention of total phenol, antioxidant activity and colour of garlic powder during 90 days storage at ambient temperature. Similarly, the mineral content also improved as a result of foaming agents. Among treatments, foam mat dried garlic powder prepared by using 1.5% Xanthan gum and dried at 50 °C was rated best by maintaining the quality characteristics.

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