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Effect of Milling Methods and its Temperature on Quality Parameters of ByadagiChilli: With Emphasis on Cryogenic Grinding

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Abstract

The dried chillies were ground to obtain chilli powder using selected milling machines i.e. Spice pulverizer, low temperature pulverizer, and cryogenic grinder. The proximate composition and quality parameters of the dried Byadagichilli and chilli powder were determined with emphasis on cryogenic grinder. The proximate composition (moisture, protein, fat, total minerals, crude fiber and carbohydrates) of chilli powder milled using selected milling methods ranged between 8.91 to 10.08%, 15.35 to 16.85%, 8.15 to 12.21%, 8.25 to 12.08%, 25.76 to 26.54%, and 25.70 to 28.65%. The colour values of cryogenic grinder were observed to be 40.15 (L), 33.66 (a*), 37.28 (b*) and was found to be much better than low temperature pulverizer 39.34 (L*), 32.06 (a*), 36.80 (b*) and normal spice pulverizer 35.84 (L*), 30.09 (a*), 31.39 (b*), respectively. The capsaicin content was found to be retained more in cryogenic grinder (0.017%) followed by low temperature pulverizer (0.012%) and chilli pulverizer (0.007%). The retention of nutrients was found to be more in cryogenic grinder as compared low temperature pulverization and chilli pulverization.*

Keywords: Milling method, chilli, cryogenic grinder, grinding.

Introduction

Chilli is known for its acidic flavor (pungency) and color. Pungency of chilli is the function of alkaloid capsaicin while color is due to presence of capsanthin pigments (mainly carotenoids)[1]. Chilli occupies important place in diet over worldwide, which constitutes major share in important ingredients in daily consumed dish such as condiments, sauces, pickles, curries, chutneys etc.

A large quantity of chilli is lost during the production season when the supply is abundant. Farmers do not get a proper return for their harvest during the peak period of harvest due to the low market price. There is an increasing interest in quality dried chilli powder for both the local market and foreign market. In India currently many milling methods are used among those chilli pounding machine, spice pulverizer, low temperature pulverizer are popular methods. During grinding process lot of heat generated in the grinding chamber shoots 45^{o}Cup to 90 ^{o}Cdue to friction[2,3]. However, etheric oil, volatile components and heat-sensitive constituents of spices boils off at temperature about 50 - 60^{0}C, results in reducing of inferior qualities aroma and taste of the ground product[4,5]. For better quality retention of chilly is obtained by grinding process at lower operating temperatures. Cryogenic grinding is a unique and advanced technique of grinding process which supports in retaining virtuous flavour, colour, aroma and volatile oil of the ground product[4,6]. In cryogenic grinding technique liquid nitrogen is used to control grinding chamber temperature ranging from 0 to -21°C. Murthy et.al.[7] have reported that by the application of liquid nitrogen resulted in 26% increase of volatile oil of black pepper during grinding at the product temperature of - 20°C as in comparison to grinding at the product temperature of 62°C. Cryogenic grinding technique is advanced and used in some parts of the world. But it is a new concept in spice processing in India, especially in Karnataka.

Therefore in the present study cryogenic grinding was focused and compared with chilli pounding machine, spice pulverizer, low temperature pulverizer.Study comprised of investigations of different physico-chemical properties and cost economic analysis for chilli powder obtained from different milling methods.

Material and Methods

Raw samples of driedchillies of local variety viz., 'Byadagichilli' were collected from progressive farmers of Dharwad district, Karnataka state. Foreign materials, loose seeds, damaged and discolored chillies were removed from collected samples. Methodology followed throughout the investigation is discussed under the following sections.

Physical properties of Byadagichilli: Few healthy average dried chilli samples were collected from cleaned dried chillies to determine the physical parameters of chilli. The size of Byadagichilli was determined by measuring its length at mutual perpendicular and along the major and minor axis using Vernier caliper. The shape of chilli was determined by comparing obtained longitudinal and lateral cross sections of chilli with

standard charts. The volume of chilli was determined by platform scale method[8]. The chilli was immersed into the known volume of water filled in the measuring jar. The volume of chilli sample was estimated using the following formula.

$$\text{Volume } (mm^3) = \frac{\text{Weight of displaced water (g)}}{\text{density of water } (g\ mm^{-3})} \quad (1)$$

The weight of chilli was obtained by weighing on the balance in air. By knowing volume and weight of chilli density was obtained. The specific gravity of chilli was obtained by using following formula.

$$\text{Specific gravity} = \frac{\text{Weight of Byadagi chilli in air (g)} \times \text{Specific gravity of water}}{\text{Weight of displaced water (g)}} \quad (2)$$

Surface area of chilli was determined by using digital planimeter.

Preparation of samples: The chilliwas dried under sun till it reached required brittleness before going to milling process. The whole dried chilliwas used for milling after separation of stalks from chilli. A total of 15 kg of dried chilli sample was used to carry out present study. Then 15 kg sample were ground to obtain chilli powder using selected milling methods, that is cryogenic grinder, Low temperature pulverizer and Spice pulverizer of 5 kg each. The ground chilli powder from each milling machine was divided into three parts and packed in HDPE bags.These packaged samples were stored at room temperature for further study.

Proximate composition of dried chilli and chilli powder: The samples of dried chilli and chilli powder were analyzed for the moisture content, crude protein, crude fat, total ash, crude fibre and carbohydrates by using air oven method, micro Kjeldahl method, SOCS-PLUS apparatus, muffle furnace method, Fibra-Plus apparatus and sulphuric acid method respectively[9].

Quality parameters of Byadagichilli and chilli powder: Quality parameters of Byadagichilli and chilli powder such as color, ascorbic acid, capsaicin, pH and water activity were estimated by using Spectro-photometer, titration method, calorimetric method, pH meter and by Rotronic Hygrolab 3 water activity analyzer respectively as per the standards[9].

Economics of grinding of chilli: The economics of chilli grinding using spice pulverizer, low temperature pulverizer and cryogenic grinder was calculated using the fixed cost of machinery and operating cost. In the fixed cost annual depreciation, annual interest on investment, taxes, housing cost, repair and maintenance were computed by using straight line method.

$$\text{Annual depreciation (₹ /annum)} = \frac{\text{Initial investemnt} - \text{Salvage value}}{\text{Life in years}} \quad (3)$$

Salvage value was taken as 10% of the initial cost of the machine, interest on initial cost was 12%, taxes and housing cost and repair and maintenance cost was taken as 1% and 10% of initial cost respectively.

In operating cost, the cost of energy was taken as ₹4/- per unit. The total cost of milling was calculated by adding the fixed cost and the operating cost. The assumptions made to calculate the cost economics were 750 hours of working hours / year, working hours / dayas 8 hours, number of labors /day as one, Life of the machine was 10 years, custom hiring charges for spice pulverizer and low temperature pulverizer were taken @ of ₹ 8 /per kg and for cryo-grinder was @ of ₹ 10 per kg as per local standards**.**

Results and Discussion

The physical parameters of Byadagichilliviz., size, shape, surface area, volume, specific gravity and bulk density were found to be 10.03cm, conical, 22.25 cm^2, 5.09cm^3, 0.313 and 0.102 g/cm^3, respectively.

The effect of different milling methods on proximate composition of Bdayagichilli and Chilli powder is given in Table 1. The initial proximate composition viz., moisture, protein, fat, total minerals, crude fiber and carbohydrates content of dried chilli were observed to be 8.90%,16%, 8.44%, 13.57%, 27% and 26% respectively. The proximate composition of chilli powder milled using selected milling methods ranged between 8.91 to 10.08% (moisture), 15.35 to 16.85% (Protein), 8.15 to 12.21% (fat), 8.25 to 12.08% (total minerals), 25.76 to 26.54%

Table-1
Effect of milling methods on proximate composition of chilli powder

Methods of milling	Moisture (%)	Protein (%)	Fat (%)	Total minerals (%)	Crude fiber (%)	CHO (%)
Dried chilli	8.9	16	8.44	13.57	27	26
Chilli pulverizer	8.91	15.35	8.15	11.76	25.76	28.5
Low temperature pulverizer	9.11	16.28	9.21	12.08	26.26	25.7
Cryogenic grinder	10.08	16.85	12.21	8.25	26.54	25.96

(Crude fibre) and 25.70 to 28.65% (Carbohydrates) respectively. It is observed that, there was no much difference in the moisture content of chilli powder obtained from three milling methods. Among these, chilli powder obtained from cryogenic grinder and low temperature pulverizer machine was rich in carbohydrates, protein, fat and total minerals. The chilli powder obtained from the cryogenic grinder recorded the highest retention of carbohydrate due to low operating temperature maintained in the grinding chamber. The chilli powder from cryogenic grinder was found to be superior to the chilli powder obtained by low temperature pulverizer and spice pulverizer. The loss in the nutrient of chilli powder obtained from chillipulverizerwas due to the excess heat generated during milling process in the grinding chamber. The most of the nutrient constituents were retained in chilli powder obtained from the cryogenic grinder and low temperature pulverizer due to the exposure of the samples to the below zero and low temperature maintained during milling process as compared to chillipulverizer which generated high temperature during milling[4,7].

Table 2 depicts the quality parameters of dried chilli and chilli powder from selected milling methods. The quality parameters viz., colour; ascorbic acid, capsaicin content, pH and water activity of dried chilli were found to be 22.86 (L*), 10.88 (a*) and 10.13 (b*); 68.57mg/100g, 0.024% and 5.0, respectively. The above quality parameters of chilli powder varied significantly and ranged between of 35.84 to 40.15 (L*), 30.09 to 33.66 (a*) and 31.39 to 37.28 (b*), 18.57 to 21.42 mg/100g, 0.017 to 0.007, 4.99 to 5.06 and 0.562 to 0.620 respectively. However the colour values of cryogenic grinder were observed to be 40.15 (L*), 33.66 (a*), 37.28 (b*) and was found to be much better than low temperature pulverizer 39.34 (L*), 32.06 (a*), 36.80 (b*) and normal spice pulverizer 35.84 (L*), 30.09 (a*), 31.39 (b*), respectively (figure-1 (b)). The ascorbic acid was unstable especially on exposure to oxygen and heat generated during milling.

Table-2
Effect of milling methods on quality characteristic of chilli powder

Method of milling	Quality characteristics						
	Colour			Ascorbic acid (mg/100g)	Capsaicin (%)	pH	Water activity
	L*	a*	b*				
Dried chilli	22.86	10.88	10.13	68.57	0.024	5.00	0.554
Chilli pulverizer	35.84	30.09	31.39	11.42	0.007	4.90	0.562
Low temperature pulverizer	39.34	32.03	37.28	18.57	0.012	5.02	0.583
Low temperature pulverizer	39.34	32.03	37.28	18.57	0.017	5.06	0.620

Table-3
Economics of different milling methods

Sl. No	Particulars	Spice Pulverizer	Low Temperature Pulverizer	Cryogenic Grinder
1	Variable cost, Rs/h	26.25	24.75	33.75
2	Total fixed cost, Rs/h	12.87	08.72	15.45
3	Cost of operation, Rs/kg	0.98	1.35	4.92
3	Cost of operation, Rs/h	39.12	33.47	49.20
4	Custom hiring charge, Rs/kg	08	08	10
5	Custom hiring charge, Rs/h	320	200	200
6	Break-even point , h/annum	33	38	80
7	Payback period , years	0.55	0.64	1.68

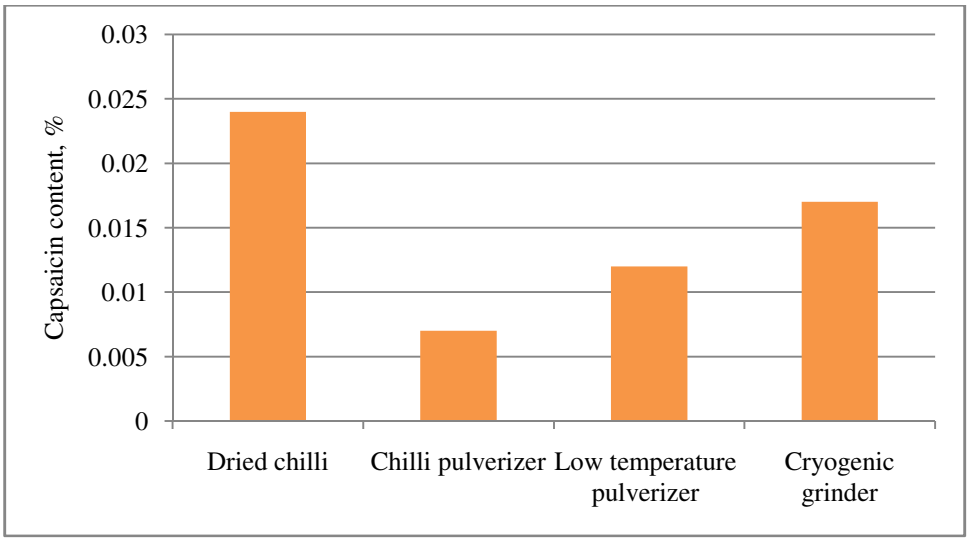

Figure-1
Quality parameters analysis results (a) capsaicin and

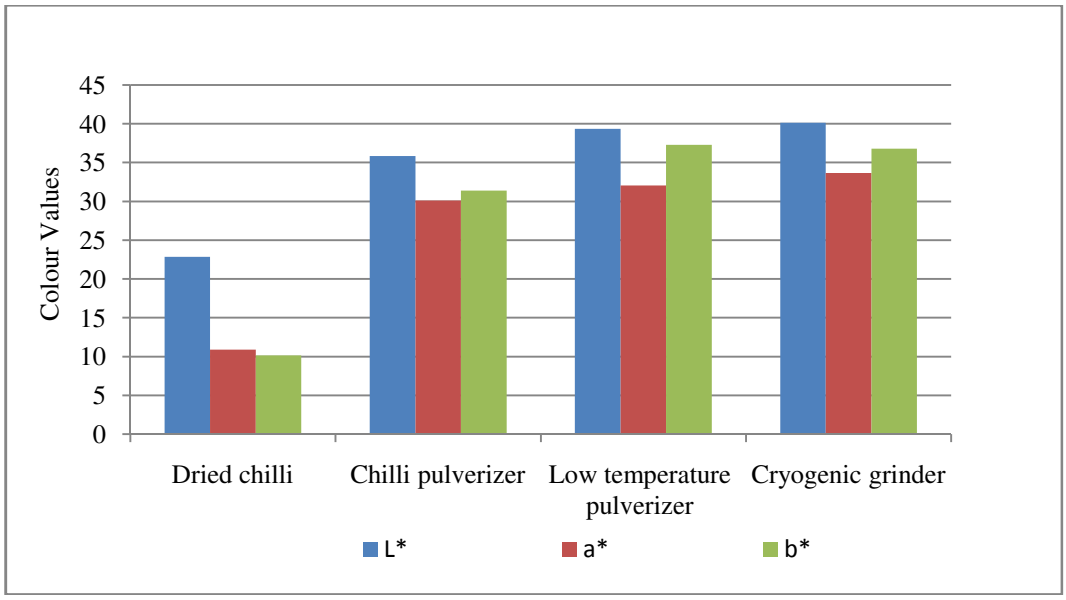

Figure-2
Colour value of chilli powder.

Whereas, in case of pulverization the loss of capsaicin might be due to the excess heat generated during milling in spice pulverizer (Figure-1 and 2). However as compared to the other milling methods the capsaicin content retained was more in cryogenic grinder and followed by low temperature pulverization due to the low temperature maintained around the grinder[6,7]. The water activity of the sample is directly in relationship with the moisture content of the sample. The water activity was found to be the highest in cryogenic grinder followed by low temperature pulverizer and the lowest in chillipulverizer. The pH of the sample was found to be the highest in cryogenic grinder followed by low temperature pulverizer and the lowest in chillipulverizer[10]. The results of the present investigation have beenconformity with Manohar and Sridhar[2].

Table 3 presents the economics of different milling methods were calculated by using the standard test procedure for spice pulverizer, low temperature pulverizer and cryogenic grinder. The cost of operation was found to be ₹ 0.98/kg, ₹ 1.34/kg and ₹ 4.92/kg for spice pulverizer, low temperature pulverizer and cryogenic grinder, respectively. The low temperature pulverizer milling method was found to be of minimum cost i.e., operation cost of ₹ 33.47 per hour, whereas cryogenic grinder was found to be maximum with ₹ 49.20 per hour due to its high initial cost. However the quality of the product was superior in cryogenic

grinder as compared to the other milling method in terms of colour values. It was found that spicepulverizer milling method had the least payback period, whereas cryogenic-grinder had high payback period due to its low capacity. The maximum profit was got with the spice pulverizer (₹ 63785/- per annum), as compared to cryo-grinder (₹ 24855/- per annum) due to its low capacity.

Conclusion

Dried chillies were ground to obtain chilli powder using selected milling machines viz., Cryogenic grinder, Low temperature pulverizer and Spice pulverizer. The more retention of nutrients was obtained in cryogenic grinder as compared low temperature pulverization and chilli pulverization. The proximate composition (moisture, protein, crude fat, total minerals, crude fiber and carbohydrate) of chilli powder milled in cryogenic grinder was observed to be 10.08%, 16.85%, 12.21%, 8.25%, 26.54% and 25.96%, respectively. The colour value of chilli powder obtained from cryogenic grinder was much better than low temperature and chilli pulverization. More capsaicin content was retained in cryogenic grinderas compared to other milling methods. The water activity and pH was found to be the highest in cryogenic grinder followed by low temperature pulverizer and the lowest in chillipulverizer. The low temperature pulverizer milling method costed the least price of ₹ 33.47 per hour (₹ 1.34/kg), whereas it was ₹ 49.20 per hour (₹ 4.92/kg) in cryogenic grinder due to its high initial cost and operating cost.

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