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Effect of popping methods on popping characteristics of amaranth grain

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Abstract
Amaranth (*Amaranthus paniculatus*) grains can be popped through intense, short, and dry heat. This was practiced by either the traditional process or improved process for popping of amaranth. Popped amaranths are quite soft in texture and are ready to eat or to be incorporated into existing or new food formulations. Because of their small seed size, different conditions are needed for the popping of amaranth than other grains. In this paper we studied two different processes exist to pop amaranth grains traditional process i.e. batch type popping machine and improved process i.e. fluidized bed system. Hence, the popping of this important grains is very much important for developing value added foods. In this regard, the study of the popping characteristics such as popping volume, popping fold and popping rate were evaluated of popped amaranth in the temperature range of 120ºC to 150ºC and time range of 5 to 30 sec. was conducted. Popping volume ranged from 0.41cm^3 to 0.54cm^3 per 100 grains; popping fold ranged from 5.5 to 6.7 and popping rate in the range of 28-80% in the entire range of temperature and time combination in traditional process. In improved process popping volume ranged from 0.42cm^3 to 0.48cm^3 per 100 grains, popping fold ranged from 5.3 to 6.1 and popping rate in the range of 44-65%.

Keywords: amaranth, popping method, popping characteristics, temperature, time

Introduction
The snack food is one of the most important areas of the food industry. Designing snack foods today can be a complex process to meet changing consumers taste and expectations and elusive search for something unique that also appeals to a wide variety of people. Most snack manufacturers use some form of existing technology such as batch type popping machine for popping the food grains to prepare snack products. Therefore, popping using advance technologies i.e. fluidized bed system are processes, which can produce better popping characteristics as compare to conventional method of popping i.e. batch type popping machine. As a simplest, inexpensive and quickest traditional method of dry heat application in conventional method of popping for preparation of popped food formulations and ready-to-eat snacks products, popping has been practiced since hundreds of years.

Popping is a type of starch cookery, where grains are exposed to high temperature for short time. Popping is a process in which kernels are heated until internal moisture expands and pops out through the outer shell of the kernel (Arkhipov *et al.*, 2005) [2]. Superheated vapor is produced inside the grains by instantaneous heating, which cooks the grain and expands the endosperm while escaping with great force through the micro pores of the grain structure. Most of the water in the kernel is superheated at the moment of popping and provides driving force for expanding the kernel once pericarp ruptures. Hoseney *et al.*, 1983 [6] proposed that during the popping of popcorn the pericarp acts as a pressure vessel and popping occurs at about 177°C, which is equivalent to a pressure of 135psi inside the kernel. Popping imparts acceptable taste and desirable aroma to the product. Popped grain being a pre-cooked ready-to-eat material can be used in snack foods, specialty foods and as a base for development of supplementary foods. Convenient snack foods like popped amaranth, popcorn, popped and puffed rice, popped sorghum, popped wheat roasted and puffed soybean and other legumes are very popular not only in Indian subcontinent, but also worldwide (Anderson, 1971; Jaybhaye *et al.*, 2014) [1, 8]. Generally, cereal grains are popped with conventional method such as hot air, hot sand, frying in hot oil, batch type popping machine and improved process i.e. fluidized bed system. To avoid the limitations of conventional popping methods, improved process, which provides better popping process in very short time.

Amaranth *(Amaranthus paniculatus)* is the most promising and important food crops due to its high protein and mineral content and can be popped rapidly with traditional process or improved process by evaporating the moisture contained within the grains, accompanied by starch gelatinization of the grains, when it is heated for popping. The popped grains of amaranth are soft in texture and taste like nutty-flavored like popcorn; therefore, popping is a simple method to render amaranth grains edible and for further processing and value addition of this nutritious commodity. In order to process amaranth and improve their texture, measuring their popping volume, popping fold and popping rate after popping is important; a high popping volume improves texture and edibility and, therefore, the quality of the final product is improved.

Traditional processes i.e. batch type popping machines have been traditionally used for popping the amaranth grains in India. However, the resulting products have certain drawbacks: (1) they have a low product quality, (2) they are prone to scratching and burning of popped particles due to overheating, and (3) the process of popping is unhygienic. These demerits also lead to low nutritional quality; e.g., burning of the nutrition in it. Therefore, a fluidized bed system is favorable for popping amaranth grains, because the operating conditions of such a popping method. Traditionally, popping is being done in small and large scale by organized and unorganized sector in the cooking pan of batch type popping machine which was heated by using electric heater with the conduction mode of heat transfer to the cereal grains. Since, this mode of heat transfer is directly proportional to temperature gradient with the thickness of the wall. Heat is passed through the physical contact by the receiving of the energy from adjacent heated atoms. Hence, Temperature control of this heater was set at the same level during popping so that heat loss may be negligible and pan was covered with the lid during processing of the grains to leaving the grains outside the heated pan. The heating was continued until complete popping took place. Till today, organized sector uses only batch type operation for popping of cereals grains (*Sharma et al., 2015*) [20].

Though a wide range of cereals are used for popping; only few of them pop well. The reason for this may be the factors which influence popping qualities of cereals, such as season, varietal difference, grain characters i.e. bran content, bran thickness, moisture content, type of endosperm, physical characters of grains and also the method of popping (*Hoke et al., 2005; Mirza et al., 2014; Joshi et al., 2014a*) [5, 13, 10]. Initial micro pore size, popping temperature, surface tension, yield stress and rupture stress are some other factors that influence the popping characteristics of the grains (Henry *et al*., 1995) [4] the processing parameters such as the temperature or flow rate of hot air, can be controlled, thus improving the qualitative end products. *Nelly and Jenny, 2002* [15] used a household corn popper to pop amaranth grains under certain operating conditions and assessed their quality in terms of their yield, expansion volume, swelling power, water solubility, and protein content. In addition, *Marek et al., 2006* [11] reported that drying at high puffing temperature made grains more rigid and less viscous. *Tatemoto et al., 2003* [22] indicated the temperature in the sample increased because of the increment of pressure when the mass transfer in a sample was low for fluidized bed drying with superheated steam and hot air. *Johanasson et al., 1997* [9] examined the variations in the internal pressure of wood chips during hot air drying and superheated steam drying. *Rattanadecho et al., 2008* [19] investigated the effect of the initial moisture content of the material on its total internal pressure during hot air drying. In addition, *Perre et al., 1993* [18] measured the internal pressure during drying in superheated steam and moist air using light concrete and softwood as sample materials. Further, *Asaeda et al., 1979* [3] investigated the effect of the total pressure gradient in the dried region of materials during the falling drying rate period on the drying rate in the case of drying techniques such as hot air drying and superheated steam drying. *Iyota et al., 2007* [7] reported that isobaric approximations are effective in estimating the vapor diffusion rate in the dried region of materials with micronized pores, and vapor flow approximations are effective in estimating the vapor flow rate in the dried region of materials with pores that are filled almost with vapor only.

However, popping treatment of amaranth grains has not been done under optimum operational conditions in consideration for product quality, such as expansion ratio and yield. This is because only a traditional process i.e. batch type popping machine has been specially designed for popping amaranth grains, and control techniques to maintain the optimal operating conditions have not yet been established. In the present study, effect of two different methods of popping of amaranth grains on popping characteristics were examined to understand the concept of popping methods and to analyze the factors which are influencing popping volume, popping fold and popping rate.

Materials and method

Sample preparation

Amaranth grains (*Amaranthus paniculatus*) were procured from local market of Ludhiana, India for conducting investigation on popping. The average initial moisture content was found to be 9.78% wb because in this range only popping quality of amaranth grains were superior. The grains were cleaned using sets of sieve to separate all foreign matter, dust, dirt, twigs, broken and immature grains. Moisture content of the sample was determined by hot air oven method as described by *Nimkar and Chattopadhyay 2001* [16]. The grain Amaranthus having a size of approximately 0.80mm were used. For conducting popping experiments, sample size of 1g amaranth grains were taken from the lot sample of amaranth grains.

Traditional popping method

The batch type popping machine (make: PRIMEX, An ISO 9001:2008 certified co.), the cooking pan was heated by using electric energy. The temperature was selected from 120ºC to 150ºC during popping and lid was covered during the experiments. The heating was continued with the 5 seconds to 30 seconds. The popped grains were removed from the hot surface as rapidly as possible, to reduce burning of particles and inhance the quality of the product. The low surface to grain heat transfer makes the traditional popping method very slow and highly inefficient.

Improved popping method

In this method the amaranth grains were popped by hot air fluidized bed system by means of moving hot air of a particular velocity the amaranth grains, which were fed in at another point, are lifted and popped by the heat in this temperature range and time. The popping time was varied depending on the method used. Then, popping characteristics such as popping volume, popping fold and popping rate were calculated with the following equations were done:

Measurements of popping characteristics

Popping volume (cm^3/100 grains): It refers to the popped volume per 100 grains.

$$Popping\ volume = \frac{Total\ popped\ volume}{100\ grains}$$

Popping fold: It was calculated as the total popped volume divided by its 100 grain weight.

$$Popping\ fold = \frac{Total\ popped\ volume}{100\ grain\ weight}$$

Popping rate (%): It was calculated based on the number of popped grains in 100 grains after popping.

$$Popping\ rate = \frac{Number\ of\ popped\ grains}{100\ grains\ after\ popping}$$

The weight of the samples was recorded on an analytical balance (Model: TB403, Denver Instrument) of accuracy 0.001g in triplicate, and their average value was recorded. Statistical Analysis were done with experimental results subjected to analysis of variance (ANOVA) using AGRES (version 7.01) software and least significant difference test was used to describe the means with 95% confidence.

Results and discussion

Effect of traditional process of popping on popping characteristics

Effect of temperature and time of popping in batch type popping machine were analyzed on popping characteristics viz. popping volume, popping fold and popping rate of popped amaranth using traditional process of popping and presented in Table 1. Popping volume varied from 0.41cm^3 to 0.54cm^3 per 100 grains, popping fold ranged from 5.5 to 6.7 and popping rate varied in range of 28-67% at 120°C, 58-62% at 130°C, 59-80% at 140°C, 50-75% at 145°C and 43-60% at 150°C. Maximum popping rate was achieved at the temperature of 140 – 145°C in this process of popping. These results were agreed with findings of *Metzger et al., 1989* [12].

Table 1: Popping characteristics of amaranth grain using traditional process

Temperature, °C	Time, sec	Popping volume, cm^3/ 100 grains	Popping fold	Popping rate, %
120	6	0.493	6.2	28
120	13	0.503	6.3	53
120	30	0.413	5.2	67
130	6	0.517	6.5	60
130	8	0.536	6.7	58
130	10	0.448	5.6	60
130	13	0.447	5.6	62
140	6	0.443	5.6	59
140	7	0.489	6.2	80
145	5	0.524	6.6	50
145	7	0.436	5.5	75
150	5	0.466	5.9	43
150	6	0.458	5.8	60

Effect of improved process of popping on popping characteristics

Effect of temperature and time of popping in fluidized bed system were analyzed on popping characteristics viz. popping volume, popping fold and popping rate of popped amaranth using improved process of popping and presented in Table 2. Popping volume varied from 0.42 cm3 to 0.48cm3 per 100 grains, popping fold ranged from 5.3 to 6.1 and popping rate varied in range of 44% to 65% in the intire range of temperature and time during popping. Maximum popping rate was achieved at the time of 30 seconds in this process. The results revealed that in the fluidized bed dryer the popping rate was decreasing with period of popping. These results were also agreed with findings of Metzger *et al*., 1989 [12].

Table 2: Popping characteristics of amaranth grain using improved process

Temperature, °C	Time, sec	Popping volume, cm^3/ 100 grains	Popping fold	Popping rate, %
150	30	0.427	5.4	65
145	32	0.452	5.7	62
140	34	0.418	5.3	54
130	35	0.434	5.5	49
120	36	0.484	6.1	44

Conclusion

The results showed that improved process of popping was better to produce popped amaranth as compare to existing traditional popping. With this also, fluidized bed system gives increased 20% more popping characteristics than batch type popping machine. In fluidized bed system of popping, popping process was completed in 30 seconds with better and increasd popping volume and popping rate rather than in traditional process of popping. This analysis showed that improved popping process saves more than 30% labour as well as processing time for making popped grains. Therefore, improved popping process in food processing is the only one innovative and substitute technology for producing best high quality popped products which can replace the existing heating applications in food industries with new fabrication scope of popping machine in continuous mode.

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