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Effect of popping methods on popping characteristics of quinoa seed

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Abstract
Popping is a kind of starch cookery, where grains are exhibit too high temperature for short time. The popped quinoa seeds are soft in texture and have a nutty-flavored taste like popcorn. Consequently, popping is an easy method to make quinoa grains edible and for more processing purposes and value addition of this nutritious product.
The present investigation was aimed to study the effect of various popping methods on popping characteristics of quinoa seeds viz, puffing volume, expantion ratio, percent puffing. In traditional process the characteristics were evaluated in the temperature range of 200 ºC to 280 ºC and time range of 90 to 13 sec, was conducted. Popping volume ranged from 7.9 to 9.1 ml, expansion ratio ranged from 2.0 to 4.4 and the percent puffing varied in range of 59 to 87%. In microwave method the characteristics were evaluated in the power level of 60 to 100 was conducted. Popping volume ranged from 6.9 to 8 ml, expansion ratio ranged from 1.9 to 3.1 and the percent puffing varied in range of 49 to 65%.

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

Introduction
Quinoa (*Chenopodium quinoa* willd) is a pseudo-cereal native to the Andean region of South America. (Maticevich *et al*., 2006) [8]. Quinoa belongs to the chenopodiaceae family, genus chenopodium. Its botanical name is Chenopodium Quinoa Willd, (Valencia- Chamorro 2003) [14].
Quinoa (pseudo-cereal) is one of the oldest crops in Andean region with approximately 7000 years of cultivation history, great cultures like the Incas and Tiahuanacu had domesticated and conserved this ancient crop, (Jacobsen 2003) [5].
Quinoa (Chenopodium quinoa willd) is the most favorable and important food crop due to its nutritional content that is high in protein and mineral content. The quinoa grains are consumed in different forms like boiled rice or used to thicken a soup or as porridge. In bread, noodles, pasta, and for sweet biscuits quinoa flour fortification is done. It can be popped quickly with various conventional as well as improved methods by evaporating the moisture content within the grains followed by starch gelatinization of the grains when they get contact to heat for popping. The popped quinoa seeds are soft in texture and have a nutty-flavored taste like popcorn. Consequently, popping is an easy method to make quinoa grains edible and for more processing purposes and value addition of this nutritious product.
As an easy, low cost and rapid traditional method of dry heat use in a conventional method of popping for production of popped food formulations and ready-to-eat snacks products, popping has been carried out since hundreds of years.
Popping is a kind of starch cookery, where grains are exhibit too high temperature for short time. Popping is a kind of method in that kernels are heated up to internal moisture content expands which result into popping out of the outer shell of the kernel (Arkhipov *et al*., 2005) [2]. Production of superheated vapor inside the grains by immediate heating, which cooks the grain and enlarges the endosperm while breaking out with great force through the micropores of the grain structure. The highest amount of the water in the kernel is superheated at the time of popping and supply driving force for break out the kernel once pericarp ruptures.
Hoseney *et al*., 1983 [3] studied that throughout the popping process of popcorn the pericarp acts as a pressure vessel and popping happen at about 177 °C, which is an analogue to a pressure of 135psi inside the kernel. Popping imparts an acceptable taste along with discreet aroma to the developed product. Popped grain being a pre-cooked ready-to-eat material can be applied in snack foods, specialty foods, and as a bottom for the development of supplementary foods. Suitable snack foods like popped amaranth, popcorn, popped and puffed rice, popped sorghum, popped wheat roasted or puffed soybean and other legumes are very famous not only in the Indian subcontinent but also worldwide (Anderson, 1971; Jaybhaye *et al*., 2014) [1, 6].
Altogether, conventional type of processes are used for the popping of cereal grains like

popping in batch type machine, hot sand, hot air, frying in hot oil, as well as improved process i.e. fluidized bed system. To avoid the constraint of conventional popping methods, improved processes, which supply better popping techniques in a very short time.

Amaranth grains obtained a soft texture and taste like nutty-flavored after the popping process same like popcorn; thus, to make amaranth grains edible, popping is one of the simple method and for additional processing along with enhancement of this nutritious commodity. It is significant to analyze the popping fold, popping rate after popping, and popping volume to process amaranth grains and improve their texture, and thus ultimately, the quality of the final product is also enhanced.

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, the effect of two different methods of the popping of amaranth grains on popping characteristics was examined to understand the concept of popping methods and to analyze the factors which are influencing popping volume, popping fold, and popping rate.

Puffed grains are broadly used as ready-to-eat products or as ingredients in snack preparation, and their demand is nowadays increasing because of changing lifestyles. Processing of pseudocereals must acquire low-cost technologies to prepare traditional or innovative final products for populations of either growing or economically rich countries. Physical, structural, or chemical modifications take place throughout the puffing process. Puffed grains undertake dehydration, starch gelatinization, increase of volume, and textural changes [Hoke *et al*., 2007] [4].

Materials and Method

Sample preparation

Quinoa grains *(Chenopodium quinoa willd)* were procured from Mamta agro (Gujarat), India for conducting investigation on popping. The grains were cleaned using sets of sieve to separate all foreign matter, dust, dirt, twigs, broken and immature grains. The moisture content of the sample was determined by hot air oven method as described by Nimkar and Chattopadhyay (2001) [9]. For conducting popping experiment, sample size of 1g quinoa grains wrere taken from the lot sample of quinoa grains.

Traditional popping method

In traditional popping method the cooking pan was heated by using electric energy. The temperature was selected from 200 to 280 during popping and lid was cover during the experiments. The heating was continued with the 90 to 13 sec. 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 insufficient.

Microwave popping method

In this method microwave energy used to pop and puff the cereal grains. The grains samples with moisture content 16 to 20% moisture content were put in a glass bowl and cover with lid. The covered bowl was kept inside for puffing of grains for popping periods of 135 to 167 sec. Three power level (60, 80, 100%) were selected for puffing the samples.

Quality parameters of puffed quinoa in terms of popping volume, expansion ratio and popping percent were evaluated by following equations.

Popping volume(ml)

It refers to the popped volume per 100 grains.

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

$$\text{Expansion ratio} = \frac{\text{Total popped volume (ml)}}{\text{Volume of raw kernels (ml)}}$$

$$\text{Percent puffing} = \frac{\text{Number of popped grains}}{\text{100 grains after popping}}$$

Result and Discussion

Effect of temperature on puffing quality of quinoa grain

Temperature	Time (sec)	Puffing volume (ml)	Expansion ratio	Percent puffing
200	90	7.91	2.05	59%
220	72	9.05	2.95	73%
240	35	8.08	4.09	80%
260	16	9.16	4.36	87%
280	13	8.06	4.12	82%

Effect of temperature and time of puffing by traditional method were analyzed on puffing characteristics i.e puffing volume, expansion ratio, percent puffing of puffed quinoa grains presented in table 8. Puffing volume varied from 7.9 to 9.1 ml, expansion ratio ranged from 2.0 to 4.4 and the percent puffing varied in range of 59 to 87% in the entire range of temperature and time during puffing. Maximum puffing percent was achieved at the time of 16 sec in this process. These results were also agreed with findings of (Konishi *et al*., 2004) [7].

Effect of microwave method on puffing quality of quinoa grain

Power level	Time	Puffing volume (ml)	Expansion ratio	Percent puffing
60	167	6.94	1.89	49%
80	126	7.13	2.19	56%
100	135	8.06	3.05	65%

Effect of power level and time of puffing by microwave process were analyzed on puffing characteristics i.e puffing volume, expansion ratio, percent puffing of puffed quinoa grains presented in table 9. Puffing volume varied from 6.9 to 8.0 ml, expansion ratio ranged from 1.9 to 3.1 and the percent puffing varied in range of 49 to 65% in the entire range of power level and time during puffing. Maximum puffing percent was achieved at the time of 135 sec at 100% power level in this process. With the further increase in time of exposure to 160 s puffing yield decreased (Mohapatra and Das, 2011), above 160 s time of puffing, charing of grains occurred at higher moisture content. Similar results were obtained by Lewis *et al*., 1992.

Conclusion

Quinoa is (*Chinopodium quinoa* willd) is an ancient grain crop that originated from the Andean region of South America. Quinoa contains higher amounts of protein and greater balance in the distribution of essential amino acids than cereals, resembling the biological value of milk protein. Quinoa seed (Bitter variety) were procured from mamta agro Gujarat (India). The quinoa seeds were cleaned and washed and then chemically treated with sodium bicarbonate and citric acid solution so as to remove saponin content to desirable level. After chemical treatment seeds were thoroughly washed under running tap water until foam disappear and finally dried under cabinet dryer. The treated and dried grains were puffed by different methods i.e conventional method and microwave method.

Puffing is a simple and less expensive processing method which improves texture and sensory qualities of grains and also there are minimum changes with nutrient composition in the processed product. The interest in puffing of quinoa seed was due to their nutritive value and health benefits. Quinoa seed is also called as miracle grain because content of good quality protein (complete amino acid profile), dietary fiber and mineral such as calcium, phosphorous, zinc and iron.

The present study carried out on puffing of quinoa grains by different methods at different time, temperature and moisture content of grains. Puffing characteristics were studied as puffing percent, expansion ratio and puffing volume. Pretreatment of cleaned quinoa grains was done to achieved (14.33, 16.25, 18.34%wb) moisture content. Standardization of pretreatment conditions was done following traditional puffing at a temperature 220, 240, 260 ^{0}C. Maximum puffing percent (87%) and expansion ratio (4.36) were observed at temperature 260 ^{0}C, 18.34% moisture content.

Microwave puffing experiments were carried out at three different power levels (80, 90,100), moisture content (14, 16, 18%) and time of exposures (120, 140, 160 sec) to optimize the parameters. The optimize parameters for microwave puffing of quinoa grains were obtained at 100 W microwave power at 18% moisture content and 135s time of exposure to obtaining maximum puffing percent and expansion ratio.

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