

ABSTRACT

Major physical and thermal properties of fenugreek and black pepper seeds were determined. Flow behavior of fenugreek and black pepper powders obtained by ambient and cryogenic grinding using Rotor mill was determined. Comparative performance of different grinders such as Rotor, Ball, Hammer and Pin mill under ambient and cryogenic grinding conditions was carried out. Both ambient and cryogenically ground powders were packed and stored for more than 6 months in various types of packaging materials for both qualitative as well as quantitative analysis.

The geometrical dimensions (length, width, thickness, equivalent diameter) of fenugreek and black pepper seeds measured by a grain shape tester were found to be increasing in nature with increasing moisture content (MC). Seeds roundness, specific gravity, volume, surface area, 1000 seed weight, true density and porosity of the fenugreek and black pepper seeds were found to be increasing in nature with increasing MC. The terminal velocity of black pepper seeds were found to be in the range of 8.7 to 10.5 m s⁻¹ whereas the terminal velocity of fenugreek seeds was found to be in the range of 9.23 to 9.43 m s⁻¹. Seeds hardness, aspect ratio, and specific surface area for both the spices were found to be decreasing in nature with increasing MC. The bulk thermal conductivity and specific heat of both the selected spices seeds were found to be increasing in nature with increasing MC and temperature.

Ambient and cryogenic grinding of fenugreek and black pepper seeds were carried out with the help of Rotor, Ball, Hammer and Pin mill to evaluate the suitability of a grinder based on some selected parameters. Rotor, Hammer and Pin mill were found to be good for small scale grinding at a feed rate of 22.5 ± 0.3 g min⁻¹ for ambient conditions and at 24.5 ± 0.5 g min⁻¹ for cryogenic grinding in a continuous process whereas Ball mill could be used for lower feed rate of 1.56 ± 0.6 g min⁻¹ for ambient grinding; and 2.08 ± 0.4 g min⁻¹ for cryogenic grinding in batch processes. Time taken in grinding an equal amount of sample to a definite size in various grinders was found to be in the order: Ball mill > Pin mill > Hammer mill > Rotor mill; order of feed rate: Hammer mill > Rotor mill > Pin mill > Ball mill; order of power consumptions: Pin mill > Hammer mill > Rotor mill > Ball mill; order of total surface area created: Rotor mill > Hammer mill > Pin mill > Ball mill. The feed rates were found to be higher in cryogenic grinding in all the selected grinders compared to that for ambient grinding. Minimum feed rate was observed for Ball mill whereas Hammer mill was found to be having maximum feed rate. Overall and specific power consumptions in ambient and cryogenic grinding of seeds were found to be more in case of ambient grinding compared to cryogenic grinding. It was found that there is minimum color difference among ambient and cryogenically ground

powders in Rotor mill whereas Hammer mill ground powder was found to be having maximum color difference among the selected grinders. Hammer mill was found to be having unique feature of being able to retain husk of the fenugreek on its grinding sieve. Such comparative study will be useful for food process industries while considering spice grinding applications as well as in academic field to understand suitability of a grinder, their grinding mechanism.

In powder flow characterization, it was found that cryogenic grinding produces finer powder compared to ambient grinding. True density, porosity and Hausner ratio showed increasing trend with increasing MC in ambient grinding whereas the increase was comparatively lower in case of cryogenic grinding for both the spices. Carr index was found to be sharply increasing for ambiently ground powders in comparison to that for cryogenically ground powders. Dynamic angle of repose was found to be higher for cryogenic grinding with increasing MC but in case of ambient grinding the increase was lower compared to that of cryogenic grinding. Angel of slide of powders on different planes was found to be increasing in nature with increasing MC. Statistical analysis of mean, mode median, variance, Skewness, Kurtosis, and Span were also reported in the present study.

Quality degradation behavior of fenugreek and black pepper powders obtained by ambient and cryogenic grinding were evaluated with the help of evaluating various parameters such as the change in color using Chroma meter, aroma and odour by sensory evaluation, change in moisture content by oven drying method and change in weight by weighing in electronic balance and antioxidant activities of stored powders by standard tests. Sensory evaluation revealed that quality in terms of color, odor, flavor, aroma and acceptability of stored fenugreek and black pepper powders for longer period (> 6 months) were found to be reduced. Glass jar and steel jar were found to be better containers for storing studied powders for longer time. Following may be the order of studied packaging material for better retentions of flavor, aroma, color etc.: Glass jar > Steel jar > Aluminum bag > Plastic jar > Polythene bag. Antioxidant activities of the cryogenically ground black pepper powder was found to be higher than that of ambiently ground powder but it was found to be decreasing in nature with the passages of time. The freshness of fenugreek powder was expressed in yellowness index and it was found to be increasing negatively which implies that powder was losing its yellow color and in turn freshness.

Keywords: Fenugreek, Black Pepper, Cryogenic Grinding, Ambient, Rotor Mill, Ball Mill, Hammer Mill, Pin Mill, Flow Properties, Thermal Properties, Physical Properties, Particle Size.