ABSTRACT

Spices contain high amounts of fat which poses problem of temperature rise during ambient grinding. Owing to this temperature rise, a substantial fraction of volatile oil which is mainly responsible for flavour, is lost from the spices. Therefore, studies on cryogenic grinding of two commercially important spices, viz., cumin seed and clove were carried out. Some physical and mechanical properties of cumin seed and thermal properties of cumin seed and clove under cryogenic and ambient conditions were evaluated as a function of moisture content. Based on the data, a cryogenic precooler using liquid nitrogen for cooling the cumin seed and clove during feeding and grinding was designed and developed. The precooler was attached to a grinder along with some other accessories, viz., air compressor, liquid nitrogen dewar, variable speed D.C. motor and gear reduction unit for cryogenic grinding of cumin seed and clove. Cryogenic grinding experiments were conducted to study influence of parameters, viz., grinding temperature, rotor speed, sieve opening size, feed rate and moisture content on volatile oil content, particle size distribution, volume mean diameter and specific energy consumption. It was observed that cumin seed could be ground at a temperature below -70°C without any deposition over the sieve surface. The increase in grinding temperature of cumin seed in cryogenic range (-160 to -70°C) had no significant effect on volatile oil, whereas increase in grinding temperature in the ambient range (40 to 85°C) significantly reduced the volatile oil from 2.86 to 2.26 ml/100 g. In comparison to ambient grinding, 31% more volatile oil retention was observed in cryogenic grinding of cumin seed. The volatile oil components, α-pinene, β-pinene, γ-terpinene, p-cymene and cuminaldehyde were not significantly affected by grinding temperature (-160 to -70°C) in the cryogenic temperature range. However, these components decreased significantly with increase in grinding temperature (55 to 85°C) under ambient condition. In cryogenic grinding (-100°C) the increase in retention of volatile components, viz., α-pinene, β-pinene, γ-terpinene, p-cymene and cuminaldehyde was in the order of 22%, 20.2%, 7.4%, 40.9% and 35% respectively of that of ambient grinding at 85°C. Feed rate, rotor speed and sieve opening size had no significant effect on volatile oil content of the ground cumin powder. Moisture content (4 to 16% d.b.) of the cumin seed had no effect on volume mean diameter, specific energy consumption and volatile oil content of the ground cumin powder. The experiments on cryogenic grinding of clove revealed that it could be successfully ground at temperature below -50°C without any deposition over the sieve surface. The increase in temperature of clove in the cryogenic range (-110 to -50°C) had no significant effect on volatile oil content, whereas increase in grinding temperature in the ambient range (55 to 85°C) significantly reduced the volatile oil content from 11.03 to 9.33 ml/100 g. In cryogenic grinding of clove, 29.5% more volatile oil retention was observed in comparison to that of ambient grinding. The machine and operating parameters, viz., grinding temperature, rotor speed, sieve opening size and feed rate, significantly affected the volume mean diameter and specific energy consumption.

Key words : *Cryogenic grinding, spices, cumin seed, clove, cryogenic precooler, physical, mechanical and thermal properties, volatile oil, freezing point, melting point, brittle point.*