Effect of Elevated Drying Temperature on Rapeseed Oil Quality

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Effect of rapeseed drying temperature on oil quality was investigated over the range 50–250°C. Total oil content was not significantly affected at 5% probability. Amounts of free fatty acids were significantly affected but remained much below the maximum permissible limit. Oil color was also significantly affected but had no specific trend of variation with temperature, and visual differentiation was difficult. Further, visual cracks and blackening were observed in rapeseeds dried at 250°C. Based on this study, elevated drying temperature up to 200°C was recommended for rapeseed without adversely affecting oil quality. This would save up to 80% drying time compared to the present practice of drying rapeseed at a maximum temperature of 93°C.

KEY WORDS: Drying, elevated-temperature drying, oil quality, oilseed, rapeseed.

Rapeseed/mustard is the second most productive oilseed crop in India. Recently, the production of rapeseed has been enhanced by almost 60% to 2.84 million tons in 1985–86 from 1.6 million tons in 1977–78 (1). With this production, India is ranked third in rapeseed production in the world. Increased production of rapeseed has necessitated storage of oilseeds before processing, which requires drying to a safe moisture level.

Heated air drying is governed by safe drying temperature in view of product quality. Rapeseed, when used as seed, is dried at a maximum temperature of 60°C in order to maintain viability (2,3). Rapeseed, when used for oil, can be subjected to drying air temperatures up to 93°C (4) without adversely affecting oil quality. However, little evidence is available in supporting this restriction.

Quality determinants to establish a drying process for edible vegetable oil are total oil content, percent free fatty acid and oil color. The effect of drying temperature on oil content of rapeseed has not been reported. Nonetheless, the data available on sunflower, safflower and flaxseed indicate that the oil content is not considerably affected by drying temperature up to 104.5, 90 and 79°C, respectively (5–8). The effect of drying temperature up to 93.3°C on free fatty acids (FFA) of rapeseed oil was insignificant (9). The same was confirmed over a temperature range of 30 to 80°C by Sutherland and Ghaly (3) and by Ghaly and Sutherland (8). The effect of drying air temperature up to 93°C on oil color was reported to be insignificant by McKnight and Moysey (9). Sutherland and Ghaly (3), however, recommended a drying air temperature only up to 70°C, above which the oil color was darker. They further observed that the oil color from rapeseed dried at temperatures of 30–80°C did not follow any particular trend and that it was difficult to differentiate visually between oil samples. More work is required to confirm the effect of rapeseed drying temperature on the color of extractable oil.

The objectives of this paper, therefore, were to determine the effect of drying temperature on rapeseed oil quality and examine the possibility of using elevated drying temperatures above 93°C in order to reduce drying time.

EXPERIMENTAL PROCEDURES

Rapeseeds, PT-30 variety, were exposed in 2.5-cm layers to heated air at 50, 65, 80, 95, 110, 125, 150, 200 and 250°C, ± 2°C. Initial moisture content of rapeseed was adjusted to 20% (dry basis), commensurate with harvesting practices in India, and the drying was continued to a moisture content of 8% (dry basis). The total drying time was noted to determine the saving in drying time at elevated temperatures. Air velocity was kept constant at 0.42 *m/s*. No attempt was made to control relative humidity because the control of humidity increases process cost and is generally not practiced commercially (10).

Quality of oil extracted from dried rapeseed was determined in terms of total oil content, percent free fatty acid (FFA) and oil color. Oil was extracted and total oil content was determined by solvent extraction at 104°C in a Soxtec apparatus with petroleum ether (boiling point 65°C). Dried rapeseeds were first ground by a hand grinder. The 'boiling' and the 'rinsing' steps in the Soxtec extractions were carried out for 45 and 30 min, respectively. This combination, compared to 20 min boiling and 12 min rinsing specified by the manufacturer, resulted in more complete oil recovery (Pathak, P.K., unpublished data). Six replications were run for each sample. AOCS official method Aa6-38 was employed to determine FFA (11). Color of oil was measured with a Beckman DU-7 spectrophotometer (Fullerton, CA) by methods Cc 13c-50 and S 2-64 (11).

RESULTS AND DISCUSSION

Oil content. Heated-air drying of rapeseed resulted in reduction of oil content to an extent of 0.41–0.93% on a moisture-free basis. However, no specific trend in this reduction with respect to temperature was observed. Further, analysis of variance (Pathak) indicated that the effect of drying temperature on the oil content of rapeseed was statistically not significant at the 5% probability level. Similar effects had been observed by Schuler and Zimmerman (5) in case of sunflower seed over a drying temperature range of 37.8–104.5°C.

Free fatty acids. FFA (average of three values) of oils extracted from rapeseeds dried at various temperatures over the range of 50–250°C are shown in Figure 1. These ranged from 0.8 to 1.3%, against 0.5% in oil extracted from rapeseed prior to drying. Analysis of variance (Pathak) showed that FFA was significantly affected by drying temperature at the 5% probability level. Critical line AA, Figure 1, drawn by adding the critical difference value of 0.24 at 5% probability to the initial FFA value of the control sample (oil extracted from rapeseed prior to drying)

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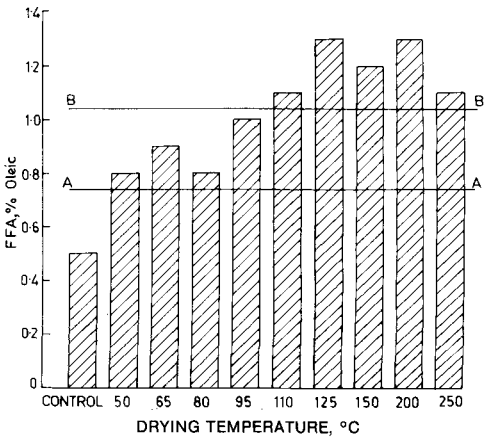

FIG. 1. Effect of drying temperature on FFA of extracted oil. AA: Critical line at 5%, CD = 0.24 (added to control); BB: Critical line at 5%, CD = 0.24 (added to 50°C and 80°C).

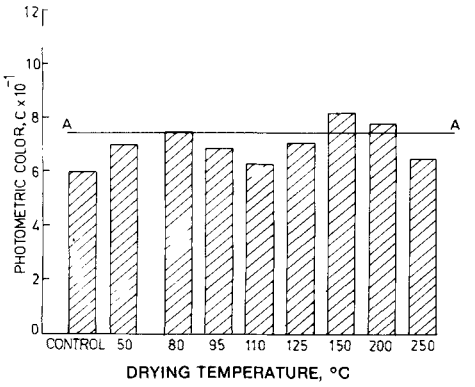

FIG. 2. Effect of drying temperature on photometric color of oil diluted 10-fold with CCl_4. AA: Critical line at 5% probability, CD = 11.34 (critical difference, CD, added to absorbance at 110°C).

indicates that the FFA in oil extracted from rapeseed dried at all the temperatures was significantly higher than that of oil extracted prior to drying. In conclusion, drying of rapeseed increased FFA of oil significantly at all the temperatures.

Comparison of FFA values at drying temperatures of 50, 65, 80 and 95°C indicate that FFA of these oils did not differ significantly from each other, because the differences are less than the critical difference. This is in conformity with the findings of McKnight and Moysey (4) over a temperature range of 35–93°C and their existing recommendation that the maximum permissible drying temperature should be 93°C.

The oils extracted from rapeseeds dried at 50 and 80°C had the lowest FFA value of 0.8% and they were considered to represent the best quality of oil extracted from rapeseed dried at the presently recommended temperature of 93°C. The critical line BB, Figure 1 drawn by adding the critical difference to this FFA value indicated that if rapeseeds are dried at elevated temperatures (above 93°C), the FFA quality of oil would be significantly different from that obtained from the presently recommended process. Nonetheless, the FFA values at all the elevated temperatures investigated were much below the maximum permissible limit of 3% on FFA prescribed by the Purified Food Adulteration Act (12). It was, therefore, felt that the elevated temperature could be used for drying rapeseed while still maintaining FFA of extractable oil much below the maximum permissible.

Oil color. Four peaks of absorbance were observed at about 430, 454, 484 and 670 nm in spectra of oils extracted from dried rapeseed. The peaks and magnitudes of absorbance were comparable to those observed by Jha (13) for filtered expeller mustard oil except the peak at 670 nm, which was not investigated by him. The absorbance values (Pathak) observed at 430, 454 and 484 nm were in accordance with yellowish color of rapeseed oil from carotenoids (14). A much lower value of absorbance at 670 nm, corresponding to the hue from pigments such as chlorophyll, was representative of mature rapeseed (14).

Analysis of variance was performed on the absorbances at the characteristic wavelengths. The effect of rapeseed drying temperature on absorbance (color) of extracted oil was found statistically significant at three characteristic wavelengths (430, 454 and 484 nm) and insignificant at 670 nm at the 5% probability level. Further, the effect was identical at all three characteristic wavelengths. Photometric color C, the combined visual effect of various complimentary hues corresponding to the characteristic wavelengths, was calculated by using the following equation (3,11) and is shown in Figure 2 along with the control (oil extracted from rapeseed prior to drying):

$$C = 1.29\ A_{430} + 69.7\ A_{454} + 41.2\ A_{484} - 56.4\ A_{670} \quad [1]$$

Drying of rapeseed darkens the color at all drying temperatures compared to the control. However, no particular trend was observed. A similar undefined trend was observed by Sutherland and Ghaly (3) over a temperature range of 40–75°C.

The lightest oil color was observed in rapeseed dried at 110°C. A critical line AA, Figure 2, was drawn by adding the critical difference at 5% probability level to the color at 110°C. Color of oil corresponding to 150 and 200°C drying temperature was significantly darker than others. Color at 80°C was just about the critical line. Visual differentiation of color amongst the oil samples was very difficult. Moreover, the differences in color at 1% probability level were insignificant. In absence of any particular trend of the effect of drying temperature on oil color and in view of no visible differentiation in color, it was felt that the color of oil could be ignored in assessing the effect of rapeseed drying temperature on oil quality.

Elevated-temperature drying. Preceding discussion indicates that the elevated drying temperature within the range of this study could be used for drying rapeseed in view of oil quality. However, it was visually observed that drying at 250°C had resulted in surface cracks and blackening of rapeseed, which could eventually affect the quality of rapeseed, if stored, as well as quality of the meal. It is, therefore, recommended that elevated drying temperature up to 200°C can be used for drying rapeseed without adversely affecting the quality of extractable oil. Drying of rapeseed at 200°C was observed (Pathak) to affect a saving of 80% in drying time when compared to drying at 95°C.

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