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Physical properties of fresh and partially fermented coffee parchment

M. SIDDHARTH AND A. KARTHIAYANI

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See end of the Paper for authors' affiliation

Correspondence to :

M. SIDDHARTH
College of Food and Dairy Technology, Koduvalli, CHENNAI (T.N.) INDIA
Email : siddharth_chennai@yahoo.co.in

ABSTRACT : Physical properties of both fresh and partially fermented arabica coffee parchment of Cauvery variety *viz.*, size, shape, angle of repose, bulk density, true density, porosity, 1000 parchment mass, hardness/crushing strength, adhering strength of mucilage to parchment and moisture content of washed parchment were studied. These data can be used for the development of machineries used in estate level processing of coffee parchment.

KEY WORDS : Physical properties, Partially fermented coffee parchment, Arabica coffee

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Processing of coffee fruits and parchments involves the knowledge of various physical properties *viz.*, size and shape, densities, 1000 beans mass and crushing strength etc. These properties of coffee beans are highly required for drying, hulling, grading, packaging, roasting and grinding in addition to the knowledge on various thermal properties of coffee beans. Physical properties of parchments are important especially in developing the washer mechanism and the knowledge on the properties *viz.*, size and shape, density and porosity are very much useful for designing and fabricating the equipment. Hence, this study was undertaken to study the various physical properties of fresh and partially fermented arabica parchment of Cauvery variety *viz.*, size, shape, angle of repose, bulk density, true density, porosity, crushing strength, 1000 parchment mass and adhering strength of mucilage to parchment.

METHODOLOGY

Materials for measurements :

The freshly harvested arabica coffee berries were collected from the Coffee Demonstration Farm, Coffee Board, Yercaud.

Size :

The size of the parchment *viz.*, length, width and thickness were determined using a dial calliper (Joshi *et al.*, 1993). Twenty parchment were randomly selected from the pulped parchment obtained from the fully ripened fruit and the mean values were reported.

Shape :

Since the shape of the parchment deviates from one another to a greater extent the study of the features like roundness ratio and sphericity are important during their conveyance inside the washer. The most widely accepted methods for determining the roundness of irregular particles as suggested by Sahay and Singh (1994) was used to find out the roundness ratio and sphericity. The following relationships were used :

$$\text{Roundness ratio} = \frac{r}{R}$$

where,
r - radius of curvature of the sharpest corner, mm
R- mean radius of the parchment, mm.

$$\text{Sphericity} = \frac{(lbt)^{1/3}}{l}$$

where,
l - largest intercept, mm
b - largest intercept perpendicular to l, mm
t - largest intercept perpendicular to l and b, mm.

Angle of repose :

Filling angle of repose was determined using a set up as reported by Sreenarayanan *et al*. (1988). This set up consisted of a circular disc placed on a platform having a scale to measure the height of the heap. The circular disc of 20, 12 and 10 mm diameters were used. The disc was placed on the platform and the parchment were allowed to fall from 30 cm height to form a heap. From the measurements of diameter and height of the heap, the filling angle of repose was calculated using the formula :

$$\theta = \tan^{-1} (2h / d)$$

where,
q -filling angle of repose, degree,
h - height of the heap, cm
d - diameter of the disc, cm.

The height was measured for all the 3 discs and the filling angle of repose was calculated. Then the mean value was reported as the angle of repose. It was measured for the parchment at 0 (fresh), 16, 20 and 24 hours fermentation levels and reported.

Porosity :

The apparatus used by Sreenarayanan *et al*. (1988) was used in measuring porosity of the parchment at different levels of fermentation.

The per cent porosity (P) was calculated using the formula :

$$P = \frac{P_1 - P_2}{P_2} \times 100$$

The experiment was repeated 3 times for each sample and the mean value was reported.

1000 parchment mass :

The mass of 1000 parchment was determined by selecting 100 parchment at random and weighing in an electronic balance of 0.01 g accuracy (Dutta *et al*., 1988). From the weight of 100 parchment, the 1000 parchment mass was calculated. The experiment was replicated 3 times and the mean value was reported.

Densities :

Densities of parchment with mucilage are important in the development of washer mechanisms and hence, the bulk density was determined experimentally and the true density was calculated.

Bulk density :

Bulk density was determined by filling a container of known volume with wet parchment and the content was weighed. The ratio between the weight and volume was calculated as bulk density (Sreenarayanan *et al*., 1988). The experiment was repeated five times by emptying and filling the container with new samples each time and the mean value was reported.

True density :

The true density was calculated from the values of bulk density and porosity using the following relationship (Mohsenin, 1980) :

$$\rho_t = \frac{\rho_b}{(1 - P_f)}$$

where,
r_t - true density, kg/m^3
r_b - bulk density, kg/m^3
P_f- porosity in fraction.

Moisture content :

The moisture content of parchment after washing was determined by drying 3 samples of each 5 g in an electric oven at 130 ± 1°C for 2 hours (Sreenarayanan *et al.*, 1988). The average value was reported.

Hardness/crushing strength :

As the hardness of parchment exceeded the measurement range of 20 kg in the 'KIYA' hardness tester (Chandrasekar, 1995), a simple loading arrangement was made to determine hardness of fresh parchment. It consisted of a load cell, loading screw and a load indicator.

The hardness of parchment was measured along 3 directions (length, breadth and thickness). The parchment was placed over the load cell and the load was applied by turning the wheel until the parchment was failed. The reading in the load indicator was noted and the actual load was read. Ten parchments were crushed each along its length, breadth and thickness directions and the mean values were reported.

Adhering strength of mucilage :

The force required to detach the mucilage from the surface of parchment known as the adhering strength of mucilage with parchment was measured with the special instrument made for this purpose. It consisted of water inlet, nozzle to produce water jet, parchment holder and pressure gauge. The parchment was placed tightly in the parchment holder and the water jet was applied on the surface of parchment. The pressure of water jet was varied by adjusting the regulating valve provided for this purpose. The pressure of water jet required to detach the mucilage was read from the pressure gauge. By multiplying the pressure by nozzle area, the adhering strength was calculated. The experiment was replicated 5 times with new sample each time for all the levels of fermented parchment including fresh parchment.

■ RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads :

Size and shape of parchment :

The maximum value of major, minor and intermediate axes dimension of parchment recorded were 13.45, 9.55 and 7.35 mm and the corresponding minimum value noted were 11.05, 7.10 and 5.05 mm, respectively. The average major, minor and intermediate axes dimensions of parchment were 12.03, 8.46 and 6.09 mm, respectively. These values are nearer to the values reported by Chandrasekar (1995) and Sundar (1997). The mean sphericity of parchment was 0.71.The highest and the lowest values of sphericity recorded were 0.79 and 0.65, respectively. Based on the classification made by Mahsenin (1970), the parchment comes under semi oblong shape. The maximum and minimum roundness ratio was recorded 0.84 and 0.61, respectively whereas a mean roundness ratio was 0.74. Mani (1996) reported the roundness ratio for tamarind kernel as 0.7 whose shape is close to the coffee parchment.

Bulk density of parchment :

The average bulk density of washed parchment was 719.0 kg/m^3. The average bulk density of fresh (or) 0,16,20 and 24 hours fermented parchment were 683.3, 468.2, 434.1 and 392.8 kg/m^3, respectively. The 1000 parchment mass was 420 g.

Table 1 : Bulk density and true density of parchment

Sr. No.	Treatments	Average bulk density (kg / m^3)	Average true density (kg / m^3)
1.	Fresh	683.3	907.4
2.	16 h fermented	468.2	610.4
3.	20 h fermented	434.1	557.0
4.	24 h fermented	392.8	457.3
5.	Washed	719.0	1065.2

The highest value of bulk density obtained was 719.0 kg/m^3 with washed parchment and the lowest value of 392.8 was obtained with 24 hours fermented parchment (Table 1). Madasamy and Gothandapani (1996) reported the average bulk density of fresh parchment as 681.37 kg/m^3. Similarly, the average bulk density of 15 hours fermented parchment was reported as 487.3 kg/m^3 (Sundar,1997).

True density of parchment :

The highest value of true density obtained was 1065.2 kg/m^3 with washed parchment and the lowest value of 457.3 kg/m^3 was obtained with 24 hours fermented parchment. The different true densities of 907.4, 610.4, 557.0, 457.3 and 1065.2 kg/m^3 were computed for fresh, 16,20 and 24 hours fermented and washed parchment, respectively (Table 1). The bulk density and true density were decreased as the fermentation time increased and it is due to decrease in number of parchment per unit volume because of loosening of mucilage during fermentation. The mean value of true density was reported as 856.57 kg/m^3 (Madasamy,1996) which is close to the value reported.

Porosity of parchment :

The average values of porosity (%) of parchment were measured as 24.70, 23.30, 22.07, 14.10 and 32.50 for fresh, 16, 20 and 24 hours fermented and washed parchment, respectively (Table 2).

Table 2 : Porosity and angle of repose of parchment

Sr. No.	Treatment	Angle of repose (degree)	Average porosity (%)
1.	Fresh	30	24.70
2.	16 hrs fermented	51	23.30
3.	20 hrs fermented	52	22.07
4.	24 hrs fermented	54	14.10
5.	Washed	26	32.50

The porosity was decreased with increased duration of fermentation. The washed parchment had the highest porosity next to the fresh parchment. Partially fermented parchment recorded lower porosity values and 24 hours fermented parchment recorded the lowest value of 14.10 per cent. Increase in volume of the mucilage during fermentation occupies the pore space between the parchment. This is the reason why the porosity value recorded was lower for the fermented parchment and higher for the washed parchment.

Angle of repose :

The angle of repose was measured for fresh, 16, 20, 24 hours fermented and washed parchment. The maximum angle of repose of 54° whereas the minimum value was obtained in washed parchment as 26°. The mean values of angle of repose of fresh, 16, 20, 24 hours fermented and washed parchment were 30, 51, 52, 54 and 26°, respectively (Table 2).

Crushing strength of parchment :

The crushing strength of parchment was determined using the instrumental set up developed for this purpose. The incremental load cracked the parchment and the minimum load required to crush or make a crack on the parchment. The crushing strength was measured along the two axes of parchment *viz.*, major and minor. Each experiment was replicated thrice and the average value was reported. The mean value of crushing strength of 0.81 N was obtained while measuring along major axis and the mean value of 2.34 N was obtained along minor axis. This is confirmed by the result reported by Sundar (1997). He reported the mean value of crushing strength for fresh parchment along the major axis as 0.965 N.

Adhering strength of mucilage with parchment :

The adhering strength of mucilage with parchment was determined for fresh, 16, 20 and 24 hours fermented parchment.

Table 3 : Adhering strength of mucilage with parchment

Sr. No.	Treatments	Average adhering strength of mucilage (N)
1.	Fresh	0.00132
2.	16 h fermented	0.00120
3.	20 h fermented	0.00099
4.	24 h fermented	0.00095

The average adhering strength of mucilage with fresh, 16, 20 and 24 hours fermented parchment were 0.00132, 0.00120, 0.00099 and 0.00095 N, respectively. The results clearly indicate that as the duration of fermentation increased, the mucilage was loosened more and hence, recorded lower force to remove the same (Table 3).

Moisture content :

The moisture content of washed parchment was recorded as 161.8 per cent (d.b) which confirmed the moisture content reported by Wilbaux (1963).

Conclusion :

The physical properties studied can be used for development of machineries for estate level processing of fresh and partially fermented coffee parchment.

Authors' affiliations:

A. KARTHIAYANI, College of Food and Dairy Technology, Koduvalli, CHENNAI (T.N.) INDIA

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