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Development of hand-operated mechanical ginger peeler

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ABSTRACT

Ginger, an underground rhizome, is valued as a spice and is used in both dry and fresh form. The process of peeling is labour-intensive and is a time-consuming operation in post-harvest handling of ginger done manually by women labour. To reduce time and labour requirement, a mechanical ginger peeler having a square mesh drum was developed. Peeling trials were conducted for varying drum loads (6kg, 8kg and 10kg), varying drum speeds (35rpm, 40rpm and 45rpm) and for different peeling durations (5 min, 10 min and 15 min). Optimum machine parameters for maximum efficiency were: drum load of 8 kg per batch, operated at drum speed of 40rpm for peeling duration 15 min. Peeling efficiency and material loss at optimum conditions were determined to be 55.60% and 4.68%, respectively. Dry ginger obtained after mechanical peeling was found to contain essential oil at 2%, oleoresin 4.6%, moisture content 9.82% and crude fibre content 2.5%.

Key words: Ginger, mechanical peeling, material loss, peeling efficiency, quality

INTRODUCTION

Ginger, the rhizome of *Zingiber officinale* Roscoe, is one of the most widely used spices of the family Zingiberaceae. India is the largest ginger producing country in the world, with annual production of 7,95,028 tons from an area of 1,38,479 ha recorded in 2008-09 (Spices Board of India, 2011). Other important ginger-producing countries are China, Indonesia and Nepal. During 2008-09, India exported 5000 tonnes of ginger valued Rs. 3,482.5 lakh to major importing countries like Bangladesh, Saudi Arabia, U.K, U.S.A, Spain, Morocco, etc.

Peeling, in the case of ginger, is an important unit-operation where fully mature rhizomes are scraped with bamboo-splits having pointed ends, to remove the outer skin before drying to accelerate the drying process. Deep scraping with knife needs to be avoided to prevent damage to oil-bearing cells present just beneath the outer skin. Excessive peeling results in reduction of essential oil content in dried produce. Peeling in ginger is a highly laborious and time-consuming operation that needs to be done immediately after harvest. Peeled rhizomes are washed before drying. Dry ginger so-obtained is valued for its aroma, flavour and pungency (Balakrishnan, 2005).

Indian dried gingers are usually rough-peeled or scraped as opposed to Jamaican gingers, which are clean-peeled. The rhizomes are peeled or scraped only on the flat side and much of the skin between the fingers remains intact. This is known as rough or unbleached ginger and bulk of the ginger produced in Kerala is of this quality. Kerala accounts for over 60% of the total dried ginger produced and about 90% of India's ginger export trade (Madan, 2005). Since ginger is an important crop of commerce, mechanization in various handling operations is of urgent need. Hence, the present study was undertaken to develop a mechanical peeler for partial peeling of ginger and to evaluate its peeling efficiency.

MATERIAL AND METHODS

Studies on mechanical peeling of ginger were conducted at the College of Agricultural Engineering, Tamil Nadu Agricultural University, Coimbatore in January 2009 using a square-mesh drum ginger-peeler developed at the university.The ginger peeler developed (Fig. 1 and 2), consists of a peeling drum of size 700 x 500 mm, fabricated using mild steel square-mesh having mesh openings of size 16mm x 16mm. The square-mesh drum enabled ginger skin removal due to abrasion, and facilitated perforation of the peeled skin to along with water into the wash-water tank. The square-mesh drum was welded on both sides to a circular mild steel flat-frame size 20 mm width x 5 mm thickness. On either side of the mesh-drum, mild steel sheet covers of

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Fig 1. Square-mesh drum ginger peeler

20 SWG were welded on to the circular frame to cover side openings. On the surface of the drum, an opening of size 390 mm x 390 mm was provided so as to feed the material. The opening was provided with a door of 390 mm x 390 mm to load and unload which could be closed with a self-locking, lever type lock.

A hollow, galvanized-iron shaft was used to mount the peeling drum. Diameter of the hollow shaft was determined using the following formula [considering that the shaft for ginger peeling unit is subjected to bending and torsion only, and the axial load acting on the shaft is zero (Khurmi and Gupta, 2006)].

$$d_0^3 = \frac{16}{\pi\,[\tau]\left\{1-\left(\frac{d_i}{d_o}\right)^4\right\}} \times \sqrt{(K_b M_b)^2 + (K_t M_t)^2} \quad ....1$$

where,

d_o is diameter of the shaft, mm; P is axial load, N; M_t is twisting moment, N mm; M_b is bending moment, N mm; $[\tau]$ is design shear stress, N mm^{-2} ; K_b is combined shock and fatigue factor applied to M_b; K_t is combined shock and fatigue factor applied to M_t; τ is shear stress, N mm^{-2}; σ_b is bending stress, N mm^{-2}; α is column action factor.

For revolving shaft with gradual loading, values for K_b=1.5, K_t=1 and $[\tau]$ = 56 Mpa = 56 N mm^2

i. Torque transmitted to the peeling drum

The peeling drum was manually operated. Considering human energy to be 0.1 hp (Sahay, 2006), torque transmitted to the drum by manual rotation at a maximum speed of 50 rpm was calculated using the following formula:

$$hp = \frac{2\,\pi\,N\,T_t}{60} \quad ......2$$

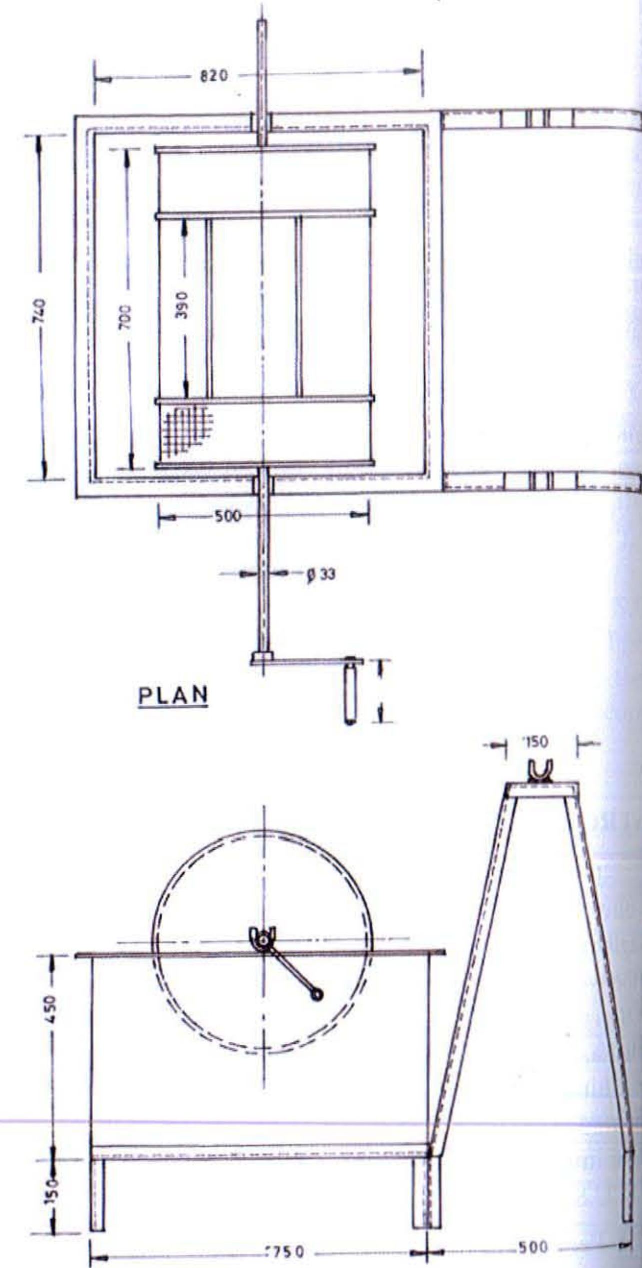


Fig 2. Schematic diagram of the ginger peeler developed

where,

hp is horse power transmitted to the peeling drum =1 hp (746 W), N is speed of the peeling drum, rpm, T_t is torque transmitted, Nm.

Maximum rotational speed of the peeling drum (assumed) = 50 rpm

$$\text{Hence, Torque transmitted} = \frac{74.6 \text{ X } 60}{2 \text{ X } 3.14 \text{ X } 50} = 14.25 \text{ N m} = 14250 \text{ N mm}$$

ii. Bending moment of the shaft

The bending moment was calculated by taking into account load acting on the drum. Assuming that Mass of the peeling drum = 20 kg, Mass of ginger to be peeled = 10 kg per batch, Total Mass = 30 kg.

Mass of the peeling drum and ginger was considered as a uniformly-distributed load acting over a span-length of 0.92m. This was converted into equivalent point load acting at the centre of the shaft. Bending moment diagram for the shaft is shown in Fig. 3.

Considering that the shaft is simply supported, maximum bending moment occurs at the centre of the shaft, and is calculated as (PSG, 1988):

$$M_{b\,max} = \frac{PL}{4} \quad ....3$$

$$M_{b\,max} = \frac{300 \times 920}{4} = 69{,}000 \text{ N mm}$$

Assuming $\frac{d_o}{d_i}$ and substituting all the values in equation (1). d_0^3 is calculated as: $d_0^3 = 17350.78$

Hence, $d_0 = 25.88 \text{ mm} \approx 26 \text{ mm}$

However, the shaft selected for fabrication of the peeler had an outer and inner diameter of 33 and 27 mm, respectively, and a length of 1540 mm.

Two bushes of 40 mm length, 27 mm inner diameter and 33 mm outer diameter were welded at the centre of the drum-cover on either side. The bush was reinforced with three spokes made of mild-steel flats sized 230 mm length x 20 mm width x 5 mm thickness, radiating from the centre towards the outer surface, and, welded on both the side-covers.

A fabricated V-block made of mild-steel flat sized 40 mm width x 6 mm thickness to a height of 40 mm rests on the outer frame of water-holding tank. The shaft with the drum was supported by the V- block.

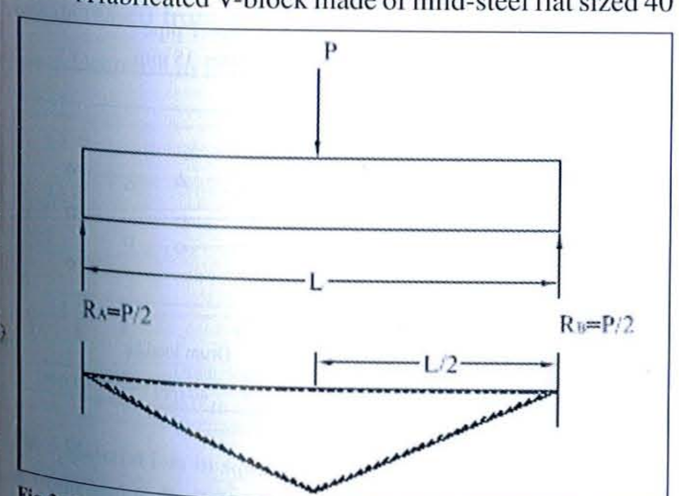


Fig 3. Bending-moment diagram of shaft

The water-holding tank was fabricated from mild-steel sheet of 20 SWG thickness to a size of 820 mm length, 770 mm width and 450 mm depth. The top of the tank was welded with a frame made of angle section of size 32 x 32 x 3 mm thickness. The frame of the tank supports the V-block which, in turn, supports the shaft and the drum.

A 250 mm long handle was provided at one end of the hollow shaft to rotate the drum manually.

Two 'A' shaped frame supports made of mild steel flat of size 25 mm x 6 mm were fastened to the water-holding tank by bolt and nut. Each A-frame was 50 mm wide at the top, 550 mm wide at the bottom with a height of 830 mm. On the top of each 'A' frame, V-block support of height 100 mm made of mild-steel flat of size 25 x 6 mm were provided to rest the drum during unloading. A mild-steel drain pipe of 35 mm diameter was provided at the bottom of the tank and extended outside for removal of wash water.

Experiments on peeling of ginger were conducted till adequate peeling of ginger was obtained in all the trials. A three-factor, completely randomized block design was followed to determine the effects of drum capacity, rotational speed and peeling duration on peeling efficiency and material loss in ginger. Peeling experiments were conducted for three varying drum capacities (6, 8 and 10 kg), for three different rotational speeds (35, 40 and 45 rpm) and for three peeling durations (5, 10 and 15 min.). All the experiments were replicated thrice.

Quality of the peeled ginger was evaluated in terms of peeling efficiency and material loss. To assess quality, a sample of 10% of the total weight was taken. The skin on the surface of the ginger was manually peeled and collected. Weight of the ginger skin before peeling was assessed in a fresh sample by manually separating the skin from ginger. Peeling efficiency and material loss was evaluated as follows (Ali *et al*, 1991):

$$\eta_p = \frac{W_{TS} - W_P}{W_{TS}} \times 100 \quad ....4$$

$$M_L = \frac{(W_1 - W_{TS}) - (W_2 - W_P)}{W_1} \times 100 \quad ....5$$

where,

η_p is peeling efficiency of ginger (%); M_L is material loss of ginger (%); W_{TS} is theoretical weight of the skin on fresh ginger (g); W_P is weight of the skin removed by hand-trimming after mechanical peeling (g); W_1 is total weight of ginger before peeling (g); W_2 is total weight of ginger after mechanical peeling (g.)

Quality of dry ginger was estimated in terms of essential oils by AOAC (1975) method, oleoresin by ASTA (1968) method, moisture content by ASTA (1968) method, and amount of crude fibre was determined by the method of Sadasivam & Manickam (1992).

Data on peeling efficiency and material loss was analyzed using AGRES (Version 7.01, Pascal Intl software solutions) statistical software. Multiple regression models were predicted using Essential Regression (version: 2.21) statistical software.

RESULTS AND DISCUSSION

A square-mesh drum ginger peeler was developed. Design specifications of the peeler developed are presented in Table 1.

Experiments on mechanical peeling of ginger were conducted by varying drum load for various peeling durations (Fig. 4a). As drum load increased from 6 kg to 10 kg for peeling duration of 10 min, peeling efficiency decreased from 40.15% to 38.15%. But, for a given drum-load of 6 kg, as peeling duration increased from 5 min to 15 min, peeling efficiency increased from 34.12% to 51.23%. Peeling efficiency thus decreased with increase in drum-load, and increased with increase in peeling duration.

As drum speed varied from 35 rpm to 45 rpm, for peeling duration of 10 min at a constant drum load of 8 kg, peeling efficiency increased from 39.86% to 44.56% (Fig. 4b).

A decrease in peeling efficiency was observed with increase in drum-load. Peeling efficiency reduced from

Table 1. Specifications of manually-operated square mesh dru[m] ginger peeler

S.No.	Component	Specifications
1.	Peeler drum	
	Material	Mild-steel square-mesh
	Holding capacity	10 kg
	Length	700 mm
	Diameter	500 mm
	Mesh opening size	16 x 16 mm
	Side covers of the drum	Mild steel sheet 20 SWG thick
	Inlet	390 x 390 mm
	Door	390 x 390 mm
	End support for mesh	Mild-steel flat of size 20 x 5 mm
2.	Shaft	
	Material	Hollow, galvanized iron pipe
	Outer diameter	33 mm
	Inner diameter	27 mm
	Length	1540 mm
3.	Bush (2 Nos.)	
	Material	Mild-steel pipe
	Size	40 x 33 x 3 mm
4.	Water holding tank	
	Material	Mild-steel 20 SWG thick she[et]
	Size	820 x 770 x 450 mm
	Top-end support	Mild-steel L-angle of size 32 x 32 x 3 mm
	'V' block support	MS flat, 40 x 6 mm
	Height of 'V' block support	45 mm
5.	Handle	
	Material	Mild-steel flat of size 25 x 3 mm
	Length	250 mm
6.	'A' frame support (2 Nos.)	
	Material	Mild-steel flat of size 25 x 6 mm
	Size of 'A' frame	830 x 150 x 550 mm
	'V' block support	Mild steel flat of size 25 x 6 mm
	Height of 'V' block	40 mm
7.	Drain pipe	
	Material	Mild-steel pipe
	Size	Diameter 35 mm

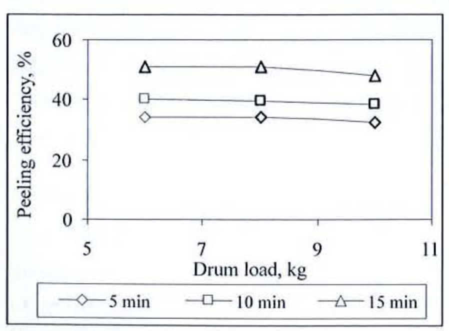


Fig. 4a

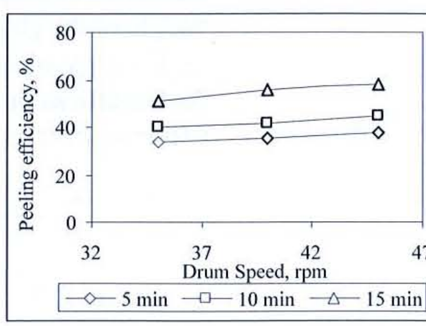


Fig. 4b

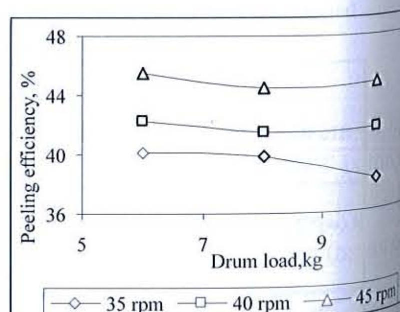


Fig. 4c

Fig. 4 Peeling efficiency in square mesh drum ginger peeler for varying
a. Drum load & Peeling duration, b. Drum Speed & Peeling duration, c. Drum load & Drum speed

42.25% to 41.49% as drum load increased from 6 kg to 10 kg at a drum speed of 40 rpm for 10 min peeling duration (Fig. 4c). But, as drum speed increased from 35 rpm to 45rpm at a drum load of 6 kg, peeling efficiency increased from 40.15% to 45.53%.

Statistical analysis showed that the effect of all independent variables like drum load, drum speed and peeling duration were highly significant ($p<0.01$) in determining peeling efficiency of ginger in the mechanical peeler. However, interactions between independent variables were non-significant. Singh and Shukla (1995) reported that during abrasive peeling of potatoes in an abrasive drum-type peeler, peeling efficiency increased with time. Similarly, peeling efficiency increased with increase in drum speed. However, in the case of increasing material load in the peeler, this trend was not seen beyond 6 min of peeling. This was so because, at the initial stage, peeling occurred only on the outer surface of potatoes. But, as peeling continued beyond 6 min, at higher batch loads some potatoes were over-peeled while some other were under-peeled.

Material loss during ginger peeling decreased from 2.45% to 2.28% (Fig. 5a) as drum load increased from 6 kg to 10 kg for peeling duration of 10 min and drum speed of 35 rpm. But, for drum load of 6 kg and drum speed of 35 and rpm, the peeling duration increased from 5 min to 15 min, material loss increased from 1.29% to 4.58%. Material loss thus decreased with increase in drum-load and increased with increasing peeling duration.

Material loss was also found to increase as drum speed and peeling duration increased. Material loss increased from 1.21% to 1.49% as drum speed increased from 35 rpm to 45 rpm (Fig. 5b). But, at a drum speed of 45 rpm, as the peeling duration increased from 5 min to 15 min, material loss increased from 1.21% to 4.51%.

Decrease in material loss was observed with increase in drum load. Material loss reduced from 2.58% to 2.33% as drum load increased from 6 kg to 10 kg at a drum speed of 40 rpm for 10 min peeling duration (Fig. 5c). But, as drum speed increased from 35 rpm to 45 rpm at a drum speed of 6 kg and peeling duration of 10 min, material loss increased from 2.45% to 2.75%.

Significance of the effect of drum-load, drum-speed and peeling duration on material loss was statistically analyzed. It was observed that material loss was significantly influenced by drum load, drum speed, peeling duration and by interactions between independent variables. Peel loss in potatoes in an abrasive drum peeler was evaluated by Singh and Shukla (1995) who reported peel loss to vary from 3.80 to 10.37 % for batch-load varying from 5 kg to 20 kg, time varying from 4 min to 10 min and speed varying from 30 to 50 rpm. Peel loss increased linearly with peeling time, drum speed and loading intensity.

Relationship between peeling efficiency (η_p) and material loss (M_L) for various drum loads (L), drum speeds (S) and peeling duration (T) in a square-mesh drum peeler was predicted by multiple regression models as follows:

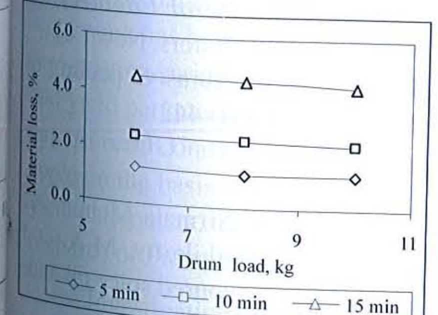
$$\eta_p = 16.41 + 1.156T + 0.229\,S - 0.250\,L + 0.02683\,TS - 0.04617\,TL + 0.00475\,SL \quad \ldots (6)$$

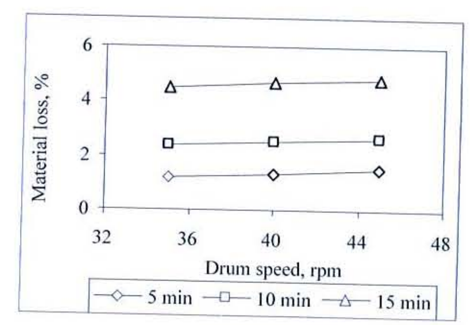
$(R^2=0.97)$

$$M_L = -1.051 + 0.443\,T + 0.0099\,S - 0.174\,L - 0.0017\,TS - 0.0066\,TL + 0.00517\,SL \quad \ldots (7)$$

$(R^2= 0.96)$

From equation (6), it is evident that peeling efficiency was positively correlated with peeling duration and drum-speed and negatively correlated with drum load. Coefficients of independent variables indicated that influence of peeling duration was the highest, followed by drum load and drum speed. Equation 7, explains that material loss was positively





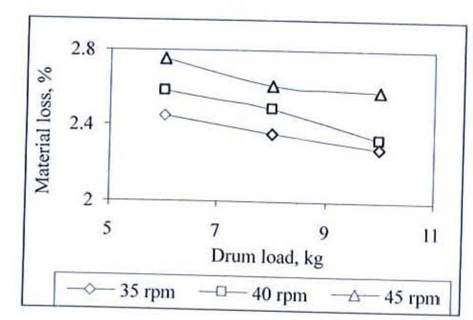


Fig. 5 Material loss in square mesh drum ginger peeler for varying
a. Drum load & Peeling duration b. Drum Speed & Peeling duration c. Drum load & Drum speed

Table 2. Statistical analysis of peeling data

Parameter	Peeling efficiency			Material loss		
	F-value	CD (5%)	SE	F-value	CD (5%)	SE
Drum load (L)	10.52**	0.97	0.48	112.36**	0.76	0.038
Drum speed (S)	61.26**	0.97	0.48	952.82**	0.76	0.038
Peeling duration (T)	757.29**	0.97	0.48	4743.75**	0.76	0.038
L x S	0.15^{NS}	1.68	0.84	12.08**	0.13	0.066
S x T	1.99^{NS}	1.68	0.84	46.11**	0.13	0.066
L x T	1.72^{NS}	1.68	0.84	17.10**	0.13	0.066

Table 3. Quality of mechanically peeled ginger

Constituent	Value (%)
Essential oils	2.0
Oleoresin	4.6
Moisture	9.82
Crude fibre	2.5

correlated with peeling duration and drum speed, and negatively correlated with drum-load. The coefficients of independent variables indicated that influence of peeling time was highest, followed by drum load and drum speed.

Analysis of variance for linear regression model to determine peeling efficiency indicated that the regression model was highly significant (p <0.01) as evident from the F-value calculated (118.27) and R^2 value (0.97). Analysis of variance for linear regression model to determine material loss describes that the regression model is highly significant (p<0.01) as observed from the F-value (40.55) and R^2 value (0.96). Hence, the models developed were adequate to describe the relationship between all treatment combinations of drum-load, drum speed and peeling time with respect to peeling efficiency and material loss of ginger in the square-mesh drum mechanical peeler.

The result of trials conducted on mechanical peeling of ginger, have revealed that peeling of ginger was associated with material loss. For production of dry ginger of commercial grade, it is necessary to minimize material loss so that the quality is not affected. Maximum output from the peeler was obtained at a drum-load of 8 kg for drum speed of 40 rpm and for peeling duration of 15 min. At these conditions, peeling of ginger was sufficient to produce commercial grade dry ginger. Peeling efficiency at optimum machine parameters was 55.60% and material loss was 4.68%. Quality of the sun-dried ginger obtained at optimum operating conditions of the square-mesh drum ginger peeler was determined and was found to have essential oils at 2%, oleoresin 4.6%, moisture content 9.82% and crude fibre content of 2.5% (Table 3).

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Short communication

Varietal assessment, heritability estimates and correlation studies in apple cultivars of South Kashmir

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ABSTRACT

A study was conducted to assess agronomic performance and heritability estimates among different cultivars of apple in district Pulwama of Kashmir valley. Twenty cultivars aged 20 to 22 years were selected for the present study. Data were collected on physical and chemical characters of fruit and yield of the tree. Results revealed that 'Red Delicious' (315.43kg) and Ambri (310.40kg) Difenoconazoled highest yield among all the cultivars. Red Delicious apple recorded maximum fruit weight (182.63g). maximum TSS (16.35%) and total sugars (12.11%) with least acidity (0.07%) was recorded in Ambri apples. All the characters studied showed high heritability estimates except for cropping efficiency (61.06%) which scored least heritability. Length (0.843) and breadth (0.854) of fruit positively and significantly correlated with weight of the fruit. Acidity was negatively correlated with all other biochemical characters.

Key words: Heritability, correlation, varietal assessment, apples, cropping efficiency

Apple is an important fruit crop grown in the temperate region of India. It accounts for 43.30 per cent of total area under fruits and 80.18 per cent of total fruit production in Jammu and Kashmir. It is major cash crop and is the backbone of economy in the state. It is grown in almost all the districts of Kashmir valley, in an area of 1.27 hectares with annual production of 1354.6 thousand metric tons (Anonymous, 2009). Apple productivity in the state has been on the increase since the past two decades because, farmers have adopted recent technologies. Although farmers grow only a few varieties, there is a tremendous diversity in apple germplasm in the departmental and farmers' orchards that remains to be exploited. Although a lot of work has been done on quality and yield parameters a few, existing varieties dominating Kashmir valley, on quality and yield parameters varietal assessment in other varieties has not been conducted so far. To assess these varieties of apple on the basis of physico-chemical characteristics and yield parameters, the present study was undertaken in local orchards of Pulwama district in South Kashmir.

Investigations were carried out during 2008-09 in farmers' orchards of Shopian area of the district. The following 20 cultivars were selected, viz., Stark's Earliest, Tropical Beauty, Orange Sweet, Galia Beauty, King David, Black Ben Davis, Parlins Beauty, Early Shanburry, Tamma, Rome Beauty, Benoni, Lord Lambourne, Laxton's Superb, Cox's Orange Pippin, Red Gold, American Apirouge, Starkrimson, Red Delicious, Sunheri and Ambri. The experiment was laid out in Completely Randomized Block Design (CRBD) with three replications. Plants raised on seedling rootstock with a spacing of 5 x 5m aged 20 to 22 years were selected for the study. Four representative branches from each treatment in each replication were selected randomly in the four directions of tree canopy to ensure precision. Data recorded for yield efficiency was calculated as per Westwood (1993) and expressed in kg/cm². Other yield and fruit characters like yield per plant (kg), fruit weight (g), fruit length (mm), fruit breadth (mm) and biochemical analysis, viz., TSS (°Brix) were recorded. Acidity (%), reducing sugars (%), total sugars (%) and TSS/acid ratio were estimated according to Ranganna (1979). Data thus obtained were analyzed following standard procedures (Panse and Sukhatme, 1995). Coefficient of variability was calculated as per Burton and DeVane (1953) while heritability, genetic advance and genetic gain were calculated as per Johnson *et al* (1955).