Volume-4, Issue-5, October-2014, ISSN No.: 2250-0758
International Journal of Engineering and Management Research
Available at: www.ijemr.net
Page Number: 213-219

Effect of Blanching and Drying Air Temperature on Quality Characteristics of Beetroot (*Beta Vulgaris* L.*)* Leaves Powder

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ABSTRACT

The effect of blanching and drying air temperature on quality chatacteristics of beetroot leaves powder was investigated. It has been observed that both blanching and drying air temperature have significant effect on quality characteristics of beetroot leaves powder. The blanching pretreatment shows the negative effect of protein, carbohydrates, ash content and positive effect of crude fiber, moisture, fat, carotene and total phenolics content of beetroot leaves powder. Study also shows that blanching pretreatment and drying air temperature significantly affect on bulk density, rehydration ratio, angle of repose and coefficient of friction of beetroot leaves powder.

Keywords--- Angle of repose, Beetroot leaves powder (BRLP), β-Carotene, Total phenolic content (TPC), Rehydration ratio

I. INTRODUCTION

Beetroot (*Beta vulgaris* L.*)* belonging to the *Chenopodiaceae* family is indigenous to Mediterranean countries. Beetroot leaves have more nutritional value than their roots and rich in carbohydrates, protein, fiber, minerals like iron potassium, magnesium, copper, calcium, vitamins like A, B_6, E, and C and natural antioxidant like β – carotene and vitamin A [1]. Beetroot leaves are rich source of iron than spinach [2]. Beetroot leaves have remained underutilized due to lack of awareness of nutritional value of leaves [1].

Drying is a complex thermal process in which unsteady heat and moisture transfer occur simultaneously [3]. The materials are dried using several drying techniques but thin layer drying is most popular due to faster rate and minimum loss of nutrients as compared to other drying techniques [4]. Advantage of drying of vegetable is that the vegetable can be easily converted into fresh like form by rehydration and can be used in off season [5]. Dehydration is the useful techniques to increase the shelf life of perishable food for further use [6] to make it functional and nutritional rich [7, 8]. Study on effect of blanching and drying air temperature on quality characteristics of beetroot leaves powder has not been reported yet. The objective of this study was to study the effect of blanching and drying air temperature on the quality characteristics of beetroot leaves powder.

II. MATERIALS AND METHODS

Experimental plan

Fresh beetroot (*Beta vulgarus* L.) leaves were purchased from local market of Sangrur (Punjab). The selected beetroot leaves showed uniform maturity and colour. The beetroot leaves washed under running tap water followed by steam blanching for 2 minutes [9]. The steam blanched leaves were immediately cooled down under running tap water to remove excess heat and placed on paper to absorb the surface water before drying. The dehydration experiments were conducted in a pilot-scale cabinet dryer at drying air temperature varying from 50 to 80°C. The dryer was started before drying experiment to achieve the steady state condition. For each experiment 200 gm of beetroot leaves were uniformly distributed in thin layer on perforated tray. Sample weights were recorded at regular interval of time. Drying process was continued until the achievement of final moisture content in the range 3-6% (d.b). The dehydrated leaves were ground in mixer and passed through 60 BSS sieve to make uniform particle size. Prepared uniform particle size powder packed in polythene bags and used for further analysis.

Proximate analysis of beetroot leaves powder

Moisture, ash, and crude protein, crude fiber contents were determined in accordance with AOAC - Association of Official Analytical Chemists method [10]. Fat content was determined by method of AOAC [11]. Total carbohydrate (%) was calculated by deducting the sum of the values for moisture, crude protein, crude fat, crude fiber and ash from 100 [12].

Antioxidant activity

β - Carotene estimation

β - Carotene was estimated by method as suggested by [13]. Following reagents were used for the estimation of beta carotene.

Reagents for estimation - Acetone, petroleum ether (boiling point 70-80°C) and anhydrous sodium sulphate.

Procedure

5g of sample was grinded with few crystals of anhydrous sodium sulphate and mixed with 10-15ml acetone. It was then decanted then supernatant was collected in a beaker. The process was repeated twice and transferred the combined supernatant to a separating funnel. 5-10 ml of petroleum ether was added and mixed thoroughly. Two layers were separated out on standing. Discarded the lower layer and collected the upper layer in 100 ml volumetric flask, volume was made up to 100ml with petroleum ether and optical density was recorded at 452 nm. Petroleum ether was used as blank. The β-carotene was then calculated using the following expression:

$$\beta-\text{carotene}\ (\mu g/100g) = \frac{OD \times 13.9 \times 104 \times 100}{Weight\ of\ sample \times 560 \times 100}$$

Total phenolic content

The total phenolic content was determined using the Folin-Ciocalteau method. 200 µL of the extract was combined with 1.9 mL of 10-fold diluted Folin-Ciocalteau reagent and 1.9 mL of 60 g/L sodium bicarbonate solution was added. The absorbance was measured at 725 nm after sitting for 2 h at room temperature (Cary 50 Bio UV-Visible Spectrophotometer). Double distilled water was used as the blank, and the gallic acid standards were prepared using methanol. All determinations were carried out in triplicate and the total phenolic content was expressed as mg of gallic acid equivalents (GAE)/g DM of leaves [14, 15].

Physical properties beetroot leaves powder Bulk density

The Bulk density was determined using the method [16, 17]. About 3 grams of beetroot powder placed in a 10 ml graduated cylinder. The volume of the sample was recorded. Bulk density was calculated by following formula.

$$Bulk\ density\ \left(g/cm^3\right) = \frac{Weight\ of\ sample\,(g)}{Volume of\ sample\,(cm^3)}$$

Functional properties of beetroot leave powder Rehydration ratio

Rehydration ratio was the one of important factor in the dehydrated products determined by method [18]. The beetroot leaves powder (5 g) was put into a beaker and 50 ml of warm (60 °C) water was added. After ½ h, drained weight of beetroot leaves powder was taken. The weight after draining was recorded and rehydration ratio was calculated using formula.

$$\text{Rehydratio n ratio} = \frac{Weight\ of\ rehydrated\ sample}{Weight\ of\ dehydrated\ sample} \times 100$$

Frictional properties of beetroot leave powder Angle of Repose

The angle of repose of beetroot leaves powder was determine by method of [19] by using following formula.

$$Angle\ of\ repose\ (\Phi) = \tan^{-1}\left(\frac{2h}{D}\right)$$

Where,

Φ = angle of repose (°),

h = height of the pile (mm),

D = diameter of the pile (mm).

Coefficient of friction

The coefficient of static friction (μ) was determined from three structural materials namely glass, steel sheet and plywood. A plastic cylinder was placed on an adjustable tilting flat plate faced with the test surface and filled with the sample. The cylinder was raised slightly so as not to touch the surface. The structural surface with the cylinder resting on it was inclined gradually, until the cylinder just started to slide down. The angle of tilt was noted from a graduated scale [20, 21, and 22].

$$Coefficient\ of\ static\ friction\ (\mu) = Tan\,\alpha$$

III. RESULTS AND DISCUSSION

A) Effect of blanching and drying air temperature on chemical analysis of beetroot leaves powder.

Beetroot leaves are rich source of crude fiber, protein, minerals and carbohydrate. The proximate analysis of fresh beetroot leaves is given in table.1

Table.1 Proximate analysis of fresh beetroot leaves

Parameter (%)	Fresh leaves
Moisture content	89.98
Crude Protein	2.44
Fat	0.012
Carbohydrate	3.31
Crude Fiber	2.31
Ash content	1.94

Blanching pretreatment and drying air temperature affected the quality characteristics like Chemical analysis, physical, frictional and functional properties of beetroot leaves powder. The detailed descriptions of effect of blanching and drying air temperature on various properties of BRLP are discussed below.

Moisture content

The moisture content of unblanched and blanched beetroot leaves powder dried at 50°C was 5.63±0.015 and 6.15±0.032 % (db), respectively (Table.2). This indicates that the blanching pretreatment resulted in more retention of moisture in the final dried product as compared to the unblanched product. The more retention of water in the blanched product may be due irreversible structural changes in leaves. Increase of drying air temperature has resulted in decrease of residual moisture content of beetroot leaves powder (Table.2). The average residual moisture content of blanched BRLP dehydrated at 50, 60, 70 and 80°C were 6.15±0.032, 5.59±0.031, 4.79±0.010 and 3.22±0.212 % (d.b), respectively. This might be because that higher the drying air temperature, lower will the relative humidity of the air and more will be the removal of moisture from the product. [23] reported an increase in operational temperature in a certain time, leads to a decrease in the moisture content of the samples (onion) since the evaporation rate increases with increasing temperature. The variation of moisture content with blanching and drying air temperature is given in Figure.1.

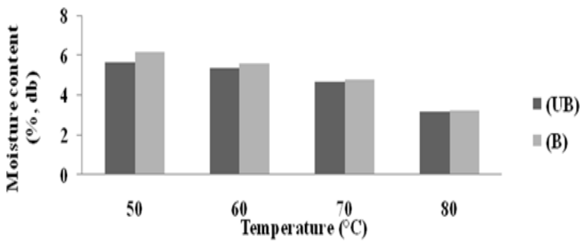

Figure.1 Effect of blanching and drying temperature on moisture content of BRLP

Table.2 Chemical analysis of beetroot leaves powder (on dry basis).

Parameter		Beetroot leaves powder			
		50 °C	60°C	70°C	80°C
Moisture content	(UB)	5.63±0.015^{a}	5.34±0.015^{b}	4.66±0.010^{c}	3.14±0.03^{d}
(%, db)	(B)	6.15±0.032^{a}	5.59±0.031^{b}	4.79±0.010^{c}	3.22±0.212^{d}
Crude Protein	(UB)	21.02±0.794^{a}	19.76±0.513^{b}	18.58±0.252^{c}	17.97±0.208^{d}
(%,db)	(B)	19.06±0.351^{a}	18.54±0.306^{b}	17.92±0.361^{c}	16.54±0.498^{d}
Crude Fat	(UB)	1.44±0.031^{b}	1.43±0.057^{b}	1.48±0.061^{a}	1.44±0.018^{b}
(%, db)	(B)	1.57±0.021^{a}	1.53±0.030^{a}	1.56±0.035^{a}	1.52±0.121^{a}
Carbohydrate	(UB)	31.55±0.252^{c}	31.28±0.208^{c}	33.85±0.47^{b}	35.97±1.136^{a}
(%, db)	(B)	30.29±0.737^{c}	31.15±2.007^{b}	31.08±1.320^{b}	34.83±0.407^{a}
Crude Fiber	(UB)	22.24±0.153^{d}	23.57±0.306^{a}	23.58±0.15^{a}	23.41±0.172^{b}
(%, db)	(B)	24.96±0.115^{c}	26.39±0.208^{a}	26.13±0.162^{b}	26.14±0.379^{b}
Ash content	(UB)	18.12±0.265^{b}	18.46±0.153^{a}	17.85±0.058^{c}	18.47±0.252^{a}
(%, db)	(B)	17.97±0.300^{a}	17.80±0.200^{b}	17.67±0.246^{b}	17.75±0.310^{b}
β-Carotene content	(UB)	25.53±0.252^{a}	18.26±0.586^{b}	17.23±0.306^{c}	16.13±0.256^{d}
(mg/100)	(B)	27.40±1.646^{a}	21.23±0.306^{b}	19.30±0.173^{c}	18.63±0.907^{d}
TPC	(UB)	51.41±0.52^{d}	56.42±0.25^{c}	62.08±0.24^{b}	62.33±0.32^{a}
(mg/gm)	(B)	56.56±0.18^{d}	57.02±0.24^{c}	62.35±0.25^{b}	63.05±0.30^{a}

(Mean±S.D. with different superscripts in a row differ significantly ($p < 0.05$))

Crude protein content

The total protein content of the unblanched and blanched beetroot leaves powder dried at 50 °C temperatures was 21.02±0.079%, and 19.06±0.351% (db), respectively (Table.2). This indicates that the blanching resulted in decrease of protein content of the BRLP. This might be due to the reason that there might be thermal degradation and leaching of soluble amino acids during blanching. [24] also reported the reduction in protein content during blanching of artichoke heads.

The increase of drying air temperature has also resulted in decrease of total protein content (Table.2). The average protein content of blanched BRLP dehydrated at 50, 60, 70 and 80 °C were 19.06±0.351, 18.54±0.306, 17.92±0.361, and 16.54±0.498% (db), respectively (Table.2). The reduction of protein content with increase of drying air temperature might be due to protein denaturaion. [25], also reported the decrease of protein content of dried okra with increase of drying air temperature. The variation of protein content shown in figure.2.

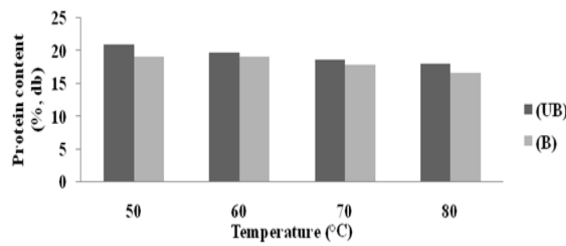

Figure.2 Effect of blanching and drying temperature on protein content of BRLP

Crude fat content

The total fat content of unblanched and blanched beetroot leaves powder dried at 50 °C was 1.44±0.031 and 1.57±0.021% (db), respectively (Table.2). This indicates that the blanching resulted in increase of fat content BRLP. During blanching, the dry matter of the leaves will decrease due to the leaching of soluble components like minerals, sugar and vitamins into water. As the fat is insoluble in water, therefore the percentage of fat will increase in the remaining dry matter. [26] also reported that increase in fat content of cabbage outer leaf powder after blanching. Increase of drying air temperature show the non significant ($p > 0.05$) effect on fat content of BRLP. Average fat content of blanched and unblanched sample dried at 50 to 80 °C temperature is 1.545 and 1.45 % (db), respectively (Table.2).

Carbohydrate content

The total carbohydrate content of unblanched and blanched beetroot leaves powder dried at 50°C was 33.33±0.252 and 30.29±0.737 % (db) respectively (Table.2). Blanching pretreatment responsible to decrease of carbohydrate content of BRLP. This might be due to leaching of soluble component like minerals, sugar and vitamins in water during blanching resulting into decrease in total solid. [26] also reported that decrease of carbohydrate content of cabbage outer leaf powder after blanching. Increase in drying air temperature show the non significant ($p > 0.05$) effect on carbohydrate content of BRLP. The average carbohydrate content of blanched and unblanched sample is 31.84 and 33.16 % (db), respectively (Table.2).

Crude fiber content

The crude fiber content of unblanched and blanched beetroot leaves powder dried at 50°C was 22.24±0.153 and 25.96±0.11% (db), respectively (Table.2). This indicates that the blanching pretreatment resulted in increase in crude fiber content of BRLP. This might be due to the leaching of soluble solids during blanching which inturn result in decrease of total dry matter. Therefore, an increase in proportion of the crude fiber per unit dry matter has been observed in the blanched samples. [26] also reported the loss of low molecular weight component such as minerals, sugar and vitamins from the plant cells to hot water during blanching; and decrease in the total solid thus led to the relative increase in the fiber content on dry basis during study on cabbage outer leaves. Increase in drying air temperature show the non significant ($p > 0.05$) effect on crude fiber content of BRLP. The average crude fiber content of unblanched and blanched sample is 23.11 and 25.89 % (db), respectively (Table.2).

Ash content

The total ash content of unblanched and blanched beetroot leaves powder dried at 50 °C temperature was 18.12±0.265 and 17.53±0.300 % (db), respectively. Blanching pretreatment resulted in decrease in ash content of BRLP. This might be due the loss of minerals during blanching resulted in decrease in dry matter led to decrease of ash content [26]. The average ash content of blanched and unblanched BRLP is 17.80 and 18.22 % (db), respectively (Table.2). Drying air temperature does not destroy the minerals.

β- Carotene content

The total β- Carotene content of unblanched and blanched beetroot leaves powder dried at 50 °C was 25.53±1.646 and 27.40±0.252 mg/100gm (db), respectively (Table.2). This indicates that the blanching pretreatment resulted in increase of β- Carotene content of BRLP. This might be due to retention of β-carotene during blanching. [27] reported the increase of β-carotene after blanching of leafy vegetables.

A decrease in β- Carotene content of beetroot leaves powder has been observed with increase in drying air temperature. The average β-carotene content of blanched BRLP dehydrated at 50, 60, 70 and 80°C were 25.53±0.252, 18.26.26±0.586, 17.23±0.306 and 16.13±0.256 mg/100gm (db), respectively (Table.2). [28] also reported the degradation of β-carotene with increase of temperature during hot air drying of tomato. The variation of β-carotene content with blanching and drying air temperature is given in Figure.3.

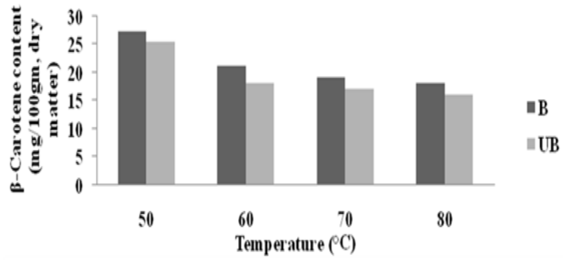

Figure.3 Effect of blanching and drying temperature on β-carotene content (db) of BRLP

Total phenolic content

The total phenolic content of unblanched and blanched beetroot leaves powder dried at 50 °C was 51.41±0.52 and 56.56±0.18 mg/gm (db), respectively (Table.2). This indicates that the blanching pretreatment resulted in increase of total phenolic content of BRLP. It may be due to the possible breakdown of the phenolic compounds during blanching. [29], also reported the increase in total phenolic content of vegetables during blanching due to breakdown of tannin into simple phenol. Increase of drying air temperature has resulted in increase of total phenolic content of BRLP (Table.2). The average total phenolic content of blanched BRLP dehydrated at 50, 60, 70 and 80 °C temperature were 56.56±0.18, 57.02±0.24, 62.35±0.25 and 63.05±0.30 mg/gm (db), respectively (Table.2). It might be due to shorter drying time at high temperature. [30] also reported the increase in TPC content of pepper at high temperature. The formation of phenolic compound at high temperature might be because of the availability of precussors of phenolic molecule by non enzymatic interconversion between phenolic molecules [31]. The variation of total phenolic content with blanching and drying air temperature is given in Figure.4.

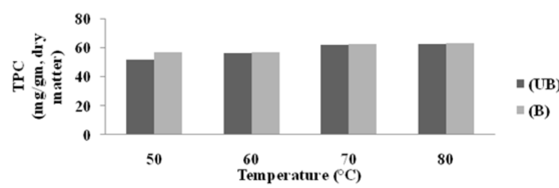

Figure 4 Effect of blanching and drying temperature on TPC content (db) of BRLP.

B). Effect of blanching and drying air temperature on moisture dependent properties of beetroot leaves powder.

Physical property

Bulk density

The bulk density of unblanched and blanched beetroot leaves powder dried at 50 °C was 0.555±0.001 and 0.574±0.0217 g/cm^3, respectively (Table.3). This indicates that the blanching pretreatment resulted in increase in bulk density of BRLP. It may be due to more structural changes during blanching resulting in more compact structure on dehydration. Increase of drying air temperature has resulted in increase of bulk density of beetroot leaves powder (Table.3). The average bulk density of blanched BRLP dehydrated at 50, 60, 70 and 80°C were 0.57±0.0217, 0.62±0.003, 0.66±0.004 and 0.69±0.038 g/cm^3, respectively. It may be due to the decrease in residual moisture content in the powder with increase in drying air temperature. [32], reported the increase in bulk density of dehydrated rhubarb (*Rheum Ribes L.*) with increase in drying air temperature. The variation of bulk density with blanching and drying air temperature is given in Figure.5.

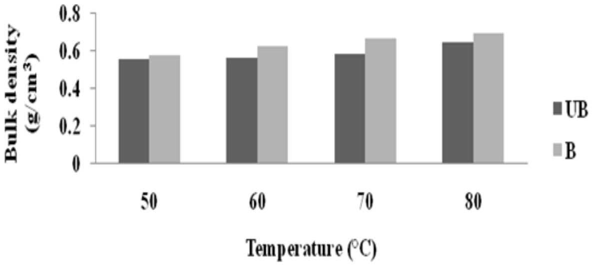

Figure 5 Effect of blanching and drying temperature on bulk density of BRLP.

Table.3 Properties of beetroot leaves powder

Property			Beetroot leaves powder			
			50°C	60°C	70°C	80°C
Bulk density		UB	0.55±0.001^c	0.56±0.002^c	0.58±0.584^b	0.64±0.039^a
(g/cm^3)		B	0.57±0.0217^d	0.62±0.003^c	0.66±0.004^b	0.69±0.038^a
Rehydration		UB	4.72±0.007^a	3.47±0.005^b	3.19±0.003^c	3.06±0.057^d
Ratio		B	3.57±0.011^a	3.36±0.003^b	3.09±0.010^c	2.01±0.119^d
Angle of		UB	55.23±0.525^a	55.02±0.715^b	54.78±0.270^c	54.19±0.533^d
Repose		B	53.88±0.118^a	53.10±0.506^b	52.36±0.214^c	51.17±1.119^d
Coefficient of Friction	Glass	UB	0.682±0.013^a	0.604±0.010^b	0.588±0.008^c	0.515±0.014^d
		B	0.718±0.014^a	0.636±0.010^b	0.621±0.012^c	0.525±0.019^d
	Steel	UB	0.668±0.001^a	0.641±0.007^b	0.626±0.009^c	0.614±0.003^d
		B	0.748±0.005^a	0.728±0.005^b	0.719±0.009^c	0.705±0.008^d
	Plywood	UB	0.782±0.004^a	0.768±0.008^b	0.733±0.003^c	0.719±0.003^d
		B	0.837±0.005^a	0.789±0.003^b	0.742±0.005^c	0.727±0.006^d

(Mean±S.D. with different superscripts in a row differ significantly ($p < 0.05$))

Functional properties

Rehydration ratio

The rehydration ratio was assessed because the incorporation of beetroot leaves powder into food products requires rehydration. The rehydration ratio of unblanched and blanched beetroot leaves powder dried at 50 °C was 4.72±0.007 and 3.57±0.011, respectively. This indicates that the blanching pretreatment resulted in decrease in rehydration ratio. It might be due to damage of beetroot leaves tissues leading to loss of permeability and water absorption. [33] also reported the decrease of rehydration ratio of amaranthus leaves after blanching pretreatment.

Increase of drying air temperature has resulted in decrease of rehydration ratio of beetroot leaves powder (Table.3). The rehydration ratio of blanched BRLP dehydrated at 50, 60, 70 and 80°C were 3.57±0.011, 3.36±0.003, 3.09±0.010 and 2.01±0.119 respectively. It might be due to cellular rupture during drying resulted into loss of water absorption capacity of BRLP. [34], also revealed the irreversible cellular rupture and dislocation occur during drying result in loss of tissue integrity producing dense structure, reduced hydrophilic properties. The variation of rehydration ratio with blanching and drying air temperature is given in Figure.6.

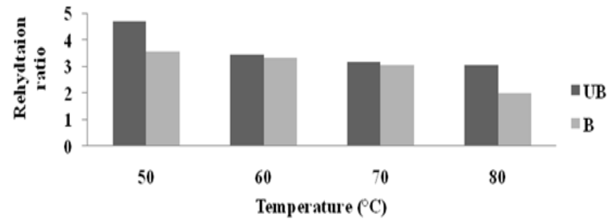

Figure 6 Effect of blanching and drying temperature on rehydration ratio of BRLP.

Frictional properties

Angle of repose

The angle of repose of unblanched and blanched beetroot leaves powder dried at 50°C was 54.19±0.533 and 51.17±1.119 degree, respectively. It was observed that blanching pretreatment resulted in decrease in angle of repose of BRLP. Blanched samples were found to have lesser value of angle of repose as compared to the unblanched sample basically due to compact structure for blanched beetroot powder. [9], also reported the angle of repose of Moringa leaf powder decrease by blanching pretreatment.

Increase of drying air temperature has resulted in decrease of angle of repose of beetroot leaves powder (Table.3). The angle of repose of blanched BRLP dehydrated at 50, 60, 70 and 80°C temperature were 53.88±0.118, 53.10±0.506, 52.36±0.214 and 51.17±1.119 degree respectively. Increasing drying air temperature resulted in decrease in angle of repose it might be due to low moisture content at high temperature. Low moisture content responsible for free flowing characteristics of beetroot leaves powder resulted in lower angle of repose. [35], reported the angle of repose decrease with increase in drying air temperature due to the less moisture content at high temperature during study on effect of temperature and stirring rate on flow and compactability properties of simvastatin spherical crystals. The variation of angle of repose with blanching and drying air temperature is given in Figure. 7.

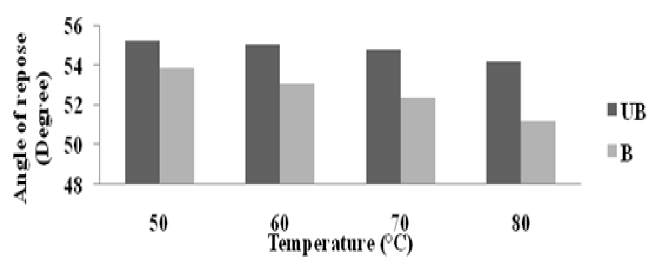

Figure 4.15 Effect of blanching and drying temperature on AOR of BRLP.

Coefficient of friction

Among the three different surfaces used, glass surface was found to exhibit least coefficient of friction as compared to the plywood and steel surface. The plywood surface responded highest coefficient of friction, it may be due to its rough surface in comparison to other surfaces (Table.3).

Blanching pretreatment significantly affect on coefficient of friction of blanched beetroot leaves powder. Blanched beetroot leaves powder exhibit high moisture content caused to increase in coefficient of friction. Coefficient of friction decrease with increase in drying air temperature it might be due to low moisture content at high drying air temperature. [36], also reported the increase of coefficient of friction with increase in moisture content of barnyard millet grain and kernel.

IV. CONCLUSION

Blanching pretreatment significantly affect on quality characteristics of beetroot leaves powder. Blanching pretreatment responsible for increase in moisture content, fat content crude fiber content, β-carotene content and total phenolics content of beetroot leaves powder and decrease in protein, carbohydrates and and ash content. Increase in drying air temperature significantly affect on protein content, β - carotene content, total phenolic content of beetroot leaves powder and non significantly affect on carbohydrates content, fat content, crude fiber content and ash content of beetroot leaves powder. This study also indicate that the blanching and drying air temperature significantly affect on bulk density, rehydration ratio, angle of repose and coefficient of friction of beetroot leaves powder.

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