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Research Article

Physical Characterization and Optimization of Blanching Process of *Moringa Oleifera* (var. PKM-1) Pods

Amee Ravani[1]*, S V Anadani[1], R R Gajera[2] and R V Prasad[1]

[1]College of Food Processing Technology and Bioenergy, Anand Agricultural University, Anand, GUJARAT
[2]College of Horticulture, Anand Agricultural University, Anand, GUJARAT

Abstract

The present project was undertaken to study preliminary aspects of *Moringa oleifera* pods. The aim was to utilize moringa pods for commercial value added products. Moringa pods of different maturity levels were analyzed for physical characteristics. Moringa pods were evaluated for the pod mass, pulp and peel percent, pulp to peel ratio, edible index, waste index, pod diameter, pod length, number of seeds per pod and hardness. Hot water blanching of moringa pod pieces of different sizes were carried out at selected temperatures. The most effective water blanching was noticed at 95°C with 64 mm pod length where peroxidase inactivation time was 9.41 min and pulp yield was 40.67%.

Keywords: *Moringa oleifera*, moringa pods, physical characteristics, edible index, blanching, peroxidase

***Correspondence**
Author: Dr. Amee Ravani
Email: ameeravani@aau.in

Introduction

The “miracle vegetable” moringa (drumstick) was chosen for the present investigations. Moringa plant is most inexpensive and credible alternative not only to provide good nutrition, but also cure and prevent many diseases. It is an underutilized vegetable crop in India and almost all parts of the tree are edible. The pods of moringa contains high amount of Ca, Mg, K, Mn, P, Zn, Na, Cu, and Fe. Moringa is one of the richest plant sources of vitamins A, B_1, B_2, B_3, B_6 and B_9, C, D, E and K. It has more than 40 natural antioxidants. Moringa even contains arginine and histidine two amino acids especially important for infants who are unable to make enough protein for their growth requirements. *Moringa oleifera* also consists of anti-inflammatory, anti-spasmodic, anti-hypertensive, anti-tumor, anti-oxidant, anti-pyretic, anti-ulcer, anti-epileptic, diuretic, cholesterol lowering, renal, anti-diabetic, and hepatoprotective activities. It has also long been labeled for its great cosmetic value in recent years [1-3]. Traditionally, besides being green vegetable, it is also widely known for its health benefits. Moringa provides a rich and rare combination of nutrients, amino acids, antioxidants, antiaging and anti-inflammatory properties for nutrition and healing. Since 1998, the World Health Organization has promoted moringa as an alternative to imported food supplies to treat malnutrition [4]. There is an urgent need to design and develop strategies to explore and utilize benefits of this miracle tree. Commercialization of various value added moringa products is the only way to utilize this commodity. Looking to the health prospect of the moringa pulp its market demand, there is a great scope for the value addition of moringa pulp in terms of development of value added products. There is a gap between raw produce and market requirement of this neglected tree. A technology for extraction and preservation of moringa pulp for direct consumption as well as for various products for value addition needs to be explored. Considering these issues, study was undertaken to study preliminary aspects regarding moringa pods. The present investigations include determining physical characteristics of moringa pods. Blanching is a pre-treatment carried out for fruits and vegetables before being converted or processed into value added food products. Most prominent quality degradation enzyme i.e. polyphenol oxidase needs to be inactivated through blanching treatment for better product quality retention during value addition as well as for better storage quality [5].

Present investigations could be used to assess physical properties of moringa pods, which would be used for designing of handling and processing equipment for commercialization. Collected data provides idea about pod mass, pulp and peel percent, pulp to peel ratio, edible index, waste index, pod diameter, pod length, number of seeds per pod and hardness of different maturity levels of selected variety of moringa pods. Optimization of blanching time temperature combinations could be utilized as an important pre-treatment for peroxidase enzyme inactivation as well as maximum retention of pulp in moringa during blanching.

Materials and Methods

Moringa pods (var. PKM 1) were procured from horticultural farm of Anand Agricultural University, Anand.

Moringa pods of different maturity levels were analyzed for physical characteristics viz. the pod mass, pulp and peel percent, pulp to peel ratio, edible index, waste index, pod diameter, pod length, number of seeds per pod and hardness [6].

Pulp yield, peel percent and pulp to peel ratio

Hundred moringa pods were randomly drawn from the bulk heap, marked and weighed. The pods were cut and the pulp and peel were separated using stainless steel knife. The content of pulp and peel from the individual pod was determined by measuring the weight of each fraction. The weight was measured with an electronic top pan balance of 1 kg capacity having least count of 0.01 g. The number of seeds per pod was counted manually. The pod diameter was measured using digital vernier calipers and pod length was measured using scale. The pulp yield, peel percent and pulp to peel ratio were calculated as per the formula given below. The average values for hundred pods were reported.

$$\text{Pulp (\%)} = \frac{\text{Weight of edible portion per pod}}{\text{Weight of pod}} * 100$$

$$\text{Peel (\%)} = \frac{\text{Weight of nonedible portion per pod}}{\text{Weight of pod}} * 100$$

$$\text{Pulp to peel ratio} = \frac{\text{Pulp percent of pod}}{\text{Peel percent of pod}}$$

Edible and waste index

Edible and waste index of moringa pods were calculated for the 100 pods selected randomly and average values were reported. The index was calculated using the formula given below;

$$\text{Edible index} = \frac{\text{Weight of edible portion of pod}}{\text{Weight of whole pod}}$$

$$\text{Waste index} = \frac{\text{Weight of peels}}{\text{Weight of whole pod}}$$

Hardness

The hardness of moringa pod was measured using texture analyzer (Model: TA-HDi, Make: Stable Micro Systems, U.K) The 100 g compression load cell with 2 mm diameter (P/2) cylinder probe was used for piercing pod sample. The pre-speed and post-speed of the probe was fixed at 1 $mm.s^{-1}$ and 10 $mm.s^{-1}$ and the test speed was 1 $mm.s^{-1}$ during compression.

Hot water blanching was carried to inactivate of peroxidase enzymes in moringa pods because as per the filler trials steam blanching resulted in non-uniformity in the enzyme inactivation. Hot water blanching of moringa pod pieces of different sizes were carried out at selected temperature and time combinations as suggested by Muftugil, (1985) [7] with slight modifications. The independent variables for the experiments were pod length (50, 70 and 100 mm) and blanching temperature (85, 90 and 95 °C). Fresh cut pod pieces were blanched in thermostatically controlled water bath. The pieces to water ratio was taken to 1:5 w/v during water blanching to minimize the temperature variation. The samples were drawn continuously at 0.5 min interval up to 60 min to carry out peroxidase inactivation. Time of blanching was considered as a factor for enzyme inactivation.

Qualitative test for POD

The blanched moringa pieces were crushed in a porcelain bowl immediately after blanching. Ten to twenty grams of crushed sample was taken in a test tube and 20 ml distilled water was added. Guaiacol (1 %) and hydrogen peroxide (0.3 %) solutions were then prepared as prescribed by Ranganna (1986) [8]. Guaiacol solution (1 ml) and hydrogen peroxide solution (1.6 ml) were poured into the test tube and the contents were thoroughly mixed. A rapid and intensive brown-reddish tissue coloring within 5 min indicated a high peroxidase activity. The gradual appearance of a weak pink color indicated an incomplete peroxidase inactivation or low peroxidase activity and no color development after 5 min indicates the reaction was negative and the enzymes were considered inactivated. The response observations were peroxidase inactivation time and pulp yield. These pre-treatment parameters were optimized using full factorial design for minimum blanching time and maximum pulp yield.

Results and Discussion

The pods of moringa variety PKM-1 were procured form horticulture farm of Anand Agricultural University, Anand were analyzed for physical characteristics as per the procedures described in previous section. Moringa pods of different maturity were analyzed for physical characteristics. The immature, matured and over matured pods of moringa were analyzed for their quality characteristics. Immature pods were harvested after 10 to 15 days of flowering, while matured moringa pods were harvested after 25 to 30 days of flowering. The over-matured moringa pods were harvested after 48 to 50 days of flowering. The immature and matured pods can be consumed as vegetables, while over matured pods are utilized for seed purpose. The data obtained on pod pulp, peel, pulp to peel ratio, diameter, height and number of seeds in pod is presented in **Table 1**.

Table 1 Physical characteristics of moringa pods

Parameter	Physical characteristics		
	Immature	Matured	Over-matured
Pod mass (g)	24.43 ± 0.97	64.54 ± 5.29	93.82 ± 0.65
Pulp (%)	40.85 ± 0.18	44.39 ± 3.82	59.66 ± 0.73
Peel (%)	59.15 ± 1.18	55.61 ± 3.82	40.34 ± 0.73
Pulp to peel ratio	0.70 ± 0.04	0.81:1	1.48 ± 0.04
Edible index	0.41 ± 0.01	0.44 ± 0.04	0.60 ± 0.01
Waste index	0.59 ± 0.01	0.56 ± 0.04	0.40 ± 0.01
Pod diameter (mm)	6.2 ± 0.002	12.3 ± 0.09	13.3 ± 0.03
Pod length (mm)	443.3 ± 0.58	576.0 ± 5.81	666.7 ± 1.53
Number of seeds per pod	8.67 ± 0.06	18 ± 2.5	23 ± 1
Hardness of pod (N)	29.8 ± 0.63	19.61 ± 0.58	24.94 ± 0.62

The average mass was 24.43, 64.54 and 93.82 g for immature, matured and over matured pods, respectively. The pods contained 40.85, 44.39 and 59.66 % of edible pulp percentage and 59.15, 55.61 and 40.34 % peel for immature, matured and over matured pods, respectively. The pulp to peel ratio increased with increasing level of maturity of pods. The ratios were 0.70, 0.81 and 1.48 for immature, matured and over matured pods, respectively. The average edible index was 0.41, 0.44 and 0.60 and the waste index was 0.59, 0.56 and 0.40, for immature, matured and over-matured pods, respectively (**Plate 1**).

Plate 1 Physical characterization of *Moringa oleifera* pods

The average pod diameter and pod length was 6.2, 12.3, 13.3 mm, and 443.3, 576.0, 666.7 mm for immature, matured and over matured pods respectively. The average number of seeds for immature, matured and over-matured pods was 8.67, 18 and 23, respectively. The pod diameter, numbers of seeds and length were found to increase with increase in maturity.

The hardness values for pods were 29.8, 19.61 and 24.94 N, for immature, matured and over matured pods, respectively. The hardness data indicates that the immature pods were very hard followed by over-matured pods compared to matured pods.

The results of the present investigation are in good agreement with the results reported by Foidl *et al.*, (2001) [9]. They reported an average weight of moringa pods as 76 to 79 g, and contained 12 to 17 seeds. The percent weight of kernel was 72.5 to 74.5 and percent weight of hull was 27.5 to 25.5. Santoshkumar *et al.*, (2013) [10] reported the weight of moringa pod (var. PKM 1) was 144 g, length of pod was 750 mm, diameter was 70 mm and number of seeds per pod was 16. Since, matured moringa pods are utilized for consumption purpose; these were selected for further experimentation. Resmi *et al.*, (2005) [11] evaluated variability among moringa accessions from central and southern Kerala.

Standardization of Blanching parameters

Hot water blanching of moringa pod pieces in different size was carried out at selected temperature and time to inactivate peroxidase enzyme and to study the effects of blanching parameters on pulp yield. The data pertaining on the effect of pod length and blanching temperature is presented in **Table 2**.

Table 2 Effect of pod length and blanching temperature on peroxidase inactivation and pulp yield

Treatment No.	Pod length (mm)	Blanching temperature (^oC)	Peroxidase inactivation time (min)	Pulp yield (%)
1	75	95	10.0	41.45
2	50	90	23.5	42.79
3	50	95	9.5	40.79
4	75	85	41.67	42.47
5	75	85	41.5	41.36
6	75	85	41.0	40.8
7	50	90	23.0	39.47
8	100	95	10.0	40.79
9	50	85	40.0	42.47
10	100	85	43.0	41.36
11	100	90	24.5	41.24
12	75	90	24.5	43.4
13	75	90	24.0	40.89
14	50	95	8.5	40.47
15	100	90	24.5	39.76
16	50	85	41.5	40.36
17	100	95	11.0	40.24
18	75	95	9.5	39.89
19	100	95	11.5	44.24
20	100	90	25.0	44.36
21	50	95	8.0	43.98
22	100	85	42.5	42.47
23	75	95	10.0	43.98
24	50	90	22.0	42.76
25	75	90	25.0	40.87
26	50	85	40.5	41.37
27	100	85	42.5	40.17

To visualize the combined effect of two factors on the responses, three dimensional surface graphs were generated for the fitted models. The analysis of variance (ANOVA) was conducted on experimental data and the significance of pod length and blanching temperature as well as their interactions on peroxidase inactivation time (min) and pulp yield was calculated. The quadratic model was fitted to the experimental data. Statistical significance of linear, quadratic and interaction effects were calculated for each response and are given in **Tables 3** and **4**.

Effect of pod length and blanching temperature on peroxidase inactivation

Effect of process variables on peroxidase inactivation time is depicted in Table 2 Peroxidase inactivation time ranged from 8 to 43 min. The maximum peroxidase inactivation time (43 min) was observed at experiment no 10 with 100 mm pod length and 85 ^{o}C blanching temperature. The minimum peroxidase inactivation time (8 min) was observed at experiment no 21 with 50 mm pod length and 95 ^{o}C blanching temperature (**Plate 2**).

Plate 2 Blanching adequacy test of *Moringa oleifera* pods

The results showed that among linear effects, pod length and blanching temperature had highly significant effect on peroxidase inactivation time (p<0.01) at 1 % level (**Table 3**). Interaction effect of pod length and blanching temperature was found to be non-significant. Quadratic effect of blanching temperature was found to be highly significant (p<0.01) at 1 % level. Other quadratic effect was found to be non-significant. The regression equation describing the effect of process variables on peroxidase inactivation time of moringa pod is given as below.

$$\text{Peroxidase inactivation time (min)} = 850.933 + 0.055*A - 15.27B + 0.000333AB - 0.000296A^2 + 0.067B^2$$

Effect of pod length and blanching time on peroxidase inactivation time is shown in **Figure 1**. From graphical presentation, it can be seen that with increase in blanching temperature, the peroxidase inactivation time decreased. There was slight increase in peroxidase inactivation time with increase in pod length. An increase in temperature of 10 ^{o}C, resulted in reduction of the activity of enzymes by half of its original value. The other factors affected the enzyme inactivation time include type of vegetables and their maturity, size, type of heating medium etc. This may be the reason for decrease in peroxidase inactivation time on increase in blanching temperature. At specific blanching temperature, peroxidase inactivation time decreased with decrease in pod length which might be due to the availability of more surface area and heat penetration to the core.

Table 3 ANOVA for effect of pod length and blanching temperature on peroxidase inactivation

Source	**Df**	**Sum of Squares**	**Mean Square**	**p-value Prob> F**
Model	5	4584.71	916.94	< 0.0001
Pod length-A	1	18.00	18.00	< 0.0001
Blanching Temperature-B	1	4549.63	4549.63	< 0.0001
A*B	1	0.021	0.021	0.8058
A^2	1	0.21	0.21	0.4418
B^2	1	16.86	16.86	< 0.0001
Residual	21	7.06	0.34	0.3503
Lack of Fit	3	1.15	0.38	
Total	18	4591.77		
R^2		0.99		
Adj R^2		0.99		
CV (%)		2.31		

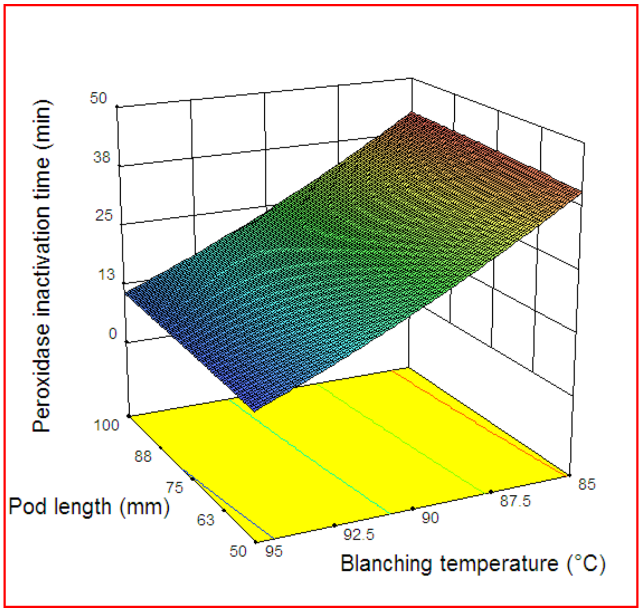

Figure 1 Effect of pod length and blanching temperature on peroxidase inactivation

Muftugil (1985) [7] reported that the inactivation of peroxidase enzyme time very much depends on temperature of the blanching medium and size of vegetables. The enzyme inactivation was faster in samples which had large surface to volume ratios. Fast penetration of heat to the centre could explain fast enzyme inactivation during blanching. Peroxidase inactivation was faster at the higher temperature blanching.

Effect of pod length and blanching temperature on pulp yield

Effect of process variables on pulp yield is depicted in Table 2. The pulp yield ranged from 38.36 to 43.25 %. The maximum yield (43.25 %) of pulp was observed for experimental combination of 100 mm pod length and 90 ^oC blanching temperature. The minimum value (38.36 %) of pulp yield was observed for experimental combination of 50 mm pod length and 90^oC blanching temperature.

The results showed that among linear effects, pod length and blanching temperature was found to be non-significant on pulp yield (Table 4). Interaction effect of pod length and blanching temperature was found to be non-significant. Quadratic effect of pod length and blanching temperature was found to be non-significant. The regression equation describing the effect of process variables on pulp yield of moringa pod is given as under.

$$\text{Pulp yield (\%)} = - 5.46 + 0.00164A + 0.98 B + 0.000153AB – 0.0001.0A^2 + 0.00537B^2$$

Table 4 ANOVA for effect of pod length and blanching temperature on pulp yield

Source	Df	Sum of Squares	Mean Square	p-value Prob> F
Model	5	0.64	0.13	0.9983
A-Pod length	1	0.001606	0.001606	0.9804
B-Blanching Temperature	1	0.50	0.50	0.6648
AB	1	0.004408	0.004408	0.9675
A^2	1	0.024	0.024	0.9248
B^2	1	0.11	0.11	0.8398
Residual	21	54.38	2.59	0.9992
Lack of Fit	3	0.060	0.020	
Total	18	55.02		
R^2		0.63		
Adj R^2		0.63		
CV (%)		3.97		

Effect of pod length and blanching time on pulp yield is shown in **Figure 2**. From the RSM graph, it can be seen that with increase in blanching temperature, there was negligible increase in pulp yield. With increase in pod length, pulp yield remained constant. When blanching temperature increased, peroxidase inactivation time reduced which also leads to lower the leaching losses of moringa pulp in blanching water. This means more edible portion was retained in the pod. The reason for increase in pulp yield at higher blanching temperature might be due to this phenomenon. Results revealed that the pulp yield was higher during high-short blanches as compared with low-long blanches. The length of pod did not affect the edible index due to constant pulp to peel ratio and this may be the reason for similar pulp yield on varying the pod length. Gajera *et al.*, (2014) [12] reported that bottle gourd juice yield was increased linearly with increase in temperature and non-linearly with slices thickness during blanching.

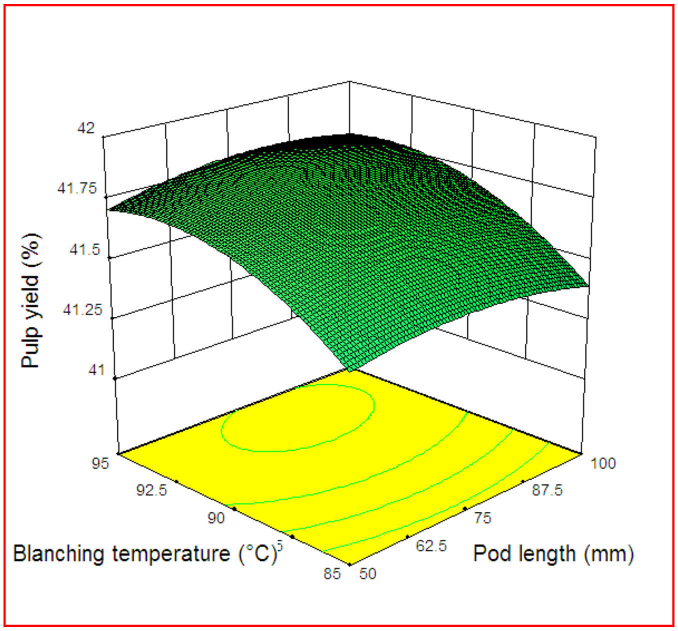

Figure 2 Effect of blanching temperature and pod length on pulp yield

Optimization of pre-treatment (blanching) parameters

The dependent parameters which affected the blanching of moringa pods were pod length and blanching temperature. For optimum quality of moringa pods, blanching time should be minimum and pulp yield should be maximum. Hence, these dependent parameters were taken into consideration for optimization of blanching conditions. With the help of two factorial completely randomized design statistical analyses and the design-expert 10.0.1.0 software, the optimization of the blanching parameters was done. The optimized conditions are presented as below;

The optimized conditions of moringa pods are;

1. Pod length : 64 mm
2. Blanching temperature : 95°C
3. Peroxidase inactivation time : 9.41 min
4. Pulp yield : 40.67%.

The validation of the optimized solution was done by conducting the experiment at above levels of variables.

Conclusion

The average mass of moringa was 24.43, 64.54 and 93.82 g for immature, matured and over matured pods, respectively. The pods contained 40.85, 44.39 and 59.66 % pulp and 59.15, 55.61 and 40.34 % peel for immature, matured and over matured pods, respectively. The pulp to peel ratio increased with increasing level of maturity of pods. The ratios were 0.70, 0.81 and 1.48 for immature, matured and over matured pods, respectively. The average edible index was 0.41, 0.44 and 0.60 and the waste index was 0.59, 0.56 and 0.40, for immature, matured and over matured pods, respectively. The pod mass, pulp percent, pulp to peel ratio and edible index were found to increase with maturity of the pods. The most effective water blanching was noticed at 95°C with 64 mm pod length where peroxidase inactivation time was 9.41 min and pulp yield was 40.67%. Blanching temperature influenced peroxidase inactivation time significantly. Pod length did not influence pulp yield. The pulp yield (38.36 to 43.25 %) was higher during high-short blanches compared to low-long blanches.

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