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Evaluation of various properties of cookies after *Moringa* leaf powder addition

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Abstract
The effect of *Moringa oleifera* leaf powder on some physico-chemical, textural and sensory properties of wheat (*Maida)* cookies were determined. The experiment was laid out in a completely randomized design (CRD) with four treatments (4, 6, 8, and 10% *moringa* leaf powder incorporation with wheat *maida*) and with three replications. The cookie's samples were allowed to cool at ambient temperature (30°C±1°C) and analysed for some physical properties, textural properties, and sensory attributes. *Moringa* leaf powder substitution in the cookies significantly (p<0.05) increased the moisture content, weight, diameter, and thickness of cookies from 10.16 to 13.20%, 13.04 to 15.76 g, 5.56 to 5.57 cm, and 0.93 to 1.42 cm respectively, while decreased spread ratio from 5.99 to 3.92. For the textural properties of cookies dough, the penetration force of cookies increased and the springiness of cookies dough decreased from 4.567 N to 6.432 N and from 1.39 mm to 1.10 mm respectively. Colour values (L^*, a^* and b^*) of cookies dough decreased due to the dilution of gluten in the dough and darker MLP. All the judges rated maximum to the blended cookies i.e. 7.90 for 4% replacement of *moringa* leaf powder, as compared to other combinations of 6, 8, and 10% *moringa* leaf powders. The overall results indicated that positive response of *moringa* leaf powder substitution to wheat *maida* up to 4% level because when increasing the percentage of MLP, it contains high chlorophyll content in the formulation of high fibre and low moisture containing bread and cookies affecting their overall quality.

Keywords: *Moringa* leaf powder, cookies, physical properties, textural properties, substitution, supplementation

1. Introduction
Cookies are usually baked until crisp or just long enough to keep their softness, however, some are not baked at all. Cookies are produced with a range of components such as sugar, spices, chocolate, butter, peanut butter, nuts, or dry fruits in a number of styles. Cookies are a convenient snack product that has been dried to very low moisture content and is consumed by both children and adults for energy.

Moringa has the potential to improve nutrition, increase food security, promote rural development, and assist long-term sustainability in underdeveloped countries. *Moringa oleifera* provides more nutrients per gram of plant material than many other plant species. *Moringa* leaves are anti-bacterial and anti-inflammatory. Leaf tea overcomes gastric ulcers and diarrhoea. *Moringa* leaves are a better source of food for those suffering from malnutrition due to their high protein and fiber content. Also, leaves treat with fevers, bronchitis, eye and ear infections, and inflammation of the mucus membrane. The iron content of the leaves is very high and they are reportedly prescribed for anaemia. The leaves are the most nutritious part of the plant is a better source of Vitamin B, C, K, and provitamin A as beta carotene, manganese, and protein among other essential nutrients (Moyo *et al.*, 2011) [20]. It provides more than seven times the vitamin C found in oranges, 10 times the vitamin A found in carrots, 17 times the calcium found in milk, 9 times the protein found in yoghurt, 15 times the potassium found in bananas, and 25 times the iron found in spinach (Fahey, 2005; Rockwood *et al.*, 2013) [9, 24]. *Moringa* is nature's gift to mankind. It is especially promising as a food source in the tropics because the tree is in full leaf at the end of the dry season when other foods are typically scarce. It is also an important crop in tropical countries and all parts of *moringa* are edible.

In this study, the effect of replacing wheat flour with *Moringa* leaf powder on the textural properties, physical properties, and sensory evaluation of cookies was investigated.

2. Materials and Methods

2.1 Sample procurement/Preparation

Wheat flour (*maida*) and all baking components (sugar, oil, salt, yeast, ammonia powder, fat, milk, etc.) were obtained from the local Market of Rahuri and matured *Moringa oleifera* leaves were gathered from Mahatma Phule Krishi Vidyapeeth, Rahuri, Ahmednagar, Maharashtra. The leaves were destalked, washed, and dried using a tray dryer at 60 ºC. Dried *moringa* leaves were subjected to milling in the laboratory by using a grinding mill according to the process described by Abraham *et al.*, (2013) [1]. The doughs for the cookies samples were made from five blends of wheat flour (WF) and *Moringa* leaf powder (MLP) in the following ratios: 100:0, 96:04, 94:06, 92:08, and 90:10, with 100 percent WF serving as a control sample.

The equipment required for the present study was used from the Department of Agril. Process Engineering, Dr. A. S. College of Agricultural Engineering and Technology, MPKV, Rahuri. The cookies were prepared in a bakery plant and analytical work was carried out in the laboratory of the Department of Food Science and Technology, Post Graduate Institute, MPKV, Rahuri.

2.2 Baking

Ingredients for making cookies are given in table 1. For making 250g of cookies, composite flour 100 gm of hydrogenated vegetable fat 30g, and powdered sugar 60g, were completely combined. Refined wheat flour, dried *moringa* leaves powder, and baking powder was all mixed together at the same time. Both blends were combined, and the dough was shaped into a sheet and cut with an impression cutter. It was then baked for 12 minutes at 180 ºC and cooled according to Ajibola *et al.*, (2015) [3]. The flow chart for the complete process of the preparation of cookies was given in fig 1.

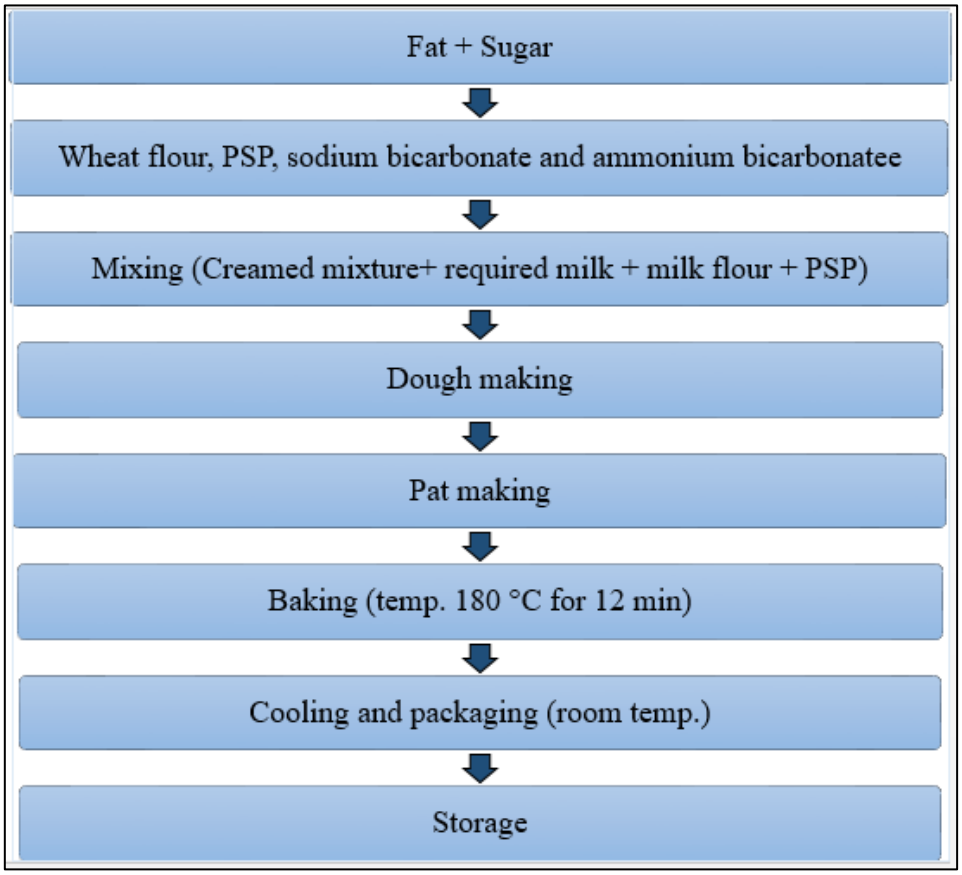

Fig 1; Flow sheet with process parameters for cookie's preparation

2.3 Analyses of cookies

2.4.1 Physical properties

The recommended methods of the Association of Official Analytical Chemists (AOAC, 2000) [4] were used to determine the moisture content of the cookies. Five randomly selected cookies from each sample were used to determine the cookie weight, diameter, thickness, and spread ratio as stated by Oyewole *et al.*, (1996) [22] and modified by Emelike *et al.*, (2015) [8]. The diameter (D) was measured by taking two measurements from one cookie in 90° rotations. Five cookies were measured for height (thickness) by collecting three measurements from one cookie and calculating the average of the five. The spread ratio is calculated by dividing the diameter values by the thickness values as given by (Sylwia *et al.*, 2012) [25].

Table 1: Ingredients for the preparation of 250 g cookies

Ingredients (g)	Ratio				
	100:0	**96:04**	**94:06**	**92:08**	**90:10**
Moringa leaf powder	0	10 g	15 g	20 g	25 g
Fat	30 g	30 g	30 g	30 g	30 g
Sugar	60 g	60 g	60 g	60 g	60 g
Salt	1.00 g	1.00 g	1.00 g	1.00 g	1.00 g
Ammonia bicarbonate	0.70 g	0.70 g	0.70 g	0.70 g	0.70 g
Baking powder	1.00 g	1.00 g	1.00 g	1.00 g	1.00 g

2.4.2 Texture analysis

Penetration force and springiness of cookies were measured using Instron Universal Texturometer and texture analyzer (Model-TMS PRO- U.S.A) respectively in the instrumentation laboratory. The absolute peak force of the

resulting curve was considered as the penetration force of the cookies (Bourne, 2002; Singh *et al.*, 1993) [5]. The data were analyzed automatically by inbuilt software already present in the machine to measure the springiness as described by Bourne, (1978) [26].

2.4.3 Colour analysis of cookie dough
The colour of MLP cookies was measured using Colour Scanning Machine in the instrumentation laboratory. Colours were measured using the CIELAB scale with a 10° observer and a D65 illuminant. It allows you to read in terms of *L**, *a**, and *b**. The deviation of the colour of the sample to the standard was also observed and recorded in the computer interface (Gulia *et al.*, 2010) [12].

2.4.3 Organoleptic evaluation of the prepared cookies
Sensory evaluation of the cookies samples was done 24 hours after baking to assess colour and appearance, texture, flavour, and overall acceptability (Abraham *et al.*, 2013) [1] on a 9-point hedonic scale. The mean of ten observations was considered for evaluating the quality.

2.5 Statistical Analysis
Every trial was replicated three times. The data were statistically evaluated to evaluate the statistical significance of the treatments. According to the strategy provided by the authors, a completely randomised design (CRD) was utilised to test the significance of the data (Panse and Sukhatme, 1989; Kapoor and Gupta, 2004) [23, 13].

3. Results and Discussion
3.1 Effect of MLP on physical properties of cookies
Table 2 shows the data on the physical properties of composite cookies produced from MLP powder. The moisture content of cookies ranged between 10.160 to 13.197%. The lowest moisture content of cookies 10.160±0.444% was observed for T_0, whereas the highest moisture content 13.197±0.094% was observed for T_4. The weight of cookies ranged from 13.040 to 15.760g. Data shows that the moisture content of cookies increases with an increasing percentage of MLP. The water absorption and water retention capacity of MLP may account for the higher moisture content and weight of *Moringa*-added cookie samples. A similar result for moisture content and inverse results for the weight of cookies were given by (Ajibola *et al.*, 2015 and Emelike *et al.*, 2017) [3]. Similar results for an increase in the weight of cookies were found by Chinma *et al.*, (2006) [11] and found that increased the weight of cookies, when increasing the amount of wheat flour with sesame flour blends in the composite dough.

The diameter of cookies dough ranged from 5.560 to 5.670 cm. Similar results for these when the composite dough was substituted with Bambara groundnut protein concentrate were reported by (Kiin-Kabari and Giami 2015) [8]. The mean values of the thickness of cookies dough ranged from 0.928 to 1.424 cm. An increase in thickness value when increasing percentages of MLP in cookies was due to the dilution of gluten and less water available for gluten hydration in the composite dough (Ajibola *et al.*, 2015; Mohamed *et al.*, 2014; Sharma *et al.*, 2013 and Dachana *et al.*, 2010) [3, 19, 15, 6]. The spread ratio of cookies dough ranged from 5.999 to 3.918. These were due to the decrease and increase in diameter and thickness respectively. These findings were similar to (Mc Watters 1978) [17] who reported that the use of composite flour increases dough viscosity and forms aggregates by competing with limited free water available in cookie dough and thereby limiting cookie spread.

Table 2: Physical properties of cookies fortified with MLP

Treatments	Moisture content (%)	Weight (gm)	Diameter (cm)	Height or thickness (cm)	Spread ratio
T_0	10.160±0.444	13.040±0.114	5.560±0.065	0.928±0.035	5.999±0.242
T_1	11.730±0.043	13.940±0.167	5.738±0.021	1.108±0.008	5.179±0.028
T_2	12.390±0.142	14.480±0.327	5.670±0.026	1.214±0.013	4.671±0.063
T_3	12.733±0.075	15.000±0.141	5.594±0.017	1.302±0.034	4.299±0.122
T_4	13.197±0.094	15.760±0.181	5.578±0.029	1.424±0.028	3.918±0.063
S.E.	0.092	0.083	0.014	0.010	0.046
C.D. @ 5%	0.399	0.266	0.048	0.035	0.171
C.V.	1.797	1.388	0.644	2.204	2.658

3.3 Effect of MLP on Textual properties of cookies
The data on the textural properties of composite cookies dough is given in Table 3. Mean values of the penetration force of cookies ranged between 4.567 N (Control) to 6.432 N. Mean values of the springiness of cookies ranged from 1.397 mm (Control) to 1.100 mm. Data shows that the penetration force of cookies increases with an increasing percentage of MLP. Changes in penetration force might be due to the dilution of gluten and less water available for the hydration of gluten this was found by (Mohamed *et al.*, 2014) [19] for MLP cookies. Similar results for textural properties of cookies dough were found by (Drisya *et al.*, 2013) [7] for curry (*murraya koenigii)* leaves powder inclusion in composite dough from level 0-15% and found that springiness decreased from 1.80 to 1.10 mm due to the powder contains high protein, fibre, calcium and iron, and causes dilute the gluten and produced harder cookie dough with less cohesiveness and springiness than the control sample (Fig. 2).

Also, these findings are in line with those (McWatters, 1978) [17] who reported that increase in penetration force when increasing peanut flour in the cookies and this was due to the rapid partitioning of free water to hydrophilic sites during mixing. Data shows that the springiness of cookies decreases with an increasing percentage of MLP. A decrease in springiness (mm) value of cookies dough with increasing levels of MLP in the composite dough was given by (Dachna *et al.*, 2010) and found that the high protein, dietary fibre, calcium, and iron content in the MLP diluted the gluten and produced hard dough decreased the cohesiveness, adhesiveness, gumminess, and springiness from 0.124, 8.53, 8.56 and 1.01 to 0.072, 8.34, 8.34 and 0.832, respectively.

Table 3: Textural characterisstics of MLP cookies dough

Treatments	Penetration Force (N)	Springiness (mm)
T_0	4.567±0.060	1.397±0.020
T_1	4.840±0.040	1.300±0.010
T_2	5.079±0.470	1.250±0.010
T_3	5.407±0.030	1.163±0.050
T_4	6.432±0.040	1.100±0.010
S.E.	0.0246	0.006
C.D. @ 5%	0.08	0.824
C.V.	0.020	0.857

3.3 Effect of MLP on colour values (*L*, a*, b**) of cookies

Food colour analysis is an important topic that is always linked to the market and consumer acceptance since it determines the first impression of any food product. The *L* a* b** values are used to explain the colour changes between control and modified formula cookies; data on colour values can be found in table 4.

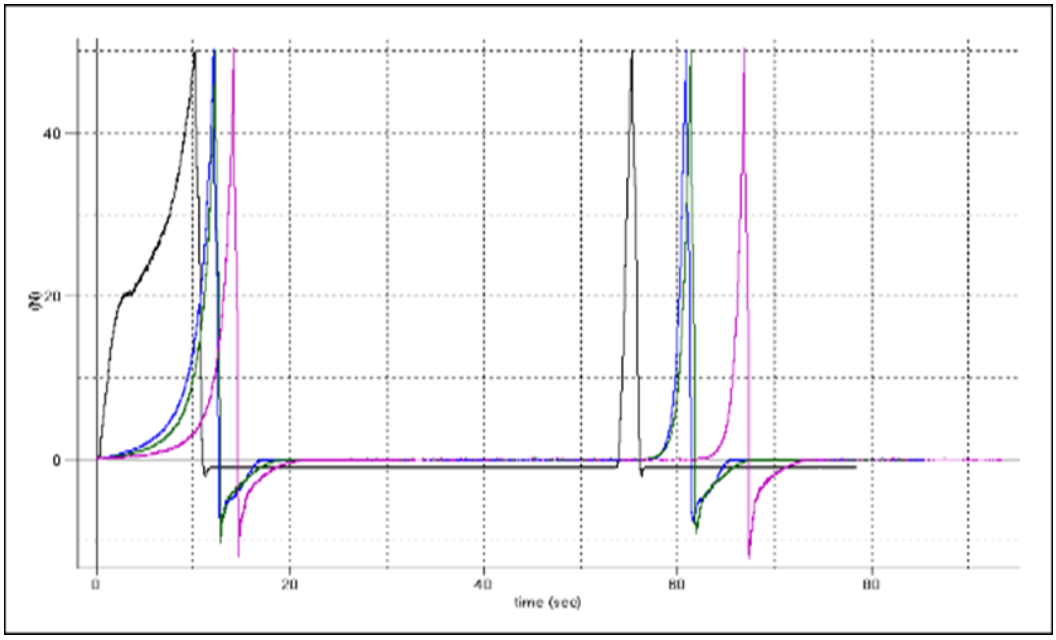

Fig. 2: Effect of different levels of addition of MLP on the springiness of cookies for sample (T_1, T_2, T_3 and T_4)

Table 4: Effect of different levels of MLP on colour values of cookies

Treatments	*L**	*a**	*b**
T_0	56.415±0.074	8.613±0.060	22.563±0.135
T_1	58.891±0.020	4.262s±0.024	19.797±0.011
T_2	56.266±0.040	2.195±0.005	18.454±0.121
T_3	51.919±0.033	0.879±0.0125	15.710±0.022
T_4	50.908±0.010	1.188±0.0030	15.381±0.013
S.E.	0.0184	0.0122	0.0352
C.D. @ 5%	0.076	0.055	0.152
C.V.	0.076	0.866	0.448

The mean values of *L** of cookies ranged from 56.415 (Control) to 50.908. The increase in MLP concentration moved cookies from the red colour area and put them into the green colour area as a control sample *a** value of 8.613±0.06. Mean values of *b** cookies ranged from 22.563 (Control) to 15.381. It can be concluded that the colour of cookies becomes less bright with the addition of MLP, which means that the addition of MLP to the cookies gave darker cookies samples. These differences in *L** values of cookie dough were mainly due to the effect of temperature on heat-sensitive compounds such as carbohydrates, proteins, and vitamins, which causes colour degradation in fresh food this result was found by Hawlader *et al.*, (2006) [14].

Similar results for change in colour values (*L*, a*, b**) of cookies dough were found by many authors. For MLP cookies with incorporation levels of 3-15% in the composite dough (Mohamed *et al.*, 2014) [19] found a decrease in *L*, a*, and b** values from 75.89, 1.96 and 26.18 to 48.70, -0.69 and 9.95 was due to the darker colour of MLP. Also, similar results were found by (Galla *et al.*, 2017; Drisya *et al.* (2013) [10, 7] and they revealed that, a decrease in the value of *L*, a*, and b** from 55.36, -3.35 and 13.91 to 40.74, 0.61 and 4.42 respectively, with increasing levels of spinach leaf powder concentrations from 0-15% in the composite dough.

3.4 Organoleptic characteristics of the cookie's samples

The general appearance of the cookie's samples is shown in plate 1 while the mean scores of the sensory attributes are graphically shown in fig.3. The mean score of all organoleptic criteria in the current investigation was used to calculate the overall acceptability rating. From table 5 it was revealed that the overall acceptability score of cookies decreased at the 4% level (7.90) and was comparable to the control sample (8.50). Cookies produced with *maida* and MLP were found to be acceptable up to 6% substitution, but at 8% and 10% replacement, the total acceptability score was significantly lower than the control. MLP-supplemented cookies at 8% substitution show the lowest overall acceptability score (7.20)

and were found to be unacceptable. Whereas, *maida* plus MLP-supplemented cookies at the 10% level had the poorest overall acceptability score (6.90) and hence were considered unacceptable.

Beyond a 6% level of MLP substitution, the scores for organoleptic features such as colour, texture, flavour, and taste were generally lower than those of whole-wheat cookies. As a result, the whole-wheat cookies scored higher than the MLP composite cookies in terms of overall acceptability. Overall acceptability scores of MLP-supplemented cookies did not differ from those of the control by more than 15% and were deemed acceptable.

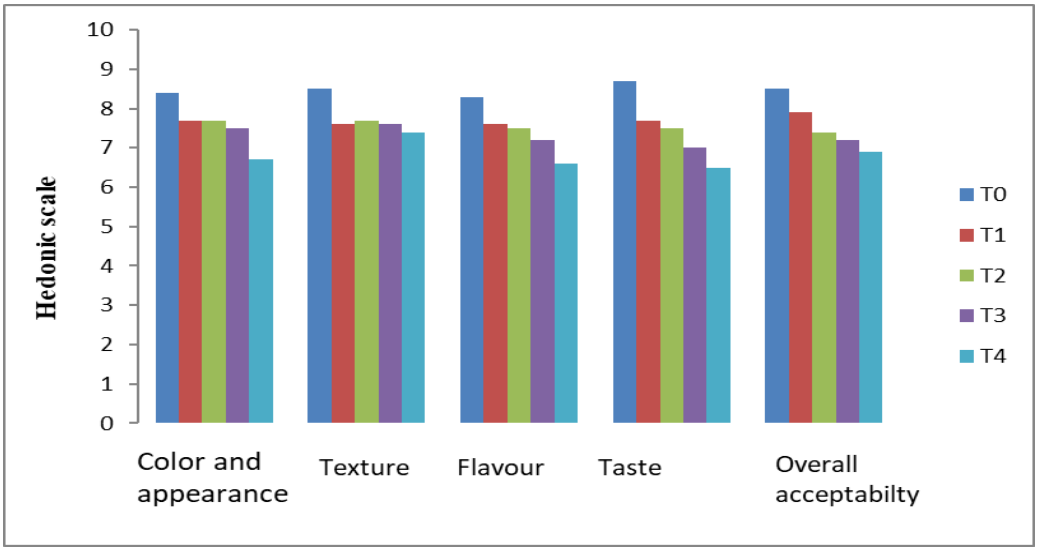

Fig 3: Effect of different levels of addition of *Moringa* leaf powder on Sensory characteristics of cookies

Table 5: Effect of MLP on sensory characteristics of the cookie's samples

Treatments	Colour and appearance	Texture	Flavor	Taste	Overall Acceptability
T_0	8.40	8.50	8.30	8.70	8.50
T_1	7.70	7.60	7.60	7.70	7.90
T_2	7.70	7.70	7.50	7.50	7.40
T_3	7.50	7.60	7.20	7.00	7.20
T_4	6.70	7.40	6.60	6.50	6.90
S.E.	0.292	0.282	0.364	0.309	0.336
C.D.@5%	0.841	0.812	1.056	0.906	0.987
C.V.	12.446	11.849	16.014	13.544	14.643

The cookies with more than 6% MLP had like green leaf taste according to the panellists. This means that preparatory processing measures (such as heat treatment) are needed to optimise the performance of MLP before it is used in wheat flour fortification.

Similar results for MLP cookies were found by Ajibola *et al.*, (2015) [3] and Mohamed *et al.*, (2014) [19]. Similar results for the overall acceptability of MLP cookies were found by Emelike *et al.*, (2015) [8] and revealed that the decrease in acceptability was due to the effects of different drying methods on the physico-chemical and sensory properties of cookies and found that the control sample had the highest sensory acceptance (8.30) than other samples. Similar results overall acceptability of MLP cookies were reported by (Dachana *et al.*, (2010) [6]; Mohamed *et al.*, (2014) [19] and Nwakalor and Chizoba, 2014) [21] and the study found that the cookies were acceptable up to the 10% level of MLP in the composite dough.

4. Conclusion

Moringa leaf powder substitution in the cookies significantly (p<0.05) increased the moisture content, weight, diameter, and thickness of cookies from 10.16 to 13.20%, 13.04 to 15.76 g, 5.56 to 5.57 cm, and 0.93 to 1.42 cm respectively, while decreased spread ratio from 5.99 to 3.92. For the textural properties of cookies dough, the penetration force of cookies increased and the springiness of cookies dough decreased from 4.567 N to 6.432 N and from 1.39 mm to 1.10 mm respectively. Colour values (L^*, a^* and b^*) of cookies dough decreased due to the dilution of gluten in the dough and darker MLP. All the judges rated maximum to the blended cookies i.e. 7.90 for 4% replacement of *moringa* leaf powder, as compared to other combinations of 6, 8, and 10% *moringa* leaf powders.

5. Future Studies

The application of rheological properties for different confectionary products can be studied. For better use of exploration of MLP in different food products such as chapatti, pasta, cake, noodles, etc. can be undertaken to standardize the recipe of preparation with the aid of rheological studies on a pilot scale.

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