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Development of antioxidant rich low calorie cookies with mango kernel powder, Palm sugar and inulin

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Abstract
The present study was conducted to develop antioxidant rich low calorie cookies using mango kernel powder, palm sugar and inulin. The cookies were prepared by substituting whole wheat flour with mango kernel powder at 0%, 15% and 30% as an alternative of refined wheat flour; butter with inulin at 0%, 7.5% and 15% as an alternative of hydrogenated fat and sugar was fully altered with palm sugar (25g, 30g and 35g). The cookies were prepared by conventional creamy method. Sensory analysis was conducted by panel members for optimization of ingredients such as mango kernel powder, palm sugar and inulin. Sensory analysis showed that increasing level of mango kernel powder above 15% lower the sensory attributes such as appearance (8.33-4.50), texture (8.16-4.00), aroma (7.83-4.50), taste (7.66-3.66) and overall acceptability (8.00-4.16). Cookies prepared with 15% mango kernel powder and 85% whole wheat flour; 44.4g butter and 3.6g inulin and 30g palm sugar scored high value for all sensory attributes. Proximate analysis such as moisture content, ash content, protein content crude fibre, fat content, carbohydrate, energy value, water activity, antioxidant activity and colour value were found out for optimized antioxidant rich cookies and control cookies. The proximate analysis of antioxidant rich cookies shows the highest level of crude fibre content, and ash content compared to control cookies. The highest level of antioxidant activity was observed in developed cookies than control. Energy value and water activity is significantly lower than control sample.

Keywords: Mango kernel powder, antioxidant activity, water activity, palm sugar, sensory analysis

1. Introduction
Mango (*Mangifera Indica*) is the king of fruit, grown in many tropical and subtropical regions of India. India is the major producer of world which produces 40% of total world production that is 21.12 million tonnes (Ministry of agriculture, Government of India, 2020). Only 20% of mango production was processed for product development such as jam, juices, beverage, powder, squash etc., The solid waste which was produced in mango processing industry contains 12 to 15% of peel, 5 to 10% of pulper waste (stalk, trimming and fibre) and 15% to 20% mango kernel (Ramasamy *et al.*, 2020) [17]. The discarded mango kernel is considered as a major mango industry waste, which cause pollution in the environment where disposal is a bigger problem. The mango kernel powder is a good source of protein, fat, carbohydrates and minerals such as calcium, magnesium, potassium, phosphorus, sodium and oleic acid (Masud *et al.*, 2020; Yatnatti *et al.*, 2014) [15, 21]. Mango kernel contains antioxidant due to presence of polyphenols, phytosterols and micro nutrients such as zinc, copper and selenium (Masibo and Qian, 2008) [14].
Cookies are one of the important bakery products, per capita intake of cookies is 2.1 kg/annum (Federation of Biscuit Manufacturers of India). The major raw materials used for preparation of cookies are refined wheat flour, sucrose and fat which makes bakery product as energy densed. Ingredients used in commercial cookies are lack in important nutrients. The dietary fibre and nutrients were health promotion composites are not available in refined wheat flour. The hydrogenated fat consist of trans-fat, is harmful to human health. Palm sugar significantly reduces glucose level compared to other artificial sweeteners. The palm sugar not only potential as natural sweetener but also has antioxidant property (Sia *et al.*, 2010) [19]. Inulin occurs in plants and chicory roots are richest source used as a prebiotic and fat replacer (Crystyjan *et al.*, 2015) [12].
Hence, an attempt was made to incorporate mango kernel powder with whole wheat flour instead of refined wheat flour, butter with inulin instead of hydrogenated fat and sugar with palm sugar to improve functional properties such as antioxidant, fibre and provide various health benefits.

With this background the current research work was carried out to develop antioxidant rich low calorie cookies with improved nutritional value.

2. Materials and Methods

The ingredients such as mango kernel powder, wheat flour, butter, sugar, inulin powder and palm sugar was purchased from local market of Chennai. The present study was carried out in College of Food and Dairy Technology, Koduveli, Chennai.

2.1 Cookies formulation

Cookies were prepared by creamy method at different proportion of mango kernel powder, palm sugar and inulin as shown in Table 1. Whole wheat flour (100g) is replaced by mango kernel powder in three different percentages (0%, 15% and 30%). Inulin is used as a butter (48g) replacer which was added in three different percentages (0%, 7.5% and 15%). Sugar was fully replaced by palm sugar at three different levels (25g, 30g and 35g). Cookies prepared without mango kernel powder and inulin with sugar is used as control sample.

2.2 Cookies preparation

The cookies were prepared with slight modification in the method prescribed by Dignity *et al.*, (2018) [6]. The cookies were prepared as mentioned in the process flowchart (Figure 1) by using the ingredients given in Table 1.

Table 1: Cookies formulation with variation of ingredients

Treatments	Cookies Formulation				
	Whole wheat flour (g)	Mango kernel powder (g)	Palm sugar (g)	Butter (g)	Inulin powder (g)
Control	100	-	-	-	-
T_1	100	-	25	48	-
T_2	100	-	30	48	-
T_3	100	-	35	48	-
T_4	100	-	25	44.4	3.6
T_5	100	-	30	44.4	3.6
T_6	100	-	35	44.4	3.6
T_7	100	-	25	40.8	7.2
T_8	100	-	30	40.8	7.2
T_9	100	-	35	40.8	7.2
T_{10}	85	15	25	48	-
T_{11}	85	15	30	48	-
T_{12}	85	15	35	48	-
T_{13}	85	15	25	44.4	3.6
T_{14}	85	15	30	44.4	3.6
T_{15}	85	15	35	44.4	3.6
T_{16}	85	15	25	40.8	7.2
T_{17}	85	15	30	40.8	7.2
T_{18}	85	15	35	40.8	7.2
T_{19}	70	30	25	48	-
T_{20}	70	30	30	48	-
T_{21}	70	30	35	48	-
T_{22}	70	30	25	44.4	3.6
T_{23}	70	30	30	44.4	3.6
T_{24}	70	30	35	44.4	3.6
T_{25}	70	30	25	40.8	7.2
T_{26}	70	30	30	40.8	7.2
T_{27}	70	30	35	40.8	7.2

Butter and sugar were creamed using an electric mixer at medium speed for 5 minutes. Then Inulin, whole wheat flour and Mango kernel powder were added and mixed thoroughly and added to the cream mixture as above, where they were all mixed together to form a dough. The dough was rolled and sheeted to a uniform thickness using roller pin, sheeted and cut into circular shapes with the help of cutter. Unbaked cookies were placed in a baking tray and kept in preheated baking oven at 175 °C for 15 ± 5 minutes. The baked cookies were cooled for 5 minutes at room temperature and removed from baking tray. Cookie samples were cooled and stored in airtight aluminum pouches until further use. Control cookies were prepared with wheat flour and sugar.

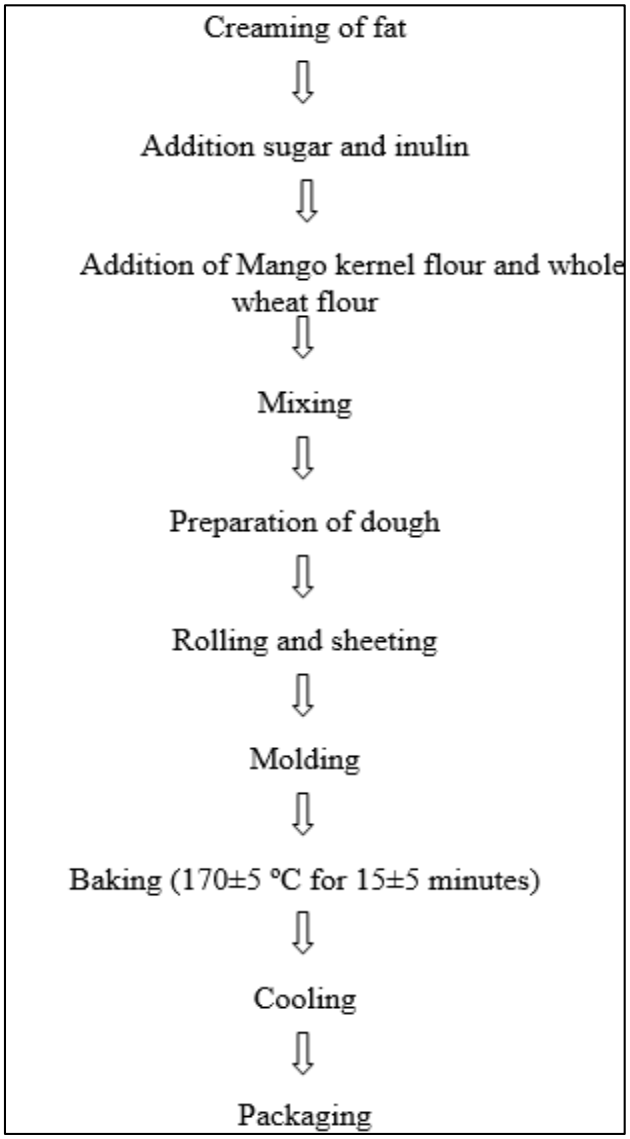

Fig 1: Flow chart for the preparation of antioxidant rich cookies

2.3 Optimization of ingredients for antioxidant rich cookies formulation

The developed 27 cookies and control cookies were evaluated by sensory panel members for various sensory attributes such as appearance, taste, aroma, texture and overall acceptability and the scores were given using 9 point hedonic scale. Based on the scores given by panelist and statistical analysis, the best ingredient formulation compared with the control was selected for further studies (Bhat *et al.*, 2015) [4].

2.4 Physical properties of cookies

Antioxidant rich cookies and control cookies were analysed for physical parameters such as weight, diameter, thickness, spread ratio, volume and density were determine as per the methods described by Dignity *et al.*, (2018) [6].

2.5 Proximate properties of cookies

Optimized antioxidant rich cookies and control cookies were analysed for proximate parameters such as moisture content, protein content, fat content, crude fibre and ash content as per AOAC method, (2005) [1].

The total carbohydrate was calculated by difference method as:

$$\% \text{ Carbohydrate} = 100 - (\% \text{ Moisture} + \% \text{ Protein} + \% \text{ Fat} + \% \text{ Ash})$$

Energy value of cookies (Kcal/100 g) was determined by using formula method (Ikuomola *et al.*, 2017) [9].

$$\text{Energy value(Kcal)} = (4 \times \% \text{ Protein}) + (4 \times \% \text{ Carbohydrate}) + (9 \times \% \text{ Fat})$$

2.5 Antioxidant activity of cookies

Antioxidant activity by DDPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging activity of each sample was measured using the method described with some modifications (Jan *et al.*, 2015) [10]. The absorbance at 517nm was measured after each sample solution had incubated in dark for 30 minutes. Percentage inhibition scavenging activity was calculated by using formula

$$\text{Antioxidant activity (\%)} = \frac{(A_{control} - A_{sample})}{A_{control}} \times 100$$

Where, A is absorbance.

2.6 Colour value of cookies

Spectrophoto calorimeter Miniscan MS/Y/2500 (Hunter lab, Reston, VA, USA) was used to measure the colour of control and antioxidant rich cookies. The colour was expressed using the lightness (L*), redness (a*), yellowness (b*) CIE system according to method described by Kluklin and Savage, (2018) [13].

2.7 Water activity of cookies

Water activity of cookies was measured using water activity meter (Labtouch - a_w System, Novasina AG, Switzerland) method described by Sharma and Gujral, (2014) [18].

2.7 Statistical analysis

The data obtained from various trails under all experiments were analysed by statistical method of one way analysis of Variance (ANOVA) using SPSS IBM Version 20.0 Software with six replicates. The data were statistically analysed as mean ± standard deviation (SD) and means were compared (Florence *et al.*, 2014) [7].

3. Result and Discussion

At present there is a great demand and market value for antioxidant rich and low calories product owing to its health benefits. The developed antioxidant rich cookies and control cookies were evaluated by various physical, proximate, sensory; colour, water activity, antioxidant activity and results were tabulated.

3.1 Sensory evaluation

The mean ± SE scores of 27 cookies and control cookies were evaluated by sensory panel members for various sensory attributes such as appearance, taste, aroma, texture and overall acceptability of antioxidant rich cookies optimized by adding different proportion of ingredients and their statistical analysis were presented in Table 2.

From the sensory result it was observed that all the sensory attributes such as appearance, aroma, texture, taste and overall acceptability of 15% mango kernel powder incorporated cookies were comparable with control cookies. It was also observed that there was no significant difference between control and butter replacement of 7.5% with inulin. Appearance, texture, aroma and overall acceptability were decreased significantly ($P \leq 0.01$) with increasing mango kernel powder and inulin beyond incorporation level of 15% mango kernel powder and 7.5% inulin. It might be due to incorporation of mango kernel powder increased the hardness of cookies by reducing water holding capacity. Kaur, (2017) [11] revealed that incorporation of mango seed kernel flour upto 30% in chapatti was accepted by panel members. Palm sugar have does not any significant effect on sensory attributes except taste. Hence 15% replacement of mango kernel powder (85 g of whole wheat flour with 15g of mango kernel powder) and 7.5% replacement of inulin (44 g of butter with 3.6 g of inulin) and 30g of palm sugar were selected for preparation antioxidant rich cookies (T_{14})

Table 2: Mean ± S.E values of Sensory evaluation of cookies (9-point hedonic scale) (n=6)

Samples	Sensory Attributes				
	Appearance	Texture	Aroma	Taste	Overall acceptability
Control	8.50^{g}±0.22	8.33^{f}±0.21	8.00^{j}±0.22	7.83^{h}±0.16	8.16^{h}±0.05
T_1	8.16^{fg}±0.16	8.00^{ef}±0.00	7.50^{hi}±0.21	7.50^{gh}±0.22	7.79^{fg}±0.07
T_2	8.16^{fg}±0.16	8.00^{ef}±0.00	7.66^{ij}±0.22	7.50^{gh}±0.22	7.83^{fgh}±0.05
T_3	8.16^{fg}±0.16	8.00^{ef}±0.00	7.50^{hij}±0.22	7.33^{fgh}±0.21	7.75^{fg}±0.09
T_4	8.00^{fg}±0.00	7.83^{ef}±0.16	7.50^{hij}±0.21	7.33^{fgh}±0.21	7.66^{fg}±0.12
T_5	8.00^{fg}±0.00	7.83^{ef}±0.16	7.66^{ij}±0.22	7.50^{gh}±0.22	7.75^{fg}±0.12
T_6	8.00^{fg}±0.00	7.83^{ef}±0.16	7.50^{hij}±0.16	7.16^{efgh}±0.16	7.62^{fg}±0.08
T_7	7.33^{de}±0.21	6.50^{cd}±0.22	6.83^{efghij}±0.00	6.33^{de}±0.21	6.75^{e}±0.12
T_8	7.33^{de}±0.21	6.50^{cd}±0.34	7.00^{fghi}±0.16	6.50^{def}±0.22	6.83^{e}±0.10
T_9	7.33^{de}±0.21	6.50^{cd}±0.22	6.83^{efgh}±0.21	6.16^{d}±0.16	6.70^{e}±0.07
T_{10}	7.83^{ef}±0.16	7.50^{e}±0.22	7.33^{ghij}±0.21	7.33^{fgh}±0.21	7.50^{f}±0.09
T_{11}	7.83^{ef}±0.16	7.50^{e}±0.22	7.33^{ghij}±0.21	7.50^{gh}±0.34	7.54^{f}±0.15
T_{12}	7.83^{ef}±0.16	7.50^{e}±0.22	7.33^{ghij}±0.21	7.16^{efgh}±0.16	7.45^{f}±0.07
T_{13}	8.00^{fg}±0.00	7.83^{ef}±0.16	7.66^{ij}±0.16	7.50^{gh}±0.34	7.75^{fg}±0.12
T_{14}	8.33^{fg}±0.21	8.16^{ef}±0.16	7.83^{j}±0.22	7.66^{gh}±0.21	8.00^{gh}±0.09
T_{15}	8.00^{fg}±0.00	7.83^{ef}±0.16	7.50^{hij}±0.33	7.50^{gh}±0.22	7.70^{fg}±0.07
T_{16}	7.16^{d}±0.16	6.50^{cd}±0.22	6.66^{defg}±0.30	6.83^{defg}±0.16	6.79^{e}±0.11
T_{17}	7.16^{d}±0.16	6.50^{cd}±0.34	6.83^{efgh}±0.33	6.83^{defg}±0.30	6.83^{e}±0.12

T_{18}	$7.16^{d}\pm0.30$	$6.50^{cd}\pm0.22$	$6.66^{defg}\pm0.16$	$6.50^{def}\pm0.34$	$6.70^{e}\pm0.11$
T_{19}	$7.00^{d}\pm0.25$	$6.66^{d}\pm0.21$	$6.16^{cde}\pm0.34$	$6.33^{de}\pm0.21$	$6.54^{e}\pm0.15$
T_{20}	$7.00^{d}\pm0.00$	$6.66^{d}\pm0.21$	$6.50^{def}\pm0.30$	$6.33^{de}\pm0.21$	$6.62^{e}\pm0.15$
T_{21}	$7.00^{d}\pm0.25$	$6.66^{d}\pm0.33$	$6.16^{cde}\pm0.21$	$6.16^{d}\pm0.47$	$6.50^{e}\pm0.22$
T_{22}	$5.50^{b}\pm0.22$	$5.83^{bc}\pm0.16$	$5.66^{bc}\pm0.25$	$4.83^{bc}\pm0.30$	$5.45^{cd}\pm0.07$
T_{23}	$6.33^{c}\pm0.21$	$5.50^{b}\pm0.22$	$6.00^{bcd}\pm0.21$	$5.00^{c}\pm0.25$	$5.70^{d}\pm0.11$
T_{24}	$5.83^{bc}\pm0.30$	$5.50^{b}\pm0.22$	$5.33^{b}\pm0.22$	$4.66^{bc}\pm0.33$	$5.33^{c}\pm0.16$
T_{25}	$4.66^{a}\pm0.21$	$4.16^{a}\pm0.30$	$4.50^{a}\pm0.21$	$4.16^{ab}\pm0.16$	$4.37^{ab}\pm0.16$
T_{26}	$4.83^{a}\pm0.16$	$4.33^{a}\pm0.21$	$4.66^{a}\pm0.21$	$4.33^{abc}\pm0.21$	$4.54^{b}\pm0.15$
T_{27}	$4.50^{a}\pm0.22$	$4.00^{a}\pm0.31$	$4.50^{a}\pm0.34$	$3.66^{a}\pm0.33$	$4.16^{a}\pm0.83$
F value	36.875**	30.576**	19.167**	22.233**	89.507**

*Significant ($p\leq 0.05$)
**Highly Significant ($p\leq 0.01$)
^{NS}Non Significant (p>0.05)
Mean bearing different superscripts a, b, c, d, e, f, g, h, i, j within column differ significantly

3.2 Physical properties of developed cookies

The results of physical properties of cookie were shown in Table 3. Diameter, spread ratio and baking loss of antioxidant rich cookies (T_{14}) were significantly ($p\leq 0.01$) higher than control cookies (T_1) due to incorporation of mango kernel powder and inulin. Weight, thickness and volume of antioxidant cookies was significantly ($p\leq0.05$) decreased due to low moisture content of mango kernel powder. The result was supported by the finding of Yatnatti *et al.*, (2014) [21] who reported that the moisture content of mango kernel flour was 7.05%.

Table 3: Mean ± S.E values of Physical properties of cookies (n=6).

Physical properties of cookies			
Parameters	**Control cookies**	**Antioxidant rich cookies**	**F value**
Weight (g)	4.67±0.05	4.15±0.06	32.90**
Diameter (mm)	47.69±0.01	48.60±0.04	426.983**
Thickness (mm)	6.86±0.18	6.58±0.05	2.126*
Spread ratio	6.97±0.18	7.38±0.06	4.184*
Volume (cm^3)	12.25±1.08	12.21±1.26	2.568*
Density (g/cm^3)	0.38±0.32	0.34±0.10	0.16^{NS}
Baking loss (%)	19.95±0.01	22.62±0.00	7.255*

*Significant ($p\leq0.05$)
**Highly Significant ($p\leq 0.01$)
^{NS} Non Significant (p>0.05)

3.2 Proximate composition of developed cookies

Proximate compositions of control and T_{14} cookies were shown in Figure 2. The moisture content of T_{14} cookie is significantly ($p\leq 0.01$) decreased to 3.85% from control cookies moisture content 4.54%. The result of ash content, carbohydrate content and crude fibre content showed a significance increase ($p\leq 0.01$) in T_{14} sample than control sample, it might be due high fibre content of inulin and high ash content mango kernel powder (Masud *et al.*, 2020; Kryststyjan *et al.*, 2015) [15, 12]. The protein content and energy value of T_{14} cookies were significantly ($p\leq 0.01$) decreased from control. The results are in agreement with the findings of Chauhan *et al.*, (2016) [5] who reported protein content decreased with incorporating amaranth flour.

Table 4: Mean ± S.E values of Colour values for cookies (n=6)

Colour values of cookies			
Parameters	**Control cookies**	**Antioxidant rich cookies**	**F value**
L*	52.92±0.24	51.65±0.02	25.805*
a*	8.80±0.17	4.49±0.18	281.927**
b*	17.01±0.32	13.87±0.16	73.161**

**Highly Significant ($P< 0.01$)

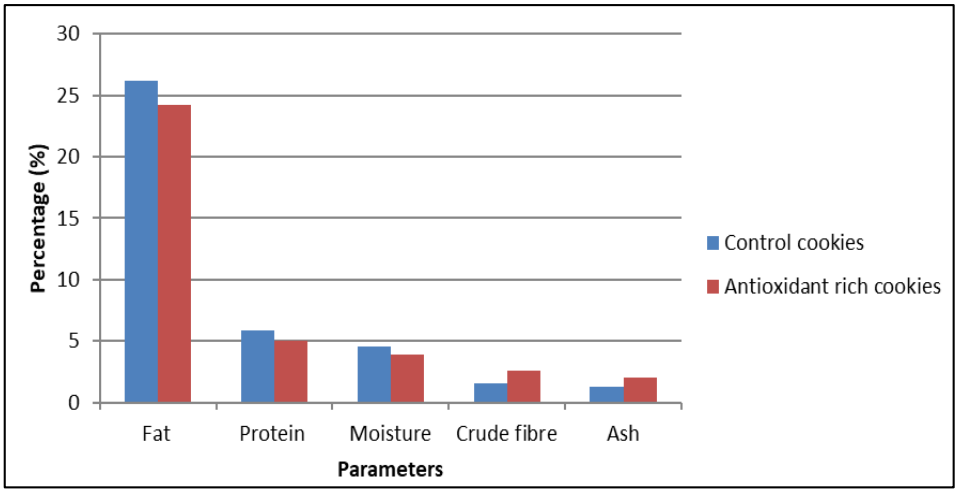

Fig 2: Proximate composition of cookies

3.3 Colour value of cookies

Colour values of cookies were presented in Table 5. The results of colour value indicates that redness (a*) and yellowness (b*) of antioxidant rich cookies (T_{14}) were significantly different ($p \leq 0.01$) from control cookies due to addition of mango kernel powder and inulin (Awolu *et al.*, 2018) [2].

3.4 Antioxidant and water activity of developed cookies

The antioxidant activity and water activity of control and antioxidant rich cookies was shown in Table 5. The antioxidant activity of T_{14} cookie (24.22%) was significantly higher than control cookie that is 6.95% due to high antioxidant activity of mango kernel powder and palm sugar. The same was supported by the findings of Ifesan, (2017) [8]. Water activity of antioxidant rich cookies was significantly ($p \leq 0.01$) decreased with incorporation of mango kernel powder and inulin due to low moisture content of cookies as described by Bandyopadhyay *et al.* (2014) [3].

Table 5: Mean ± S.E values of Antioxidant and water activity of cookies (n=6)

Antioxidant and water activity			
Parameter	**Control cookies**	**Antioxidant rich cookies**	**F value**
Antioxidant activity (%)	6.95±0.43	24.22±0.64	489.356**
Water activity (%)	0.20±0.00	0.16±0.00	1537.60**

**Highly Significant ($P < 0.01$)

4. Conclusion

The Antioxidant rich cookies were prepared by substituting refined wheat flour with whole wheat flour and mango kernel flour (0, 15% and 30%); hydrogenated fat with butter and inulin (0%, 7.5% and 15%) and sugar with palm sugar. Cookies containing 15% mango kernel flour, 30g palm sugar and 7.5% inulin showed higher sensory performance compared to other proportion of mango kernel powder was selected for further studies. Sensory attributes and proximate composition was similar to control cookies. Antioxidant activity was higher in cookies developed with 15% mango kernel powder. Energy value and water activity of control cookies was higher than cookies contained 15% of mango kernel powder. For large scale cookies production, mango kernel flour can be incorporated up to 15% level, without affecting the sensory characteristics of cookies.

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