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Effects of acid modified psyllium husk (*Plantago ovata* F.) Incorporation on the physical properties and color tonality of cookies

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Abstract
Acid modification of psyllium husk with concentration of 0.65 % HCl in the ethanol solvent for solvent ratio of 1:6 (w/v) as psyllium husk: solvent ratio, significantly decrease the hydration capacity; oil absorption capacity & water up-taking rate of psyllium. In the present investigation, an attempt had been made to incorporate acid modified psyllium husk in the cookies and study its impact on the physical properties and colour tonality of cookies sample. The native and modified psyllium husks were mixed with refined wheat flour (maida) at the substitution levels of 0, 6, 9 and 12 per cent (w/w) for preparation of psyllium husk incorporated cookies. Results regarding physical properties revealed that maximum weight was recorded in N_3 cookie sample (9.84g) followed by control cookie (9.32g) sample and M_1 cookie sample (8.82g), while highest value of diameter 4.90 cm, almost at par with control (4.82 cm) was observed in case of M_1 cookie sample. Similarly, minimum value for thickness was recorded as 0.98 cm for M_1 sample, whereas M_1 & M_2 cookies sample recorded maximum values of 5.00 & 4.65 respectively for spread ratio more than control cookie sample (4.63).Top grain development was found increased in modified psyllium husk incorporated cookies. The Color tonality observations of cookies found that L* value maximum 68.81 in Control cookie sample followed by sample N_1 and M_1 cookies sample with value of 66.15 & 66.09 respectively. Further maximum a* value of 8.02 was observed in M_1 cookie sample containing 6% modified psyllium husk and maximum b* value noted for control sample was 32.38 followed by M_1 cookie sample (29.66).

Keywords: psyllium husk, acid modification, cookies, color tonality, dietary fiber, physical properties

Introduction
Functional food components are potentially beneficial components found naturally in foods or added to them as functional ingredients, and includes carotenoids, dietary fiber, fatty acids, flavonoids, isothiocyanates, phenolic acids, plant stanols and sterols, polyols, prebiotics and probiotics, phytoestrogens, soy protein, vitamins and minerals. Dietary fibers include cellulose, hemicellulose, polyfructoses, galacto oligosacharides, gums, mucilages, pectins, lignin and resistant starches, and are classically divided into soluble or insoluble. More recently, some are proposing the use of the terms "viscous" and "fermentability" in place of soluble and insoluble to describe the functions and health benefits of dietary fiber (Wolever,2016) [1]. Both soluble and insoluble fibers pass through the stomach and small intestine undigested, but when they reach the large intestine they are fermented by colonic bacteria in different extensions. As a result of the fermentation process short chain fatty acids are produced, providing the important health benefits of fiber. Functional fiber is something that manufacturers deliberately add to food products to provide similar health benefits to those of dietary fiber, without adding significant calories. Dietary fiber is one of the valuable dietary interventions against a number of health disorders. There is no doubt that fibers, in particular viscous dietary fibers, have positive effects on human health, both in the prevention and in treatment of chronic diseases. Further, Dietary fibers from Psyllium have been used extensively both as pharmacological supplements, food ingredients; in processed food to aid weight control, to regulation of glucose control for diabetic patients and reducing serum lipid levels in hyperlipidaemias (Baljit, 2007) [2]. Fermentation and water absorption of dietary fibre components result in several beneficial health effects. Dietary fibre intake has been associated with alleviation of constipation, regulation of lipid and glucose/insulin metabolism, and carcinogenesis.

Health claims on the beneficial effects of PSH, approved in 1998 by the US Food and Drug Administration, have led to the inclusion of PSH in cereals and fibre supplements (Luccia and Kunkel 2002a) [3]. However, its strong water-absorbing and gelling properties (Gelissen *et al*. 1994) [4] make it difficult to handle and process, and present a real challenge when incorporating PSH in food and beverage formulas (Chan 1988, Yu and Perret 2003b) [5, 6].

Based on the previous studies, acid modification of psyllium husk presents a competitive potential of being applied in food industry due to its lower cost than enzymatic methods. In the present study an attempt has been made to incorporate acid modified psyllium husk in the cookies and its impact analysis on the physical characteristics and colour tonality of different prepared cookies sample have been carried for formulation of optimum commercial recipe of cookies containing acid modified psyllium husk as a natural source of dietary fiber without disturbing the physical properties and color tonality of the cookies.

Materials and Methodology

Psyllium Husk of indigenous variety was purchased from market of Parbhani district, Maharashtra.

Acid modification of Psyllium husk

Acid modification of psyllium husk was carried as per the standards given by Syed *et al*. (2018) [7] using 0.65 % HCI treatment in ethanol for ratio of 1:6 (w/v) as PSH: Solvent containing 0.65 % HCl for improving functional properties of psyllium husk without affecting the dietary fiber and arabinoxylan contents as required for exploration of psyllium husk as a source of dietary fiber in the value addition of cookies.

Development of psyllium husk incorporated cookies

Traditional creaming method was used for the preparation of cookies. Basic recipe used for preparation of cookies is given in Table 1.

Shotening and sugar were creamed until mixture became light and fluffy. Refined wheat flour was sieved with sodium bicarbonate and ammonium bicarbonate. The cream was mixed with flour and sufficient quantity of milk was added to form dough. Then sheet of dough was prepared having thickness of 0.5 cm and manually shaped into circular form (diameter: 60 mm, thickness: 5 mm). The pieces were placed in the baking tray and baked at 180-200 °C for 15 min in an electrically heated baking oven. The cookies were allowed to cooled on wire racks 27 ^{0}C for 30 minutes, packed in various packages and stored at ambient temperature (Uysal *et al.*, 2007; Amit *et al.*, 2014; Rajiv *et al*., 2012) [8-10]. The flow chart for preparation of cookies is given in Figure 1.

Table 1: Basic recipe used for preparation of cookies

Ingredients	Quantity
Refined wheat flour (maida) (g)	100
Sugar (g)	52
Shotening (g)	48
Sodium bicarbonate (g)	1
Ammonium bicarbonate (g)	1
Milk (ml)	20

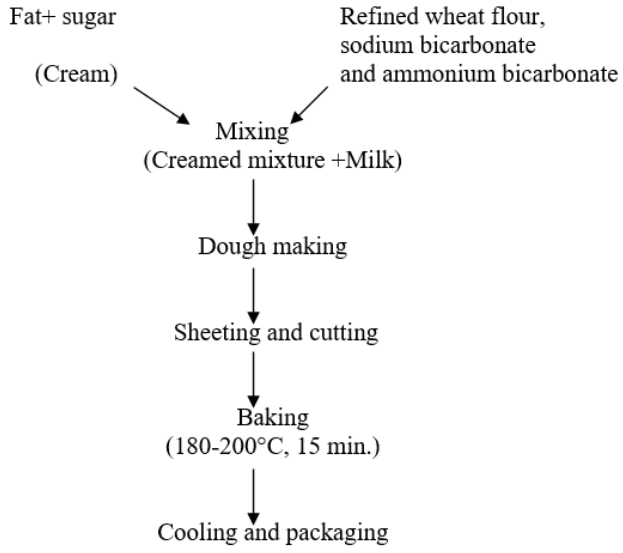

Fig 1: Flow chart for preparation of cookies

Preparation of native psyllium husk incorporated cookies

The native psyllium husk was mixed with refined wheat flour (maida) at the substitution levels of 0, 6, 9 and 12 per cent (w/w) and other ingredients were used as per recipe to prepare cookies by using standard creaming method. Prepared cookies were subjected to organoleptic evaluation and suitable blend of refined wheat flour (maida): native psyllium husk was selected for the further experiment.

Composite flour utilized in the preparation of cookies was prepared by blending the definite proportion of native psyllium husk with refined wheat flour (maida) in the following blends (Table 2).

Table 2: Composite flour of native psyllium husk for cookies

Treatments	Composition of flour	
	Refined wheat flour (Maida) (g)	Native psyllium husk (g)
N_0	100	00
N_1	94	06
N_2	91	09
N_3	88	12

Formulations of native psyllium husk incorporated cookies

Refined wheat flour (maida) was replaced with native psyllium husk as per formulations given in Table 3.

Table 3: Formulations of native psyllium husk incorporated cookies

Ingredients	N_0	N_1	N_2	N_3
Refined wheat flour (maida) (g)	100	94	91	88
Native psyllium husk (g)	-	06	09	12
Sugar (g)	52	52	52	52
Shotening (g)	48	48	48	48
Sodium bicarbonate (g)	1	1	1	1
Ammonium bicarbonate (g)	1	1	1	1
Milk (ml)	20	20	20	20

Preparation of modified psyllium husk incorporated cookies

Modified psyllium husk was mixed with refined wheat flour (maida) at the substitution levels of 0, 06, 09 and 12 per cent (w/w) and other ingredients were used as per recipe to prepare cookies by using standard creaming method. Prepared cookies were subjected to organoleptic evaluation and suitable blend of refined wheat flour (maida): modified psyllium husk was selected for the further experiment.

Composite flour utilized in the preparation of cookies was prepared by blending the definite proportion of modified psyllium husk with refined wheat flour (maida) in the following blends (Table 4).

Table 4: Composite flour of modified psyllium husk for cookies

Treatments	Composition of flour	
	Refined wheat flour (Maida) (g)	Modified psyllium husk (g)
M_0	100	00
M_1	94	06
M_2	91	09
M_3	88	12

Formulations of modified psyllium husk incorporated cookies

Refined wheat flour (maida) was replaced with modified psyllium husk as per formulations given in Table 5.

Table 5: Formulations of modified psyllium husk incorporated cookies

Ingredients	M_0	M_1	M_2	M_3
Refined wheat flour (maida) (g)	100	94	91	88
Modified psyllium husk (g)	-	06	09	12
Sugar (g)	52	52	52	52
Shotening (g)	48	48	48	48
Sodium bicarbonate (g)	1	1	1	1
Ammonium bicarbonate (g)	1	1	1	1
Milk (ml)	20	20	20	20

Physical properties of psyllium husk incorporated cookies

Weight

The weight (W) of cookies was determined by weighing six cookies of approximate size and shape. This process was repeated thrice to get an average value and results were reported in g (A.A.C.C., 2000) [11].

Diameter

The diameter (D), of cookies was determined by placing six cookies edge to edge. The total diameter of the six cookies was measured in mm by using a ruler. The cookies were rotated at an angle of 900 for duplicate reading. This act was repeated twice and average diameter was reported in mm (A.A.C.C., 2000) [11].

Thickness

The thickness (T), of cookies was determined by placing six cookies on top of one another. The total height was measured in millimeters with the help of ruler. This process was repeated thrice to get an average value and results were reported in mm (A.A.C.C., 2000) [11].

Spread Ratio

Spread ratio is the ratio that depends on the values of the thickness and diameter of the biscuits. Spread ratio was determined from the diameter and thickness using the formula: (A.A.C.C., 2000) [11].

$$\text{Spread ratio} = \frac{\text{Average diameter (mm)}}{\text{Average thickness (mm)}} \times 10$$

Color tonality of Cookies

Determination of color tonality carried out by applying the method adopted by Tahira *et al*. (2013) [12]. Color measurement of cookies was carried out within 24 hours after baking. The color of sample cookies was determined by using a using CIE-Lab Color Meter (ColorFlex EZ). The values of lightness (L*), color-opponent dimensions a* (-a greenness, +a redness), b* (-b blueness, +b yellowness), illuminant (C*), and hue (h) were recorded. Each sample was analyzed in triplicate and mean value was obtained by calculation.

Results

Based on the previous research studies, native and modified psyllium husk were utilized for value addition of cookies. Comparative studies based on physical and colour properties between native & modified psyllium husk incorporated cookies were carried out to find the best formulation recipes for the value addition of cookies.

Effect of acid modified psyllium husk on physical properties of cookies

Physical properties of prepared native and modified psyllium husk incorporated cookies along with control sample were evaluated for physical characteristics like weight diameter, thickness and spread ratio and obtained values were statistically analysed and presented in Table 6. Acceptable quality in the first look being the prime objective of the bakers and consumers, makes the assessment of physical properties of the psyllium husk incorporated cookies mandatory for various aforesaid physical characteristics, so that product should be of acceptable quality.

Table 6: Physical properties of psyllium husk incorporated cookies

Treatments	Physical properties				
	Weight (g)	Diameter (cm)	Thickness (cm)	Spread ratio	Top grain Development
Control	9.32	4.82	1.04	4.63	Moderate
PSH(N)					
N_1	9.67	4.66	1.10	4.23	Most
N_2	9.75	4.64	1.14	4.07	Most
N_3	9.84	4.60	1.16	3.96	Moderate
PSH(M)					
M_1	8.82	4.90	0.98	5.00	Most
M_2	9.26	4.74	1.02	4.65	Most
M_3	9.35	4.32	1.26	3.43	Most
SE ±	0.5632	0.3766	0.0768	0.4732	-
CD @ 5%	1.6896	1.1298	0.2304	1.4196	-

* Each value is average of three determinations.

Weight

It can be observed from Table 6 that weight of the cookies varies due to treatment effects and increasing trend in the weight of cookies were found with the increase in level of psyllium husk incorporation level @ 6,9 & 12% respectively for both native and modified PSH. Weight of the cookies was highest in case of N_3 cookie sample having 12% native psyllium husk incorporation with 9.84g weight. Similar trends were observed in case of cookies incorporated with modified PSH. Highest weight was found for M_3 cookie sample having 9.35g weight. Weight of modified PSH incorporated cookies found less in comparison with native PSH incorporated cookies and control sample for all treatments. Substantial difference was observed between the weight of 6% modified PSH (M_1) cookie sample (8.82g) and 12% native PSH(N_3) sample (9.84g) as well as control(9.32g), but was not statistically significant. All the modified PSH cookies samples having less weight than the control (9.32g) except M_3 sample with 9.35g weight having 12% modified PSH incorporation level.

Acid modified psyllium husk being less in fat and protein content in comparison with the native PSH did not affected much on the overall weight of cookies upto 9% incorporation levels. The significant effect of treatment on weight of cookies may be due to addition of fiber that alters dough rheology and allied characteristics in baked products (Hussain *et al*. 2006) [13].

Diameter

The effect of treatments on diameter of the cookies presented a decreasing trend (Table 6). The diameter of control cookies was 4.82 cm, that decreased with increase in level of native psyllium husk and minimum value 4.60 cm was recorded in cookies containing 12% native psyllium husk (N_3), whereas, in case of modified PSH incorporated cookies, similar trends observed for 9% (M_2) & 12% (M_3) modified PSH incorporated cookies with recorded values of 4.74 & 4.32 cm respectively. Highest value of diameter 4.90 cm, almost at par with control (4.82 cm) was recorded for M_1 cookie sample having 6% level of acid modified PSH incorporation in the cookies.

Further, it was observed that incorporation of acid modified PSH in cookies less affected the diameter of cookies as compared to native PSH; especially 6% acid modified PSH (M_1) incorporation in cookies did not alter the diameter of cookies at all. Decreasing trends in diameter of cookies was due to addition of fiber that alters dough rheology and allied characteristics in baked products. Similar trends were also observed for native PSH incorporation in cookies by Hussain *et al*. (2006) [13]. They also found decreasing trend in cookies diameter due to addition of fiber content.

Thickness

It was found that the thickness increased gradually due to treatments with increasing level of psyllium husk except M_1 & M_2 treatments as highlighted in Table 6. Thickness of control cookies was estimated as 1.04 cm whereas, maximum value of 1.26 cm was recorded in M_3. Thickness was found decreasing in case of treatments M_1 & M_2. Minimum value for thickness was recorded as 0.98 cm for M_1 followed by M_2 with value of 1.02 cm less than control cookies (1.04 cm).

Variations in thickness within treatments was due to replacement of flour with husk thereby decreased starch and protein contents resulting gradual condensation of dough that consequently increased thickness for native PSH & for higher levels more than 11% of acid modified PSH incorporation. The results are in best agreements with the findings of Sharif *et al*. (2005) [14], they reported significant increase in thickness of cookies considering fiber, the principal factor for this change, they further recommended that up to 20% replacement of flour with fiber, found acceptable in bakery products.

Spread ratio

The data from the Table 6 indicates that the changes in width and thickness are reflected in spread ratio which was calculated by dividing the diameter (D) by thickness (T) of the cookies. Spread ratio of control cookies was found to be 4.63, which was decreased substantially and consistently from 4.23 to 3.96 with the increase in incorporation levels from 6 to 12 per cent of native PSH. These results indicated that the addition of native PSH significantly affected the thickness and diameter and thus, spread ratio of the incorporated cookies.

Previous studies of Hussain *et al*. (2006) [13] and Sharif *et al*. (2005) [14] strengthened the current results as they reported significant effect of fiber addition on spread ratio of cookies. They further elucidated that spread ratio decreased as function of fiber and the possible reason may be the absorption of moisture that increased the diameter and accordingly affected spread ratio.

Reverse trend was observed for the cookies incorporated with acid modified psyllium for the treatments M_1 & M_2 with recorded values of 5.00 & 4.65 for spread ratio more than control cookies (4.63). Spread ratio of M_1 & M_2 treatments increased as their diameter too found decreasing, due to reduction in moisture absorption capacity of the psyllium husk because of acid modification resulting in less absorption of moisture by the cookies that decreased the diameter and accordingly affected spread ratio. Moreover, the reverse trend was not found for M_3 treatment with 12% incorporation level of acid modified PSH in cookies, recorded 3.43 spread ratio value less than control.

Top grain Development

Top grain development was found to be increased in treated sample particularly modified psyllium husk incorporated cookies followed by the native psyllium husk incorporated cookies than control sample. The spread ratio of cookies made with high protein flour does not develop during baking, as non-wheat high protein flours used in biscuits exhibit greater water retention than those made from wheat flour (Ordorica and Peredes, 1990) [15]. The water in the system was insufficient to dissolve the sugar during baking which increased the viscosity and the biscuits spread at a slower rate. This decrease indicated that the biscuits lost more water upon baking.

Effect of acid modified psyllium husk on color tonality **of cookies**

Color tonality was observed following the method given by Tahira *et al*. (2014) [16]. Colour was recorded using a CIELAB uniform colour system or CIE—$L^*a^*b^*$ uniform colour space (*Lab*), where L^* indicates lightness (0 % for black and 100 % white), a^* indicates chromaticity on a green (-) to red (+) axis, and b^* chromaticity on a blue (-) to yellow (+) axis. Numerical values of a and b were converted into hue angle ($H^o = \tan^{-1} b^*/a^*$) and Chroma [Chroma = $(a^{*2} + b^{*2})^{1/2}$] (Francis, 1980) [17]. Color tonality of cookies was evaluated through estimation of L*, a* b*, c* and h* values. Statistical

data presented in Table 7 regarding these traits indicating significant differences due to treatments.

Table 7: Effect of treatments on color tonality of psyllium husk incorporated cookies

Treatments	Color Tones				
	L*	a*	b*	c* value	h* value
Control	68.81	7.71	32.38	33.28	76.61
PSH (N)					
N_1	66.15	5.76	29.39	29.96	78.90
N_2	65.77	6.85	27.98	28.81	76.25
N_3	63.06	7.51	29.61	29.84	75.58
PSH (M)					
M_1	66.09	8.02	29.66	30.77	74.89
M_2	65.44	6.40	27.03	27.80	76.70
M_3	63.86	5.93	26.74	27.36	77.51
SE ±	2.5860	0.8247	1.2546	1.5398	2.5864
CD @ 5%	7.7610	2.4741	3.7638	4.6194	7.7596

* Each value is average of three determinations

4.9.3.1 L* value

Data pertaining to the L* value highlighted in Table 7 indicated that, means for this trait was observed maximum 68.81 in Control cookie sample while the minimum 63.06 was recorded in cookies containing 12% native psyllium husk (N_3) indicating progressive decline for this trait. In case of the modified psyllium husk incorporated cookies the minimum 63.06 value was recorded for L* trait in cookies containing 12% modified psyllium husk (M_3) while maximum value 66.09 was found in sample M_1 (Cookies containing 6% modified PSH) at par with the sample N_1 (Cookies containing 6% native PSH) recorded value 66.15. Similar trend was observed for corresponding level of incorporation for native and modified psyllium husk respectively, indicating no substantial effect of acid modification of PSH on L* value as compared to the cookies containing native psyllium husk.

Decreased L* value in the psyllium husk incorporated cookies indicating darker color was due to gradual increase of psyllium husk in respective treatments. Darkening of color owes to addition of husk as fiber is considered a promising factor in the tonality of bakery products. Similar results for darker hue due to fiber supplementation in tortillas and cookies were reported by Friend *et al.* (1992) [18] and Toma *et al.* (2009) [19], respectively.

4.9.3.2 a* value

The recorded mean values of a* value explicated in Table 7 showed that increasing trend by adding up of psyllium husk but less than the control cookie (7.71) for native psyllium husk incorporated cookies. In case of modified psyllium husk incorporated cookies, reverse trend was observed, with the increase in the addition level of modified psyllium husk decrease in a* value was observed. Further, maximum a* value of 8.02 was observed in M_1 (cookie sample containing 6% modified psyllium husk). Increase in the a* value in cookies demonstrated more reddish colour in the end product owing to incorporation of psyllium husk. Earlier, similar results also found in cookies & burritos by Toma *et al.* (2009) [19] and inferred this effect because of adding fiber.

4.9.3.3 b* value

The impact of treatments on b* value of PSH incorporated cookies showed a decreasing trend for PSH incorporated cookies (Table 7). The maximum mean b* value noted for control was 32.38 that decreased to 26.74 in M_3 (cookie containing 12% modified psyllium husk). Similar studies were conducted by Tahira *et al.*(2013) [12] for dietetic cookies prepared from psyllium husk with 5, 10, 15, 20, 25% along with control for color tonality and sensory response acceptability at 0 to 60 days, respectively. They reported results regarding color tonality that, dietetic cookies showed significant variations with the addition of psyllium husk. The L* value of the cookies decreased with the addition of psyllium husk while a* and b* values were increased while during storage of 60 days of the dietetic cookies showed significant increase in L* value whilst a* and b* values were decreased.

Patricia *et al.* (2015) [20] reported that higher browning index in the fiber added cookies might be due to change in color of fiber during baking thus darker product compared to control. Similarly Hussein *et al.* (2011) [21] reported that enhanced b* values in biscuits containing higher fiber levels using flour of raw, soaked and germinated fenugreek flour blended with that of corn.

The results pertaining to the color parameters of all the cookies formulations (Incorporated with varied proportions @ 6, 9, 12% of native & modified PSH) tested indicated non-significant differences. These results were due to the protein present in wheat flour, responsible for the effects of caramelisation and Maillard browning reactions between the protein and the sugar present, as reported by Gallagher *et al.* (2003) [22]. This may also be due to the resemblance of colour between Psyllium and baked wheat flour. It was also observed that biscuits with higher levels of Psyllium showed a wrinkled surface, as previously reported by Sudha *et al.* (2007)[23] in relation to the addition of bran responsible for the reduction of surface smoothness.

Conclusion

In conclusion, the present study suggests that acid modified psyllium husk could be explored as a natural source of dietary fiber in the value addition of cookies and upto 6% modified psyllium husk substitution level with refined wheat flour (*maida*) recorded as best formulation without having adverse effect on the physical properties and color tonality characteristics of the cookies. Acid modification of psyllium husk as desired could be carried out by treating native psyllium husk with concentration of 0.65 % HCl in the ethanol solvent for solvent ratio of 1:6 (w/v) as psyllium husk: solvent ratio for improving functional properties of psyllium husk without affecting the bioactive component 'arabinoxylan' and dietary fiber contents.

Plate 1: Control cookies and cookies incorporated with 6% Native (N_1) and Modified (M_1) Psyllium husk respectively

Plate 2: Control cookies and cookies incorporated with 9% Native (N_2) and Modified (M_2) Psyllium husk respectively

Plate 3: Control cookies and cookies incorporated 12% Native (N_3) and Modified (M_3) Psyllium husk respectively

Plate 4: Selected Cookies (M_1) formulation incorporated with 6% Modified Psyllium husk

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