International Journal of Food Science and Nutrition
ISSN: 2455-4898; Impact Factor: RJIF 5.14
Received: 08-02-2019; Accepted: 11-03-2019
www.foodsciencejournal.com
Volume 4; Issue 3; May 2019; Page No. 33-37

Development of gluten free biscuits and evaluation of functional properties of composite flour

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Abstract
Gluten free biscuits, also suitable during fasting were developed utilizing different levels of water chestnut and makhana powders. Four types of formulations of biscuits were prepared with water chest nut and makhana flour. The water chestnut flour for biscuits was substituted with makhana flour in four different levels 40, 30, 20, and 10%. Biscuits were developed using creamery method and evaluated for physical properties, proximate composition, sensory characteristics and storability at room temperature. The spread ratio was found to increase from 8.4 to 11.25 with decrease in addition of makhana flour from 40 to 10%. Textural measurements showed that breaking hardness and fracturability biscuit was increased with decrease in addition of makhana powder in flour blends. The functional properties of composite flours such as swelling power and solubility, foaming capacity and stability, bulk density, least gelation concentration, water absorption power and oil absorption power get varied with percentage of flour blends. Sensory data indicated that maximum overall acceptability scores for biscuits developed using 90:10 parts of water chestnut and makhana powders in flour blend.

Keywords: water chestnut flour, makhana flour, spread ratio, texture, hardness

1. Introduction
Biscuit is the one of the oldest bakery snack item, consumed by all age groups regularly. Biscuit industry in India is expected to grow at a rate of 15 to 17% in coming years. Biscuits, which are one of the most commonly, accepted snack foods may be considered as one of the good supplementary food for distributing to the undernourished children through developmental agencies (Jha, 2014) [6].
Biscuits are typically round cakes of bread that are leavened with baking powder, baking soda or sometimes yeast. It may also refer to a cookie or cracker. They are mostly sweet and in history they were used by travelers as they were long-lasting foods and easy to carry. It is made with different kind of flour, butter, sugar and other ingredients. It is often served with tea; coffee etc. It is a snack which is widely acceptable by all age groups and easy to carry while traveling (Mehta & M, 2014) [8].
Gluten free biscuit was prepared by using water chestnut flour and makhana flour. Products made from chestnut characterized with two specific advantages: source of essential fatty acids and gluten free content (Nafisa & Hegazy, 2014) [10]. Popped makhana flour may possibly serve as a useful alternative in nutritious food products and could improve the physico-chemical, functional and sensory characteristics of products. Incorporating popped makhana flour (10-40%) in cookie formulation and examines the proximate, physical, color, textural and sensory properties of cookies (Kumar & I.S., 2015) [7].
Gluten free biscuit was useful for people suffering from celiac disease. Celiac disease, a disease caused by an immune disorder which is also known as gluten sensitive enteropathy, occurs in people who have a genetic problem with gluten when they eat it (Chopin Technologies). Increasing numbers of scientists in the medical field acknowledge the existence of this autoimmune enteropathy that is the result of permanent gluten intolerance (Mert, 2014) [9].
Overall, composites flour was a good new approach to utilizing uncommon food products as the application of composite flour produced products with different characteristics and quality (Noorfarahzilah, 2014) [11].

2. Materials and Methods
The study was conducted in the laboratory of the Department of Food Technology, Laxminarayan Institute of Technology, and Nagpur.

2.1 Materials
The raw materials used for the production of gluten –free cookies: water chestnut flour, makhana flour, sugar and fat have been purchased from M/s Bapat Mega Mart Nagpur. Lab grade ammonium bi-carbonate, sodium bicarbonate, baking soda, sodium Metabisulphite and glycerol monostearate were used from food laboratory of LIT Nagpur.

2.2 Formulation
Four flour blends, prepared using water chestnut and makhana powder are given in Table 1.
Biscuit dough was prepared and sheeted to a thickness of about 4.5 mm approximately, cut into round shape of 45 mm diameter, transferred to baking tray and baked at 180 °C for 15 min. The biscuits, after attaining the room temperature were packed in LDPE bags and evaluated for all different quality parameters.

2.3 Physical Properties
Expansion in diameter and thickness gives spread ratio of biscuit; diameter and thickness before and after baking were also recorded. Spread ratio of biscuit samples was calculated

as per standard AOAC methods. Fifteen biscuit samples were considered for determining the physical properties of different types of biscuits. (Oppong David, 2015) [12]

Table 1: Proportion of different ingredient in biscuits

Composition	A	B	C	D
Shingada flour(gm.)	60	70	80	90
Makhana flour(gm.)	40	30	20	10
Fat(gm.)	35	35	35	35
Sugar(gm.)	35	35	35	35
$NaHCO_3$ (gm.)	0.2	0.2	0.2	0.2
$(NH_4)HCO_3$(gm.)	0.5	0.5	0.5	0.5
Baking Powder(gm.)	0.3	0.3	0.3	0.3
Water(ml)	52	54	48	55
SMBS(gm.)	2.5	2.5	2.5	2.5
GMS(gm.)	5	5	5	5

2.4 Proximate and Mineral Analysis
Protein, ash, fat and crude fiber of cookies prepared with different proportion of makhana and wheat flour were quantified according to AOAC (2000). Carbohydrates were determined by difference method (Oppong David, 2015) [12]. The prepared four samples dry ashing was done in muffle furnace at 420ºC. The dry ash was then analyzed for iron and calcium content.

2.5 Functional Properties
Functional properties such as swelling power and solubility, foaming capacity and stability, bulk density, least gelation concentration, water absorption power and oil absorption power were determined by standard method (Jayamuthunagai, 2014) [5].

2.6 Textural Properties
Texture analysis was done to determine the hardness and fracturability of the four samples prepared using 3-point bending rig (HDP/3PB) using 5kg load cell, heavy duty platform (HDP/90).

2.7 Sensory Characteristics
Sensory characteristics of biscuits were evaluated for its different sensory attributes by a group of nine panelists. Sensory attributes like appearance and color, texture, odor, flavor and taste and overall acceptability for all biscuit samples were assessed using nine point hedonic scales (Oppong David, 2015) [12].

2.8 Shelf Life Study
The most accepted sample was kept for 60 days. The moisture and free fatty acid content were determined over the set intervals.

3. Results and Discussion
3.1 Physical Properties
Thickness and diameter before and after baking; spread ratio and baking loss is given below in Table 2 for four different types of biscuit samples. From the result it was noticed that, diameter and spread ratio of the composite biscuits increased with decrease in the substitution level of makhana flour. Biscuit having high spread ratio are considered most desirable (Chavhan, Saxena, & Singh, 2016) [2]. Baking loss of biscuits was observed to decrease as a proportion of water chestnut flour increases in the blend due to the high fiber content resulting in high water retention rate. Figure 1 shows the graph of spread ratio.

Table 2: Physical properties of four samples of biscuits

Composition		A	B	C	D
Weight of Dough(g)		205	208	203	201
Total Weight of Biscuit(g)		163	158	168	164
Water loss in %		20.48	24.03	17.24	18.4
Yield %		79.52	75.97	82.76	71.6
Dimension Before Baking(mm)	Diameter	4.5	4.5	4.5	4.5
	Thickness	0.3	0.3	0.3	0.3
Dimension After Baking(mm)	Diameter	4..2	4.3	4.4	4.5
	Thickness	0.5	0.4	0.4	0.4
Weight of Biscuit		5.57	6.51	7.15	6.49
Spread Ratio		8.4	10.75	11	11.3

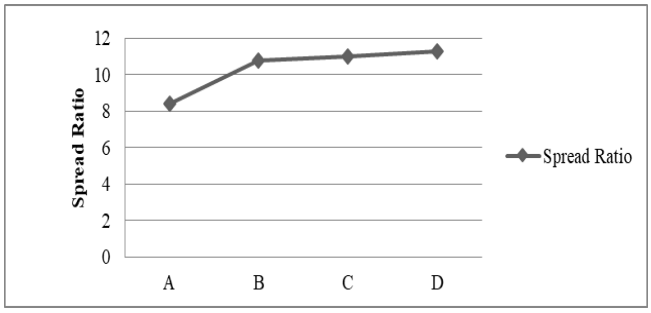

Fig 1: Graphical representation of spread ratio of different samples

3.2 Proximate and Mineral Analysis
Table 3 depicts the results obtained from proximate and mineral analysis conducted on four formulations of gluten free biscuits samples. These findings shows apart from crude fiber and calcium content in the biscuits, rest all parameters were observed to remain same. As the content of water chestnut flour increased the, crude fiber content also increased corresponding to the fact that water chestnut flour (3.8%) contained higher crude fiber than makhana flour (2.5%). Similarly, depression in the calcium content with decrease in makhana flour was due to high content of calcium in makhana flour (Nafisa & Hegazy, 2014) [10] (Kumar & I.S., 2015) [7].

Table 3: Proximate and mineral analysis of four different samples of biscuits

Parameters	A	B	C	D
Fat%	16.08±0.68	16.30±0.53	14.14±0.87	15.24±0.42
Crude Fiber%	2.75±0.18	3.14±0.09	4.82±0.14	5.13±0.25
Carbohydrate%	73.22±0.67	72.92±0.56	73.68±0.83	72.14±0.23
Protein%	6.24±0.15	5.78±0.51	5.63±0.15	6.08±0.45
Mineral%	1.71±0.08	1.53±0.02	1.73±0.05	1.41±0.07
Iron(mg/100gm)	2.85±0.30	3.33±0.77	5.35±0.43	2.9±0.54
Calcium(mg/100 gm)	233.6±0.47	248.4±0.21	184±0.86	146.16±0.27

3.3 Functional Properties
Functional properties studied of the prepared four samples are given in Table 4 below. It is evident that with the increase in concentration of water chestnut flour swelling power, oil absorption and bulk density also increased. Formation of protein-amylose complex in native starches and flours may be the cause of decreased in swelling power.

Bulk density is inversely proportional to particle size. Particle size of water chestnut flour is less as compared to makhana flour. Hence bulk density increases when water chestnut flour increases in composition.

The presence of lipids could result in reduced water absorption capacity of flours which is seen as with the increase in water chestnut flour composition, water absorption capacity decreases, due to the fact that water chestnut contain high lipids than makhana flour. Hydrophobic proteins increases with increase in water chestnut flour concentration which results in increasing oil absorption. Rest of the parameters didn't show any significant variations. These parameters are shown in graphical form in Figure 2 to Figure 6

Table 4: Functional properties of four different flour blends

Parameters	A	B	C	D
Swelling%	3.1557	4.0575	5.3035	5.9106
Solubility%	19.57	17.07	15.78	15.32
Foaming Capacity%	10	10.4	10.63	12
Foam Stability	0	0	0	0
Water Absorption (gm. /gm.)	2.952	2.616	2.492	1.949
Oil Absorption (gm. /gm.)	1.571	1.741	1.838	1.926
Bulk Density(gm./ml)	0.7692	0.833	0.909	0.9523

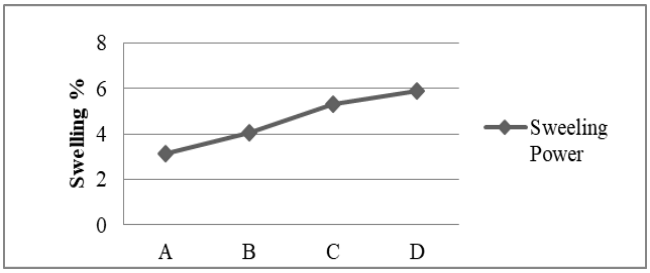

Fig 2: Graphical representation of swelling power of four flour blends

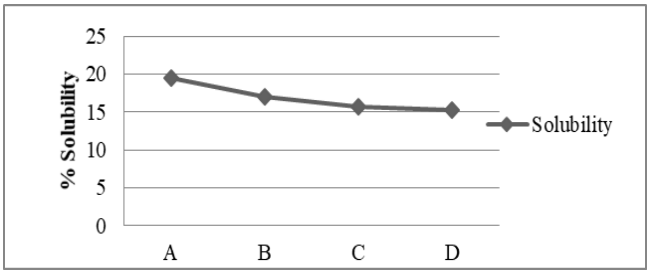

Fig 3: Graphical representation of solubility of four flour blends

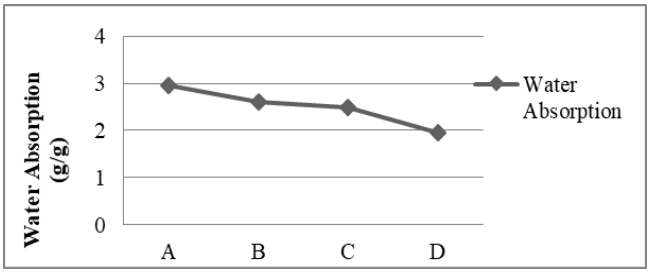

Fig 4: Graphical representation of water absorption of four flour blends

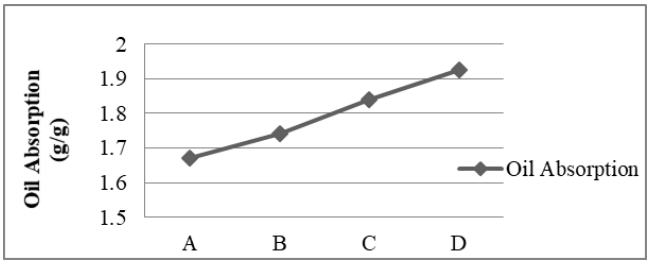

Fig 5: Graphical representation of oil absorption of four flour blends

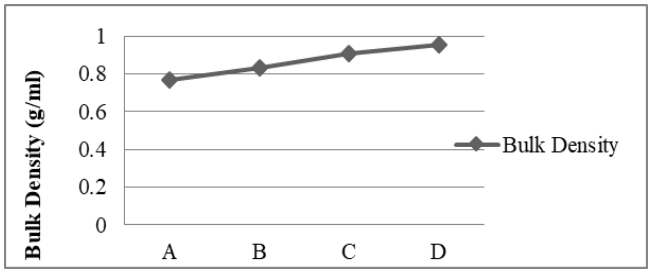

Fig 6: Graphical representation of bulk density of four flour blends

3.4 Texture Analysis

Given below in Table 5 is the data obtain from texture analysis of prepared four samples of gluten free biscuits with varying the compositions. It is evident from the data that, with decrease in fracturability, hardness increases as when makhana flour is decrease crispiness decreases. This data is produced in graphical form in Figure 7 and Figure 8.

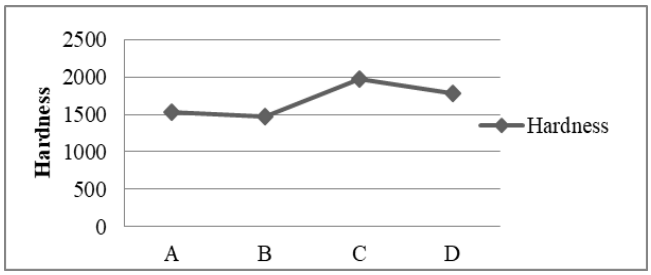

Fig 7: Graphical representation of hardness of biscuit samples

Table 5: Textural properties of four different samples of biscuits

Parameters	A	B	C	D
Hardness				
Average	1523.8	1479.3	1973.3	1777.3
Standard Deviation	218.9	231.38	533.1	644.14
Fracturability				
Average	3.0787	3/3127	3.8587	3.788
Standard Deviation	1.1257	0.2992	0.1902	1.0025

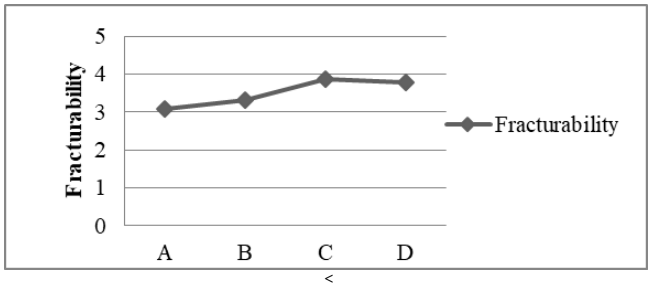

Fig 8: Graphical representation of fracturability analysis of biscuit samples

3.5 Sensory Characteristics

Table 6 gives the results obtained from sensory analysis of all four biscuit samples on 9-point Hedonic scale. It was observed that sample D with 90:10 ratios of water chestnut and makhana flour composition biscuits had highest overall acceptability.

Table 6: Sensory evaluation of four biscuit samples on 9-point Hedonic scale

Sample name	A	B	C	D	Control
Appearance	6.66±1.25	7.62±0.56	7.46±0.97	7.60±1.14	6.75±1.04
Color	6.66±1.25	7.76±0.82	7.30±0.67	7.82±1.10	7.87±0.62
Aroma	6.66±0.76	7.40±0.96	7.26±0.62	7.54±0.55	7.50±0.57
Taste	6.8±1.30	7.40±0.54	7.62±0.81	7.74±1.21	6.75±1.04
Texture	6.9±1.27	7.55±0.77	8.00±00	8.1±0.14	7.7±690
After taste	6.6±1.14	7.36±1.11	7.36±0.49	7.54±1.14	6.87±0.85
Overall acceptability	6.7±1.30	7.52±0.11	7.40±0.54	7.74±1.21	6.87±0.85

3.6 Shelf Life Study

Most accepted biscuit sample with 90:10 composition of water chestnut flour and makhana flour blend composite flour biscuits were stored at room temperature for 60 days. The changes in moisture content and free fatty acid content were studied over this period between set intervals. The data obtained is produced in the Table 7. This data is produced into a graph shown in Figure 9.

According to the graph moisture content and free fatty acid content is seen to increase over the span of 60 days. From this it can be concluded that oxidation of fats in the biscuits increases with the time. Crispiness decreases as moisture content increases with time.

Table 7: Moisture and FFA content in sample D biscuits over a period of 60 days

Days	Moisture	Days	FFA
2	3.1	4	1.45
8	3.24	8	1.59
15	3.68	16	1.68
24	3.72	18	2.091
38	3.88	33	2.69
47	3.91	44	2.76
60	3.97	60	2.83

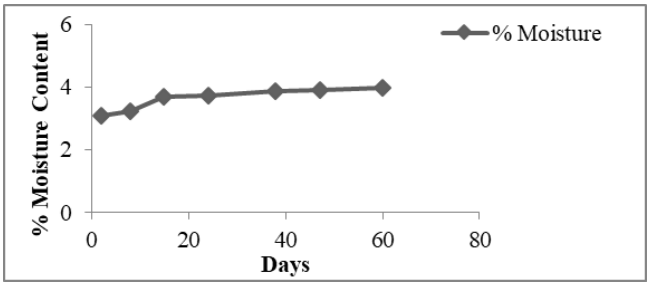

Fig 9: Variation in moisture content over the period of 60 days

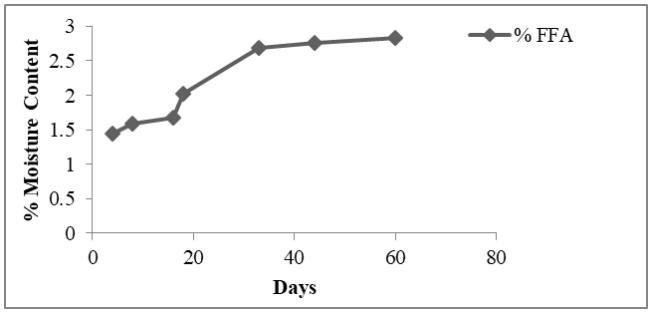

Fig 10: Free fatty acid variation in biscuits over 60 days

4. Conclusion

Gluten free biscuits were developed from water chestnut and makhana flour by varying their composition. Four different compositions of water chestnut and makhana flour were studied. In composition ratio of water chestnut flour with makhana flour were 60:40,70:30,80:20 and 90;10 respectively. Addition of water chestnut and makhana powder to biscuits increases dietary fiber and mineral contents. From the results of proximate analysis it can be concluded that calcium and iron in gluten free biscuits were found to be higher.

The functional properties of the water chestnut and makhana powder were studied. Swelling percentage, foaming capacity, oil absorption and bulk density increases with increase in quantity of water chestnut flour in composition. This may be due to increase in concentration of lipid in the composite four. Percentage of water absorption decreases with increase in Makhana flour in composition.

From shelf life study it was observed that moisture content and free fatty acid content increased with time. Sensory characteristics of biscuits were studied. Gluten free biscuits were good for consumption up to 3 months from manufacture.

Though all the levels of makhana powder in flour blends resulted in acceptable quality biscuits but the maximum mean scores for different sensory characteristics for biscuits developed utilizing 90:10 parts of water chestnut and makhana powders. Biscuits with all composition were having good storability at room temperature for 90 days period indicated the commercial scope for manufacturing of good quality fruits powders based biscuits, which can be consumed during fasting and also by people with gluten allergy.

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