The Pharma Innovation Journal 2020; 9(9): 527-532

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2020; 9(9): 527-532

www.thepharmajournal.com
Received: 01-07-2020
Accepted: 05-08-2020

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Development of potato flour based cookies and quality evaluation

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Abstract
Experiments were conducted to develop potato flour based cookies. The potatoes (Variety: Kufri Chipsona -1) were washed with fresh water to remove the adhering soil particles and peeled manually with the help of stainless steel peeler. Peeled potatoes were cut into slices of 2 mm thickness and pretreated with blanching plus 0.5% KMS solution for 3 minutes then slices were dried at 60^0 C in tray drier. The dried slices were ground to make potato flour. The various ingredients *viz*., potato flour, wheat flour, milk powder, baking powder, sugar, ghee etc were used in making cookies. Baking was done at 180^0 C for 15 minutes in deck oven. The physical proerties (diameter, thickness, volume and spread ratio), physico-chemical quality (moisture content, protein, fat, fibre and ash content) and sensory qualities (colour, flavour, taste, texture and overall acceptability) were evaluated during storage of 90 days under ambient conditions. The results of the study revealed that diameter, volume and spread ratio of cookies increased with increase in incorporation ratio of potato flour and thickness decreased with increase in incorporation ratio of potato flour. The fat, protein, ash and fibre content decreased with storage period whereas moisture content increased. The highest protein content, fibre and ash content were found in cookies made with incorporation ratio of 30:70 (30% potato flour+70% wheat flour). The sensory quality studies indicated that potato cookies in fresh condition (incorporated with 30% potato flour and 70% wheat flour) had maximum overall acceptability score of 8.05 which further decreased to 7.53 after 90 days storage. The cookies were found acceptable and "liked moderately" even after 90 days of storage on the basis of Hedonic rate scale.

Keywords: Potato flour, cookies, diameter, moisture content

Introduction
India ranks 3rd in area and 2nd in production of potato in the world after China. At world level, about 368.247 million tonnes of potato is produced. This production is obtained over an area of about 17.580 million hectare. The major potato growing countries in the world are China, Russia, India, USA, Germany, Poland, Ukraine, U.K., Turkey, Iran, Netherlands, France, New Zealand and Belgium. Potatoes (*Solanum tuberosum*) are an important global crop that can be transformed into many products impacting several health dimensions ranging from under-nutrition, food security and disease prevention to issues of over-nutrition including obesity, diabetes, heart disease. Potato tuber has many medicinal applications such as raw potato juice is used in inflammation of the stomach, large intestine and gastric and intestinal ulcers due to the antibacterial and healing properties of juice. Potato can be used as a natural remedy for the treatment of constipation and prevention of haemorrhoids. Potatoes are a great source of potassium which helps to lower and stabilize blood pressure. Due to the presence of polyphenols, potato tubers have antioxidant abilities protect the body from cancer and cardiovascular disease (Sawicka *et al.*, 2018) [16].

Among such dehydrated products, potato flour is the oldest, commercially processed potato product (Willard and Hix, 1987) [18]. During the season, when potatoes are cheap, potato flour can be prepared and stored in air tight containers and used later during off-seasons in place of fresh potatoes (Marwaha, 1997) [11]. Processing of potato into flour is perhaps the most satisfactory method of creating a product that is not only functionally adequate, but also remain for an extended period without damage (Hadziyev and steele, 1979) [5]. Different products are prepared by incorporating potato flour with other flours using different methods of cooking such as baking, roasting, steaming, boiling and deep fat frying etc. (Hahlawal and Sehgal, 1996) [6].

Nanda and Khanna, 1988 [12] reported that potato flour incorporated food products such as dalia, tomato soup, vegetable stew, khichri, sev, paratha, and upma were rated as very good and there occurred no deterioration in the appearance, colour, texture or taste of the product due to addition of potato flour. Potato flour is nowadays widely used in the food industries, specially in baking industries in the preparation of bread and biscuits. Potato flour is incorporated in the baking of bread to retain its freshness. It also imparts a distinctive, pleasing flavour and improves toasting qualities. The generally accepted level of potato flour in the bread. It can also be used advantageously in crackers, pastries, yeast raised doughnuts, cake and cake mixes (Kulkarni *et al.*, 1996) [10].

Processing of potato is very advantageous because it makes storage easier due to the reduction in bulkiness and increased in shelf life. It adds value to potatoes and therefore gives better returns. The post harvest processing of the bulky, perishable, fresh tuber into dehydrated potato products helps to extend the storage life, solve the problem of storage and serves as a means to increase the supply in off-season.

Materials and Methods

The potato variety namely Kufri Chipsona-1 was procured from the experimental farm of Central Potato Research Institute (CPRI), Modipuram for the present studies. The other materials like milk powder, sugar, PET jars, wheat flour, ghee and baking powder were procured from the local market.

Preparation of potato flour

Potatoes were washed with fresh water to remove the adhering soil particles and peeled manually with the help of stainless steel peeler. Peeled potatoes were cut into slices of 2 mm thickness using hand operated stainless steel slicer. Then potato slices were pre-treated with method such as blanching with 0.5% potassium meta bisulphite (KMS) for 3 minutes. After pre-treatments, slices were spread over the blotting paper to remove surface moisture and then dried at 60^0 C. After drying, potato slices were ground using grinder in the lab. Preparation of potato flour as shown in Fig.1.

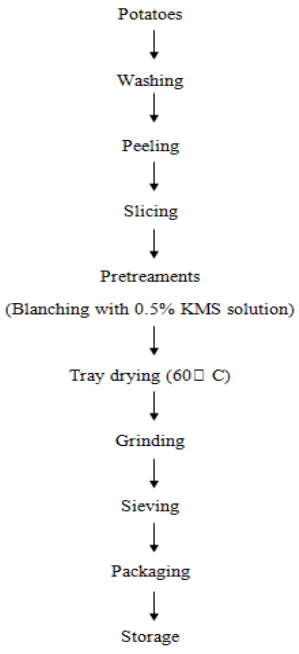

Fig 1: Process flow chart for preparation of potato flour

Cookies formulation and preparation

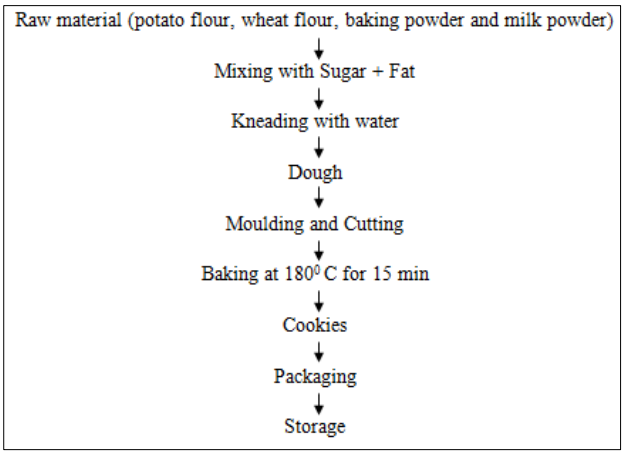

Fig 2: Process flow chart for preparation of cookies

Table 1: Ingredients for cookies

Ingredients	Samples code			
	Control	T_{10}	T_{20}	T_{30}
Wheat and Potato flour (g)	600	540+60	480+120	420+180
Sugar (g)	350	350	350	350
Milk powder (g)	50	50	50	50
Baking powder (g)	5	5	5	5
Ghee (g)	200	200	200	200
Water	22-24%	22-24%	22-24%	22-24%

Methodologies

Cookies were prepared from potato and wheat flour in ratio of 100:0, 90:10, 80:20 and 70:30 respectively and stored in PET jars under ambient condition for 90 days. Physical, physico-chemical and sensory properties were measured in all four types of cookies and each reading was taken in triplicate.

Physical properties

Thickness

Thickness of cookies were measured by four cookies stacking above the others. The average of thickness was recorded and it was measured by screw gauge in mm

Volume

Volume of cookie is defined as the area of cookies multiplied by its thickness (Jemziya and Mahendran, 2017) [9].

$$\text{Volume } (cm^3) = \frac{d^2 \Pi t}{4}$$

Where

t= thickness of cookies (cm)
d= diameter of cookies (cm)

Diameter

Diameter of cookie is measured by vernier calliper in mm. Four samples were placed next to another and the total diameter was calculated. The average of diameter was recorded (Ho and Latif, 2016) [7].

Spread ratio

The spread ratio was calculated by dividing diameter of cookies with thickness of cookies

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

Proximate composition
Protein, fat, ash, fibre and moisture content were determined according to the method described by AOAC, 1990 [1].

Sensory quality attributes
The sensory quality attributes *viz*. colour, flavour, taste, texture and overall acceptability of potato cookies, potato bread and potato extruded snacks were evaluated using 9 points hedonic rating test method as recommended by Ranganna (2010) [14]. This test measures the consumer's acceptability. A semi-trained panel consisting of both genders, more than 10 judges of different age groups having different eating habits were constituted to evaluate the quality. The judges were selected amongst the faculty members, staff and students of the university. Samples were served to the panelists and they were asked to rate the acceptability of the product through sense of organs. Different attributes *viz*. colour, flavour, texture and taste were rated on the basis of 9-Point hedonic scale ranging from 1 (extremely dislike) to 9 (extremely like).

Results and Discussion
Physical properties of cookies
Diameter
The data for variation in diameter of cookies with respect to incorporation ratio of potato flour and wheat flour is given in Table 2. The diameter of cookies ranged from 3.13 to 3.40 cm. The value of highest diameter (3.40 cm) was observed for T_{30} cookies followed by T_{20} (3.36 cm), T_{10} (3.21 cm) and lowest value (3.13 cm) for control samples (T_0). The study revealed that diameter increased with increase in the incorporation ratio of potato flour. This might be due to higher water holding capacity of potato flour. Larger cookies diameter is considered as the desirable quality attributes (Yamamoto *et al.*, 1996) [20]. Similar findings were observed by Yadav *et al.*, 2012 [19]. The study revealed that the diameter for different incorporation ratio of potato flour and wheat flour cookies were found to be significant at $p \leq 0.05$ level of significance.

Thickness
The data for variation in thickness of cookies with respect to incorporation ratio of potato flour and wheat flour is given in Table 2. The thickness of cookies ranged from 1.00 to 1.17 cm. The highest thickness (1.17 cm) was observed for control cookies (T_0) followed by T_{10} (1.09 cm), T_{20} (1.03 cm) and lowest values (1.00 cm) was observed for 30% incorporated potato flour cookies (T_{30}). The study revealed that increased level of potato flour decreased the thickness of cookies. The decrease in the thickness was due to the dilution of gluten (Aslam *et al.*, 2014) [2]. The thickness of cookies was influenced by the initial mass of the dough ball which was taken for the preparation for cookies (Jamilah *et al.*, 2011) [8]. The thickness for different incorporation ratio of potato flour and wheat flour cookies were found to be significant at $p \leq 0.05$ level of significance.

Volume
The data for variation in volume of cookies with respect to incorporation ratio of potato flour and wheat flour is given in Table 2. The volume of cookies ranged from 8.81 to 9.12 cm^3. The highest volume (9.12 cm^3) was observed for 30% potato flour incorporated cookies (T_{30}) followed by T_{20} (9.07 cm^3), T_{10} (8.99 cm^3) and lowest values (8.81 cm^3) was observed for control cookies (T_0). The study revealed that increased level of potato flour increased the volume of cookies. The volume for different incorporation ratio of potato flour and wheat flour cookies were found to be significant at $p \leq 0.05$ level of significance.

Spread ratio
The data for variation in spread ratio of cookies with respect to incorporation ratio of potato flour and wheat flour is given in Table 2 The spread ratio of cookies ranged from 2.67 to 3.40. The highest spread ratio (3.40) was observed for 30% potato flour incorporated cookies (T_{30}) followed by T_{20} (3.26), T_{10} (2.94) and lowest values (2.67) was observed for control cookies (T_0). The study revealed that increased level of potato flour increased the spread ratio of cookies. It is clear that spread ratio is mostly influenced by diameter and thickness of cookies. Larger cookies spread ratio is considered as the desirable quality attributes (Yamamoto *et al.*, 1996) [20]. The spread ratio for different incorporation ratio of potato flour and wheat flour cookies were found to be significant at $p \leq 0.05$ level of significance.

Table 2: Physical properties of cookies for different incorporation ratio of potato flour and wheat flour

Samples	Diameter(cm)	Thickness(cm)	Volume (cm^3)	Spread ratio
T_0	3.13	1.17	8.81	2.67
T_{10}	3.21	1.09	8.99	2.94
T_{20}	3.36	1.03	9.07	3.26
T_{30}	3.40	1.00	9.12	3.40

T_0= Control samples, T_{10}= 10% Potato flour+ 90% Wheat flour samples, T_{20}= 20% Potato flour+ 80% Wheat flour samples, T_{30}= 30% Potato flour + 70% Wheat flour samples

Proximate composition of cookies
Moisture Content
The variation in moisture content of cookies during storage is given in Table 3. The value of moisture content for fresh sample was highest (4.80%) for 30% potato flour incorporated cookies (T_{30}) followed by T_{20} (4.20%), T_{10} (3.40%) and lowest value (3.02%) was observed for control cookies (T_0). The study revealed that moisture content of potato cookies increased significantly with the increment of potato flour level in the cookies. This may be due to high water binding capacity of flour which retained higher moisture content in ultimate product. The study revealed that moisture content of cookies gradually increased during storage period of 90 days. The highest (5.16%) moisture content was found in T_{30} samples followed by T_{20} (4.56%), T_{10} (3.74%) and lowest values (3.28%) found in control samples (T_0) at 90 day of storage. Increase in moisture content of cookies might be due to cookies absorbed moisture from surrounding atmosphere because of hygroscopic nature of flour. The moisture content for different types of cookies was found to be significant at $p \leq 0.05$ level of significance.

Table 3: Moisture content of cookies during storage under ambient condition

Samples code	0 Day	30 Day	60 Day	90 Day
T_0	3.02	3.09	3.19	3.28
T_{10}	3.40	3.52	3.65	3.74
T_{20}	4.20	4.37	4.47	4.56
T_{30}	4.80	4.93	5.02	5.16

T_0= Control samples; T_{10}= 10% potato flour + 90% wheat flour samples; T_{20}= 20% potato flour + 80% wheat flour samples; T_{30}= 30% potato flour + 70% wheat flour samples

Effect on Protein Content

The data for variation in protein content of cookies during storage is given in Table 4. The value of protein content for fresh sample was highest (9.70%) for control samples (T_0) followed by T_{10} (9.35%), T_{20} (8.97%) and lowest values (8.38%) was observed for 30% potato flour incorporated cookies (T_{30}). The study revealed that protein content of potato cookies decreased significantly with the increment of potato flour level in the cookies. Similar trends were found by Cardenas *et al.*, 2014 [4]. They reported decrease in protein content of cookies as the incorporation of potato flour was increased. The study revealed that protein content of cookies gradually decreased during storage period of 90 days under ambient storage conditions. The highest protein content was found in T_0 samples (9.49%) followed by T_{10} (9.15%), T_{20} (8.78%) and lowest (8.17%) for T_{30} samples at 90 day of storage. A decrease in protein content might be due to increase in moisture content of the cookies during storage.

The protein content for different types of cookies were found to be significant at $p \leq 0.05$ level of significance.

Table 4: Protein content of cookies during storage under ambient condition

Samples code	0 Day	30 Day	60 Day	90 Day
T_0	9.70	9.62	9.56	9.49
T_{10}	9.35	9.28	9.21	9.15
T_{20}	8.97	8.91	8.85	8.78
T_{30}	8.38	8.30	8.22	8.17

T_0= Control samples; T_{10}= 10% potato flour + 90% wheat flour samples; T_{20}= 20% potato flour + 80% wheat flour samples; T_{30}= 30% potato flour + 70% wheat flour samples

Effect on Fat Content

The data for variation in fat content of cookies during storage is given in Table 5. The value of fat content for fresh sample was highest (24.49%) for control samples (T_0) followed by T_{10} (24.43%), T_{20} (24.39%) and lowest values (24.35%) was observed for 30% potato flour incorporated cookies (T_{30}). The higher fat in control cookies might be due to higher fat content in wheat flour as compared to potato flour (Saini *et al.*, 2017) [15]. The study revealed that fat content of cookies gradually decreased during storage period of 90 days under ambient conditions. The highest fat content (24.16%) was found in T_0 samples followed by T_{10} (24.11%), T_{20} (24.07%) and lowest (24.02%) for T_{30} samples at 90 day of storage. The decrease in fat content throughout storage period might be due to moisture uptake by the cookies from the surrounding air and breakdown of fats into different compounds (Pasha *et al.*, 2002) [13]. The fat content for different types of cookies was found to be significant at $p \leq 0.05$ level of significance.

Table 5: Fat content of cookies during storage under ambient condition

Samples code	0 Day	30 Day	60 Day	90 Day
T_0	24.49	24.38	24.29	24.16
T_{10}	24.43	24.32	24.25	24.11
T_{20}	24.39	24.26	24.20	24.07
T_{30}	24.35	24.22	24.17	24.02

T_0= Control; T_{10}= 10% potato flour + 90% wheat flour; T_{20}= 20% potato flour + 80% wheat flour; T_{30}= 30% potato flour + 70% wheat flour

Effect on Fibre Content

The data for variation in fibre content of cookies during storage is given in Table 6. The value of fibre content for fresh sample was highest (1.78%) for 30% potato flour incorporated cookies (T_{30}) followed by T_{20} (1.63%), T_{10} (1.41%) and lowest values (1.36%) was observed for control samples (T_0). The study revealed that fibre content of potato cookies increased significantly with the increment of potato flour level in the cookies. This might be due to higher content of fibre in the potato flour as compared to wheat flour (Saini *et al.*, 2017) [15]. The study revealed that fibre content of cookies gradually decreased during storage period of 90 days under ambient conditions. The highest fibre content (1.63%) was found in T_{30} samples followed by T_{20} (1.52%), T_{10} (1.28%) and lowest (1.19%) for T_0 samples at 90 day of storage. Decrease in crude fibre during storage might be due to increase in moisture content that enhances the amylase activity (Butt *et al.*, 2001, Pasha *et al.*, 2002) [3, 13]. The fibre content for different types of cookies was found to be significant at $p \leq 0.05$ level of significance.

Table 6: Fibre content of cookies during storage under ambient condition

Samples code	0 Day	30 Day	60 Day	90 Day
T_0	1.36	1.23	1.21	1.19
T_{10}	1.41	1.34	1.30	1.26
T_{20}	1.63	1.57	1.54	1.51
T_{30}	1.78	1.69	1.66	1.63

T_0= Control; T_{10}= 10% potato flour + 90% wheat flour; T_{20}= 20% potato flour + 80% wheat flour; T_{30}= 30% potato flour + 70% wheat flour

Effect on Ash Content

The data for variation in ash content of cookies during storage is given in Table 7. A bar chart showing the effect of storage period on ash content of cookies is shown in Fig. 4.36. The value of ash content for fresh sample was highest (1.41%) for 30% potato flour incorporated cookies (T_{30}) followed by T_{20} (0.82%), T_{10} (0.63%) and lowest values (0.51%) was observed for control samples T_0. The study revealed that ash content of potato cookies increased significantly with the increment of potato flour level in the cookies. The ash content of cookies increased with increased incorporation of potato flour might be due to higher ash content of potato flour than wheat flour. The study revealed that ash content of cookies gradually decreased during storage period of 90 days under ambient conditions. The highest ash content was found in T_{30} samples (1.20%) followed by T_{20} (0.59%), T_{10} (0.39%) and lowest in T_0 (0.28%) at 90 day of storage. A similar trend was observed in Sharif *et al.*, 2005 [17]. The ash content for different types of cookies was found to be significant at $p \leq 0.05$ level of significance.

Table 7: Ash content of cookies during storage under ambient condition

Samples code	0 Day	30 Day	60 Day	90 Day
T_0	0.51	0.40	0.32	0.28
T_{10}	0.63	0.49	0.43	0.39
T_{20}	0.82	0.71	0.64	0.59
T_{30}	1.41	1.31	1.26	1.20

T_0= Control; T_{10}= 10% potato flour + 90% wheat flour; T_{20}= 20% potato flour + 80% wheat flour; T_{30}= 30% potato flour + 70% wheat flour

Sensory quality evaluation

It is explicit from the data of color (Table 8) that amongst all combinations the fresh cookies (T_{30}) having 30% potato flours were awarded highest score (8.11) for color whereas control

samples (T_0) scored lowest value (7.18). All the samples were rated between "liked moderately" to "like very much". All the samples recorded progressive decrease in colour score during storage. The study revealed that colour of cookies in fresh condition (T_{30}) scored 8.11 which further lowered to 7.66 after the storage of 90 days. It is evident from the data that on the basis of hedonic scale that cookie was "liked moderately" even after 90 days of storage. From the data of flavour (Table 8) amongst all combinations the fresh cookies (T_{30}) having 30% potato flours were awarded highest score (8.01) for flavour whereas control samples (T_0) scored lowest value (7.12). All the samples were rated between "liked moderately" to "like very much". All the samples recorded progressive decrease in flavour score during storage. The study revealed that flavour of cookies in fresh condition (T_{30}) scored 8.01 which further lowered to 7.48 after the storage of 90 days. It is evident from the data of taste (Table 8) that on the basis of hedonic scale that cookie was "liked moderately". All the samples recorded progressive decrease in taste score during storage. The study revealed that taste of cookies in fresh condition (T_{30}) scored 8.03 which further lowered to 7.26 after the storage of 90 days. It is evident from the data that on the basis of hedonic scale that cookie was "liked moderately". From the data of overall acceptability (Table 8) that amongst all combinations the fresh cookies (T_{30}) having 30% potato flours were awarded highest score (8.05) for overall acceptability whereas control samples (T_0) scored lowest (7.11). All the samples recorded progressive decrease in overall acceptability score during storage. The study revealed that cookies in fresh condition (T_{30}) scored 8.05 which further lowered to 7.53 after the storage of 90 days. It was observed from the data that on the basis of hedonic scale that cookie was "liked moderately" even after 90 days of storage.

Table 8: Sensory quality of cookies

Storage periods (Days)	Colour				Flavour				Texture				Taste				Overall Acceptability			
	T_0	T_{10}	T_{20}	T_{30}	T_0	T_{10}	T_{20}	T_{30}	T_0	T_{10}	T_{20}	T_{30}	T_0	T_{10}	T_{20}	T_{30}	T_0	T_{10}	T_{20}	T_{30}
0	7.1	7.2	7.5	8.1	7.1	7.1	7.5	8.0	7.0	7.1	7.4	8.0	7.1	7.1	7.4	8.0	7.1	7.1	7.5	8.0
30	7.0	7.1	7.4	8.0	7.0	7.1	7.4	7.8	7.0	7.1	7.3	7.9	7.0	7.0	7.4	7.9	7.0	7.1	7.4	7.9
60	6.9	7.0	7.2	7.8	6.9	7.0	7.3	7.7	6.9	7.0	7.2	7.8	6.9	6.9	7.3	7.8	6.9	6.9	7.3	7.8
90	6.8	6.8	7.1	7.6	6.8	6.9	7.0	7.4	6.8	6.9	7.1	7.7	6.7	6.8	7.0	7.2	6.8	6.9	7.1	7.5

T_0= Control samples; T_{10}= 10% potato flour + 90% wheat flour samples; T_{20}= 20% potato flour + 80% wheat flour samples; T_{30}= 30% potato flour + 70% wheat flour samples

Conclusions

The diameter, volume and spread ratio of cookies increased with increase in incorporation of potato flour and thickness decrease with increase in incorporation of potato flour. The study revealed that moisture content of cookies gradually increased during storage period of 90 days. The fat, protein, ash and fibre content decreased with storage period. During storage, highest moisture content was found in 30% potato flour incorporated cookies and fat content was found in control samples. The highest protein, fibre and ash content were found in 30% potato flour incorporated cookies. Sensory quality studies indicated that potato cookies in fresh condition (incorporated with 30% potato flour and 70% wheat flour) had maximum overall acceptability score of 8.05 which further decreased to 7.53 after 90 days storage under ambient condition. These cookies were "liked moderately" even after 90 days of storage on the basis of hedonic scale.

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