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Influence of pre-treatment on functional properties of potato flour

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Abstract
Potato is the most important tuber crop in the world. It belongs to family *Solanaceae* and plays an important role in world food security as it is a cheaper and plentiful crop. It is a versatile, carbohydrate-rich food. The pre-treatments on fruit and vegetables before drying in one form or other viz., washing in water, blanching, KMS, sugar, salt either alone or in combination inhibit enzymatic browning, enhancing color, flavour and texture retention Functional properties are the intrinsic physico-chemical properties that reflect the complex interaction between composition, structure, confirmation and physico-chemical properties of protein and other food components and the nature of environment in which these are associated and measured. The functional characteristics determine the utilization and use of food material for various food products. The functional properties of potato flour namely water absorption capacity, oil absorption capacity, swelling capacity, bulk density, foam capacity and foam stability were determined. The investigation was done to study the effect of pre-treatments viz., blanching, brine solution, KMS plus blanching and KMS solution on functional properties of potato flour (Kufri Chipsona -1, Kufri Jyoti and Kufri Bahar). The water absorption, oil absorption, bulk density, foam capacity and foam stability were maximum in KMS treated flour whereas swelling capacity was maximum in blanching plus KMS treated flour. The functional properties of Kufri Chipsona-1 flour were found to be superior as compared to Kufri Jyoti and Kufri Bahar flour.

Keywords: Potato flour, pre-treatment, water absorption capacity, protein, bulk density

Introduction
Potato is a versatile, carbohydrate-rich food. When freshly harvested, it contains about 80 percent water and 20 percent dry matter content. About 60 to 80 percent of the dry matter is starch. Potato is the most important tuber crop in the world. It belongs to family *Solanaceae* and plays an important role in world food security as it is a cheaper and plentiful crop. In India, 47 potato varieties have been bred for different agro-climatic region in which 28 varieties are popular alone for north Indian plains. Out of these 19 varieties possess multiple resistances to different biotoc and abiotic stresses. Besides, nine varieties are suitable for processing purposes. These are Kufri Chipsona -1, Kufri Chipsona -2, Kufri Chipsona -3, Kufri Himsona, Kufri Jyoti, Kufri Frysona, Kufri Chandramukhi, Kufri Lauvkar and Kufri Surya. Kufri Chipsona -1 and Kufri Chipsona -3 are now being used for the industries for processing into chips and French fries. About 68% of potatoes are utilized for table purpose, 7.5% for processing, 8.5% for seed and remaining 16% produce goes waste due to pre and post harvest handling [13].

Potato protein has a balanced amino acid composition, which is superior to that of cereal protein [4]. Additionally, total vitamin and mineral levels in potato flour are higher than in wheat flour. Potatoes represent the third most important source of phenolics (especially chorogenic acid) after apples and oranges [7]. Furthermore, potatoes contain other phytochemicals such as flavonoids, polyamines, and carotenoids, which are highly desirable in the diet due to their beneficial effects on human health [8]. 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 [15]. The pre-treatments on fruit and vegetables before drying in one form or other viz., washing in water, blanching, KMS, sugar, salt either alone in combination inhibit enzymatic browning, enhancing color, flavour and texture retention

Functional properties are the intrinsic physico-chemical properties that reflect the complex interaction between composition, structure, confirmation and physico-chemical properties of protein and other food components and the nature of environment in which these are associated and measured. The functionality of food is the properties of food ingredient other than a nutritional attribute which has a great impact on its application. The functional characteristics determine the utilization and use of food material for various food products.

Developing countries suggest that processing of potato tuber into flour offer a unique opportunity of presenting the commodity in a more stable form [17]. Therefore, there is the need to know the functional properties of potato varieties for the product development and industrial application of flour. The effects of pre-treatments (brine solution, KMS solution, KMS plus blanching and blanching) on functional properties of potato flour (Kufri Chipsona -1, Kufri Jyoti and Kufri Bahar) have been investigated.

2. Materials and Methods

2.1. Materials

Three varieties of potatoes namely Kufri Chipsona-1, Kufri Jyoti and Kufri Bahar were procured from the experimental farm of Central Potato Research Institute (CPRI), Modipuram, Meerut for the present studies. Detailed methodology is given below.

2.2. 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 different method such as dipped in 5% brine solution for 6 hours (T_1), 0.5% potassium meta bisulphite (KMS) for 15 minutes (T_2), blanching with 0.5% potassium meta bisulphite (KMS) for 3 minutes (T_3), hot water blanching for 3 minutes (T_4) and control (T_0). 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

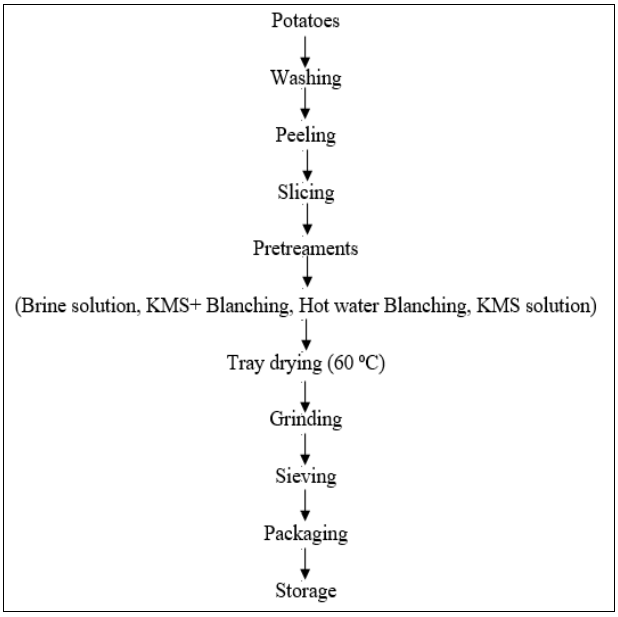

Fig 1: Process flow chart for preparation of potato flour

2.3. Functional properties of potato flour

The functional properties of pretreated potato flour such as bulk density, foam capacity, foam stability, water absorption capacity, oil absorption capacity and swelling capacity were derived by a procedure given below and each reading was taken in triplicate.

2.3.1. Water Absorption Capacity (WAC)

The water absorption capacity of the powder was determined using the method described by Sosulski, Garatt and Slinkard [16]. One gram of sample mixed with 10 ml distilled water was allowed to stand at ambient temperature (30 °C) for 30 min, then centrifuged for 30 min at 3000 rpm or 2000 x g. Water absorption capacity was examined as percent water bound per gram powder.

$$\text{WAC (\%)} = \frac{w_2 - w_1}{w_0} \times 100$$

Where,
W_0 = Weight of the sample (g)
W_1 = Weight of the centrifuge tube plus sample (g)
W_2 = Weight of the centrifuge plus sediments (g)

2.3.2. Oil Absorption Capacity (OAC)

The oil absorption capacity was determined using the method described by Sosulski, Garatt and Slinkard [16]. One gram of sample mixed with 10 ml soybean oil (Sp. Gravity 0.9092) was allowed to stand at ambient temperature (30 °C) for 30 min, then centrifuged for 30 min at 3000 rpm or 2000 x g. Oil absorption was examined as percent oil bound per gram powder.

$$\text{OAC (\%)} = \frac{w_2 - w_1}{w_0} \times 100$$

Where
W_0 = Weight of the sample (g)
W_1 = Weight of the centrifuge tube plus sample (g)
W_2 = Weight of the centrifuge plus sediments (g)

2.3.3. Bulk Density (g/cm^3)

The volume of 100 g of potato powder was measured in a measuring cylinder (250 ml) after tapping the cylinder on a wooden plank until no visible decrease in volume noticed, and based on the weight and volume, the apparent (bulk) density was calculated by the method described by Sosulski, Garatt and Slinkard [16].

$$\text{Bulk density (g/cm}^{3)} = \frac{\text{Weight of sample}}{\text{Volume of sample after tapping}}$$

2.3.4. Foam Capacity

The foam capacity (FC) and foam stability (FS) was determined by the method described by Narayana and Narasinga [12]. The 1.0 g powder sample was added to 50 ml distilled water at 30 °C in a graduated cylinder. The suspension was mixed and shaken for 5 min to form foam. The volume of foam at 30 sec after whipping was expressed as foam capacity using the formula:

$$\text{Foam Capacity (\%)} = \frac{\text{Volume of foam after whipping} - \text{Volume of foam before whipping}}{\text{Volume of foam BW}} \times 100$$

2.3.5. Foam Stability (ml)

The volume of foam was recorded after one hour the whipping was done in order to determine foam stability as per percent of initial foam volume.

2.3.6. Swelling Capacity

The swelling capacity was determined by the method described by Okaka and Potter [14]. 100 ml graduated cylinder was filled with the sample to 10 ml mark. The distilled water was added to give a total volume of 50 ml. The top of the graduated cylinder was tightly covered and mixed by inverting the cylinder. The suspension was inverted again after 2 min and left to stand for a further 8 min and the volume occupied by the sample was taken after the 8th minutes, 100 ml graduated cylinder was marked and swelling capacity (ml) calculated.

3. Results and Discussion

3.1. Water Absorption Capacity

The water absorption capacity is useful in determining the capacity of flour to take up water and swelling to improve uniformity in food. It is evident from the Table 1 that highest values of water absorption capacity (190.16%) was obtained for samples pretreated with KMS solution (T_2) followed by T_1 (170.13%), T_3 (135.78%), T_0 (130.43%) for Kufri Chipsona -1 potato flour whereas lowest values (100.18%) was obtained for blanched pretreated samples (T_4). The similar trends were obtained while comparing the pretreatments irrespective of potato varieties. The water absorption capacity ranged between 95.35 to 170.13% among all the pretreated flours. The highest value of water absorption capacity (190.16%) was obtained for potato flour (Kufri Chipsona -1) pretreated with KMS solution (T_2) followed by Kufri Jyoti (183.17%) and Kufri Bahar (171.76%). The higher water absorption capacity of Chipsona -1 flour could be attributed to the presence of higher amount of carbohydrate in the flour. The flour with high water absorption capacity may have more hydrophilic constituents such as polysaccharide. Protein has both hydrophilic and hydrophobic nature and therefore they can interact with water in foods. The good water absorption capacity of potato flour may prove useful to products where good viscosity is required such as soups and gravies. The observed variation in different flours may be due to different protein concentration, their degree of interaction with water and conformational characteristics [18].

Table 1: Water absorption capacity of pre-treated flours of different potato varieties

		Potato Varieties		
		Kufri Chipsona-1 (%)	Kufri Jyoti (%)	Kufri Bahar (%)
Pre-treatments	T_0	130.43	120.17	99.27
	T_1	170.40	159.74	148.61
	T_2	190.16	183.17	171.76
	T_3	135.78	121.19	118.72
	T_4	100.18	97.64	95.36
T_0 =Control; T_1 = Brine solution treated; T_2 = KMS treated; T_3 = Blanched+KMS treated; T_4=Blanched treated				

3.2. Oil Absorption Capacity

The oil absorption capacity is the binding of fat by the non polar side chain of proteins. The oil binding capacity of flour depends on the intrinsic factor such as protein conformation, amino acid composition and surface polarity or hydrophobicity [6]. It is evident from the Table 2 that highest values of oil absorption capacity (140.89%) was obtained for samples pretreated with KMS solution (T_2) followed by T_1 (115.74%), T_3 (113.76%), T_0 (100.56%) for Kufri Chipsona -1 potato flour whereas lowest values (98.54%) was obtained for blanched pretreated samples (T_4). The similar trends were obtained while comparing the pretreatments irrespective of potato varieties. The oil absorption capacity ranged between 87.69 to 140.89% among all the pretreated flours. The highest value of oil absorption capacity (140.89%) was obtained for potato flour (Kufri Chipsona -1) pretreated with KMS solution (T_2) followed by Kufri Jyoti (183.17%) and Kufri Bahar (171.76%). The oil absorption capacity also makes the flour suitable in facilitating enhancement in flavour and mouthfeel when used in food preparation. Due to these properties it could be used as functional ingredients in foods such as whipped toppings, sausages and sponge cakes etc. The oil absorption capacity is important since oil act as flavour retainer and increases the mouthfeel of food [2]. The major chemical component affecting oil absorption capacity is protein which is composed of both hydrophilic and hydrophobic parts.

Table 2: Oil absorption capacity of pre-treated flours of different potato varieties

		Potato Varieties		
		Kufri Chipsona-1 (%)	Kufri Jyoti (%)	Kufri Bahar (%)
Pre-treatments	T_0	100.56	97.76	90.76
	T_1	115.74	115.45	98.56
	T_2	140.89	122.81	116.78
	T_3	113.76	110.28	95.38
	T_4	98.54	95.78	87.59
T_0 =Control; T_1 = Brine solution treated; T_2 = KMS treated; T_3 = Blanched+KMS treated; T_4=Blanched treated				

3.3. Swelling Capacity

The swelling capacity is the measure of the starch ability to absorb water and also reflects the extent of associative forces in the starch granules. The swelling capacity of flours depends on size of particle, type of variety and method of processing or unit operations. It is evident from the Table 3 that highest values of swelling capacity (39.1ml) was obtained for samples pre-treated with blanched plus KMS solution (T_3) followed by T_4 (36.4 ml), T_0 (33.2 ml), T_2 (32.5 ml) for Kufri Chipsona -1 potato flour whereas lowest values (30.7 ml) was obtained for brine solution pretreated samples (T_1). The similar trends were obtained while comparing the pretreatments irrespective of potato varieties. The swelling capacity ranged between 23.5 to 40.7 ml among all the pretreated flours. The highest value of swelling capacity (40.7 ml) was obtained for potato flour (Kufri Bahar) pretreated with blanched plus KMS solution (T_3) followed by Kufri Chipsona -1 (39.1 ml) and Kufri Jyoti (37.8 ml). High starch content increases swelling capacity of flours especially starch with higher amount of blanched amylopectin [10, 3].

Table 3: Swelling capacity of pretreated flours of different potato varieties

		Potato Varieties		
		Kufri Chipsona-1 (ml)	Kufri Jyoti (ml)	Kufri Bahar (ml)
Pre-treatments	T_0	33.2	27.3	34.1
	T_1	30.7	23.8	23.5
	T_2	32.5	24.4	33.4
	T_3	39.1	37.8	40.7
	T_4	36.4	32.4	38.7

T_0 =Control samples; T_1 = Brine solution treated samples; T_2 = KMS treated samples; T_3 = Blanched+KMS treated samples; T_4=Blanched treated samples

3.4. Bulk Density

Bulk density measures the heaviness of a flour samples. It is a property that determines the porosity of a product which influences the design of package. It depends on the solid density, geometry, size, surface properties and the method of measurement. It also depends on particle density, its shape and manner in which constituents are packed on positioned with respect to each other. It is evident from the Table 4 that highest values of bulk density (0.9945 g/cm^3) was obtained for samples pretreated with KMS solution (T_2) followed by T_1 (0.9781 g/cm^3), T_4 (0.9375 g/cm^3), T_0 (0.9371 g/cm^3) for Kufri Chipsona -1 potato flour whereas lowest values (0.9322 g/cm^3) was obtained for blanched plus KMS solution pretreated samples (T_3). The similar trends were obtained while comparing the pretreatments irrespective of potato varieties. The bulk density ranged between 0.8823 to 0.9945 g/cm^3 among all the pretreated flours. The highest value of bulk density (0.9945 g/cm^3) was obtained for potato flour (Kufri Chipsona -1) pretreated with KMS solution (T_2) followed by Kufri Jyoti (0.9933 g/cm^3) and Kufri Bahar (0.9781 g/cm^3). The high bulk density of flour suggests their suitability for use in food preparation such as thickner in food products [1]. The results of bulk density revealed that it depend on the particle size and initial moisture content of the flour.

Table 4: Bulk density of pre-treated flours of different potato varieties

		Potato Varieties		
		Kufri Chipsona -1 (g/cm^3)	Kufri Jyoti (g/cm^3)	Kufri Bahar (g/cm^3)
Pre-treatments	T_0	0.9371	0.8975	0.9216
	T_1	0.9677	0.9224	0.9733
	T_2	0.9945	0.9781	0.9933
	T_3	0.9322	0.8823	0.9027
	T_4	0.9375	0.9090	0.9630

T_0 =Control samples; T_1 = Brine solution treated samples; T_2 = KMS treated samples; T_3 = Blanched+KMS treated samples; T_4=Blanched treated samples

3.5. Foam Capacity

Foaming capacity of flour is measured as the amount of interfacial area created by whipping of flour. Protein is generally responsible for foam formation. Foam capacity generally depends on the interfacial films formed by the proteins which maintain the suspension of air bubbles and slow down the coalescence rate. It is evident from the Table 5 that highest values of foam capacity (28.12%) was obtained for samples pre-treated with KMS solution (T_2) followed by T_1 (24.28%), T_0 (22.73%), T_3 (11.11%) for Kufri Chipsona -1 potato flour whereas lowest values (10.74%) was obtained for blanched pre-treated samples (T_4). The similar trends were obtained while comparing the pre-treatments irrespective of potato varieties. The foaming capacity ranged between 10.52 to 28.12% among all the pre-treated flours. The highest value of foaming capacity (28.12%) was obtained for potato flour (Kufri Chipsona -1) pre-treated with KMS solution (T_2) followed by Kufri Jyoti (26.85%) and Kufri Bahar (24.72%). The extension of heat causes denaturation of protein thereby decreasing their foaming capability [6].

Table 5: Foam capacity of pre-treated flours of different potato varieties

		Potato Varieties		
		Kufri Chipsona-1 (%)	Kufri Jyoti (%)	Kufri Bahar (%)
Pre-treatments	T_0	22.73	21.66	20.28
	T_1	24.28	22.51	22.78
	T_2	28.12	26.85	24.72
	T_3	10.74	11.71	10.52
	T_4	11.11	13.51	11.68

T_0 =Control samples; T_1 = Brine solution treated samples; T_2 = KMS treated samples; T_3 = Blanched+KMS treated samples; T_4=Blanched treated samples

3.6. Foaming Stability

Foaming stability refers to the ability of protein to stabilize against mechanical and gravitational stresses [9]. Foam formation and foam stability are a function of the types of protein, pH, processing methods, viscosity and surface tension. The good foam stabilities of flours suggest that the native protein that are solute in the continous phase (water) are very surface active in these flours [11]. It is evident from the Table 6 that highest values of foaming stability (13.98%) was obtained for samples pretreated with KMS solution (T_2) followed by T_1 (10.11%), T_0 (9.67%), T_3 (4.28%) for Kufri Chipsona -1 potato flour whereas lowest values (3.76%) was obtained for blanched pretreated samples (T_4). The similar trends were obtained while comparing the pretreatments irrespective of potato varieties. The foaming stability ranged between 2.52 to 13.98% among all the pretreated flours. The highest value of foam stability (13.98%) was obtained for potato flour (Kufri Chipsona -1) pretreated with KMS solution (T_2) followed by Kufri Jyoti (11.50%) and Kufri Bahar (10.13%). High foam stability may find application in baked confectionary products as recommended by Kaushal [11].

Table 6: Foaming Stability of pre-treated flours of different potato varieties

		Potato Varieties		
		Kufri Chipsona-1 (%)	**Kufri Jyoti (%)**	**Kufri Bahar (%)**
Pre-treatments	T_0	9.67	9.13	6.76
	T_1	10.11	10.27	4.31
	T_2	13.98	11.50	10.13
	T_3	4.28	4.07	3.54
	T_4	3.76	2.52	2.79
T_0 =Control samples; T_1 = Brine solution treated samples; T_2 = KMS treated samples; T_3 = Blanched+KMS treated samples; T_4=Blanched treated samples				

Conclusions

The functionality of food is the properties of food ingredient other than a nutritional attribute which has a great impact on its application. The functional characteristics determine the utilization and use of food material for various food products. The water absorption, oil absorption, bulk density, foam capacity and foam stability were found to be highest in KMS treated flour whereas swelling capacity was observed highest in blanching plus KMS treated flour. The functional properties of Kufri Chipsona-1 flour were found to be superior over Kufri Jyoti and Kufri Bahar flour.

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