International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2023; SP-7(2): 37-40
www.biochemjournal.com
Received: 18-05-2023
Accepted: 23-06-2023

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Potato value addition: Processing and utilization for enhanced nutrition

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DOI: https://doi.org/10.33545/26174693.2023.v7.i2Sa.188

Abstract
Dehydrating potatoes in the form of slices and grinding to make flour is the simplest and most widely used procedure to produce potato flour. Slices of Frito Lay-1533 potatoes of unmarketable grade treated in sodium chloride-ascorbic acid solution and blanched were dehydrated and then ground to make value-added potato products. Four value added products namely *chapati*, vermicelli *kheer*, fruit custard from potato flour and *upuma* from potato semolina were developed. The products were evaluated on sensory parameters using a nine-point hedonic scale and the preference for the developed products were ranked. All the value-added potato products had good overall acceptability with scores above 7 in the 9-point hedonic scale. Fruit custard had the highest mean score (8.03) for all the parameters combined. The nutrient composition of the value-added products was computed, and it was observed that the value-added products had a high nutrient profile.

Keywords: Potato, value addition, processing, utilization, nutrition

Introduction
Potato (*Solanum tuberosum* L.) is one of the major foodstuffs extensively consumed and produced globally, either consumed directly or processed. Potato is the world's third most important food crop in terms of human consumption, after wheat and rice (Devoux *et al*., 2020) [2]. In India, it is grown over an area of 2.18 Mha with an average annual production of 52.2 MT. The country held the second position in its production next to China (Global Potato Conclave, 2019) [4]. In India, potato is not primarily a rural staple but a cash crop that provides significant income for farmers. Uttar Pradesh, West Bengal, Bihar, Gujarat and Madhya Pradesh are the top five potato-producing states of India. It has historically contributed to securing food and nutrition, and avoiding poverty and hunger (Pandey and Sarkar, 2005) [16]. It provides a satiating, inexpensive, and nutrient-dense source of calories combining the wholesomeness of cereals and the delicacy and characteristic chemical composition of vegetables (Gumul *et al*, 2011) [7]. It is a versatile vegetable crop as it can be cooked or processed in number of ways Marwaha *et al*., 2010) [12]. Consumption of fresh potatoes accounts for approximately two-thirds of the harvest (Devoux *et al*., 2020) [2]. To sustain increasing production and ensure remunerative prices to farmers, processing of perishable potatoes into various processed products is a viable option to decrease the post-harvest losses, extend the shelf life, cater to consumer preferences belonging to different age groups and social strata and serve as a Means to increase supply during off-season maximizing potato utilization (Marwaha *et al*, 2006) [12]. Potatoes must meet certain requirements concerning chemical composition and quality for processing. Potato tubers high in dry matter, specific gravity and starch content are suitable for dehydrated and fried potato products (Ramazani and Aminlari, 2004) [18]. Potato chips is the most common and popular processed product consumed across the globe. However, the market for dehydrated food particulates is also rapidly growing and their reconstitution properties are important in meeting consumer expectations. The most simple and widely used procedure for the production of potato flour consists of dehydrating potatoes in the form of slices and grinding to make flour (Singh, *et al.*, 2003) [22]. However, the quality of dehydrated potato products depends mainly on pre-treatments, drying methods and drying conditions.

With this backdrop, the research was undertaken to standardize the pre-treatments for dehydration and develop value-added products from standardized dehydrated potatoes and to study the acceptability, and nutrient composition of value-added products.

Materials and Method

Frito Lay-1533 potatoes of unmarketable grade (Grade D) procured from Agricultural Research Station, Hassan, Karnataka, India were used for processing and subsequent product development. Potato powders were processed following the procedure of Raj *et al*. (2008) [17]. Potatoes were washed in tap water to remove soil particles and peeled with stainless steel peeler. Eyes and bruises were pitted out and potatoes were sliced (1-2mm) thickness using a hand-held slicing tool. Potato slices were directly dipped in 3% sodium chloride (NaCl) solution and 0.05% ascorbic acid to prevent enzymatic browning and blanched for 3 min. Pre-treated slices were treated with 2000 ppm potassium metabisulphite (KMS) for 15 min to prevent non-enzymatic browning and the slices were dried in a mechanical dryer at 60 °C for 3 h. Dried slices were then ground and sieved. Particulates that pass the 180-µm sieve (flour) were used for the optimization of *chapati*, vermicelli, fruit custard and coarser particulate that did not pass the 180-µm sieve (semolina) were used for the optimization of *upuma*.

Preparation of vermicelli: Potato flour and defatted soy flour were sieved together for thorough mixing. To the flour, 50 ml of potable water were added and kneaded to form a smooth dough. The dough was then extruded through a manual extruder and dried in an oven at 60 °C to a moisture content of 5-6%. The method of preparation of vermicelli from potato flour has been presented in Fig. 1.

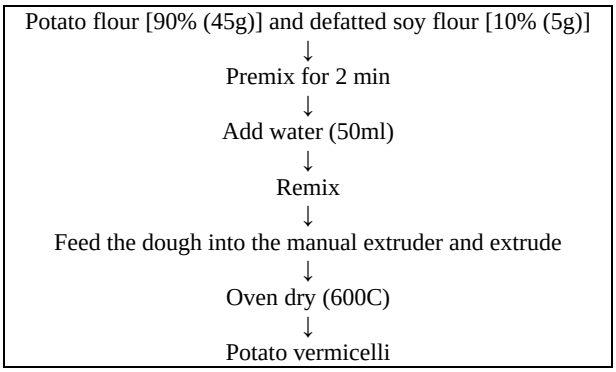

Fig 1: Preparation of potato vermicelli

Vermicelli thus prepared was used for the preparation of *Kheer*.

Product development

The following value-added products were standardized from gelatinized dehydrated potato flour and semolina namely: *Chapati*, vermicelli, fruit custard from potato flour and *upuma* from potato semolina.

1. **Chapati:** Mix wheat flour (56g), potato flour (44g) and defatted soy flour and knead to make a uniform dough. Divide the dough into small balls, roll it out and cook on both sides.
2. **Upuma:** Roast potato semolina (100g) in 1 TSP oil till aroma develops. Make seasoning with oil, mustard seeds, Bengal gram dal, black gram dal, groundnut and cumin seed. Add green chillies, onion, curry leaves and fry till onion turns slightly brown. Add water and salt to the seasoning and allow the water to boil. Add roasted potato semolina and cook.
3. **Fruit custard:** Gently mix potato flour (10g) and sugar (20g) in boiled milk (150 ml) and cooked to a thick consistency. Allow it to cool, add colour and essence and mix well. Add chopped fruits and serve chilled
4. **Vermicelli *kheer*:** Boil milk (100ml) and add roasted vermicelli (20g) and cook for about 10min under simmer flame. Add sugar, roasted cashew nuts, raisins and cardamom powder.

Organoleptic evaluation of the value-added products

The value-added products were standardized in the laboratory, and organoleptic evaluation was carried out by 20 semi-trained panels of judges from the Department of Food Science and Nutrition. A nine-point hedonic scale was adopted for the evaluation as described by Joshi (2006) [8]. The mean score for each parameter was reported. The scores represented 1 = Dislike extremely, 2 = Dislike very much, 3 = Dislike moderately, 4 = Dislike slightly, 5 = Neither like nor dislike, 6 = Like slightly, 7 = Like moderately, 8 = Like very much and 9 = Like extremely.

The judges were also instructed to rank the value-added potato products in descending order of their preference from I to IV indicating the highest to lowest preferred.

Nutrient profile of value-added products

The nutrient composition of the value-added products were computed for protein, fats, carbohydrates, energy, fibre, calcium, iron and carotene using the food composition table (Gopalan *et al*., 2004) [6].

Statistical analysis

The mean, standard error and Friedman's two-way analysis of variance were applied wherever necessary. The data were subjected to Minitab statistical software (Minitab Inc., USA and SPSS 16.0 version, 2007).

Results and Discussion

Product development

Potato powder can become the most viable value-added product due to its versatility in function as a thickener and colour or flavour improver (Yadav *et al*., 2006) [23]. However, browning of potatoes is a major problem in potato processing. Fresh potato slices quickly turn brown because of the activity of polyphenoloxidase (PPO) and peroxidase enzymes (Carillo *et al*., 2012) [1]. Enzymatic browning deteriorates not only the colour and appearance of products but also their nutritive values since many of the phenolic contents are oxidized during the process (Mishra *et al*., 2013, Saleh *et al*., 2013) [15]. Potato slices when pre-treated in sodium chloride-ascorbic acid solution and then blanched allowed polyphenoloxidase inactivation, preventing enzymatic browning. Earlier studies by Severini *et al*., (2003) [20] also showed that pre-treatments in lactic acid-sodium chloride, lactic acid-calcium chloride solution and blanching treatments allowed polyphenol oxidase inactivation. Blanching in hot water or in a salt solution facilitates the partial removal of reduced sugar from the raw material and improves the colour of the finished products. Pre-treated slices dipped in 2000 ppm potassium metabisulphite (KMS) for 15 min prevented non-enzymatic browning and the potato slices maintained the whiteness

after drying in mechanical dryer at 60 °C for 3h. Similarly, do Nascimento *et al*., (2019) [3] used sodium metabisulphite and ascorbic acid as anti-browning agents in processed potatoes. The dried slices were ground and used for the development of four value added potato products namely- *chapatti*, *upuma*, fruit custard and vermicelli *kheer*. Many value added products incorporating potato flour were developed by different researchers (Kabira, 1990; Kaur *et al*., 2015) [9, 10].

Organoleptic evaluation of the value-added products

Scores of the organoleptic evaluation of value added potato products carried out by the panel of judges and the mean values for the same have been presented in Table 1**.** All the value-added potato products had a good acceptability with scores above 7 in the 9-point hedonic scale for all the five parameters- appearance, texture, colour, flavour and taste. Fruit custard had the highest mean score (8.03) for all the parameters combined, followed by chapatti (7.90), vermicelli *kheer* (7.82) and pump (7.49). High acceptance of instant potato custard has been reported by other researchers (Sharma *et al*., 2020) [21]. The difference in the scores for colour and overall acceptability between the four products were found to be statistically significant (p<0.05). Kaur *et al*, 2015[10] have also reported high sensory scores above 8 in value added potato products - *dhokla*, *vadae*, *idli* and *tikka*. Potato flavour is an essential quality criterion, which is, in the case of a saturated market, one aspect that the consumer considers when buying the food product (Marwaha *et al*., 2010) [13]. However, the difference in the sensory scores for different value-added products were observed which is attributed to the difference in the ingredients and processing conditions used for each product (Maurya *et al*., 2014) [14, 11].

Table 1: Mean scores for the organoleptic evaluation of value-added products

Characteristics	*Chapati*	*Upuma*	Fruit custard	Vermicelli *kheer*	'F' Value
Appearance	7.85±0.38	7.54±0.66	8.15±0.69	7.85±0.55	NS
Texture	8.15±0.38	7.54±0.97	7.85±0.80	7.77±0.93	NS
Colour	8.08±0.64	7.38±0.50	8.00±0.58	8.08±0.64	*
Flavour	7.68±0.75	7.69±0.95	7.92±0.76	7.85±0.38	NS
Taste	7.69±0.48	7.46±0.66	8.15±0.80	7.69±1.25	NS
Overall acceptability	8.00±0.00	7.31±0.63	8.08±0.64	7.69±0.95	*
Mean scores	7.90	7.49	8.03	7.82	
F Value	NS	*	*	*	

*Significant at 5% level
NS – Non-significant

A comparison of the sum of ranks between the products revealed that fruit custard was the most preferred product by the panel of judges followed by *chapatti*, vermicelli *Kheer* and *upuma*. Friedman's two-way analysis of variance on the preference of the value-added products is presented in Table 2. The Friedman's test (χ^2 = 27.83) showed a significant difference between the value-added products. Raj, *et al*. (2008) [17] also reported in their study that instant custard powder prepared by incorporation of potato starch (12.07 g) and potato flour (1.34 g) was on par with custard prepared from custard powder available in the market.

Table 2: Preference among the value-added products

Value added products	Sum of Ranks	Friedman's Statistics χ^2
Chapati	II	27.83*
Upuma	IV	
Fruit custard	I	
Vermicelli *kheer*	III	

*Significant at p<0.01

Nutrient profile of value-added products

Potatoes are an inexpensive staple food that is a source of energy, modest amounts of high-quality protein, and dietary fiber and, are a good source of vitamin C, potassium, and other key micronutrients (Furrer *et al*., 2018) [5]. The nutritive value of the developed value added products has been presented in Table 3**.** *Chapati* was found to contain the highest amount of protein (13.03 g), crude fibre (2.03), carbohydrate (106 g) and energy (360 kcal). *Upuma* was found to contain the highest amount of fat (9.90 g). Calcium and carotene were observed to be highest in vermicelli *kheer* fruit custard respectively. The high protein content of *chapati* is attributed to the incorporation of defatted soy flour at 9.09 percent as soy is a low-cost, and widely available source of superior-quality protein (Yu *et al*., 2013, Maurya, 2014) [24, 14]. The higher fibre content in *chapati* is due to the incorporation of whole wheat flour up to 50.9 percent and the higher carbohydrate and energy values is attributed to the lower moisture content in the recipe. In *upuma* preparation, oil was added thus the higher value of fat was observed. The carotene content in fruit custard is contributed mainly by oranges and milk. The high calcium value in vermicelli *kheer* is contributed by milk which was added at the rate of 100ml for 20g of potato flour. Kabira (1990) [9] reported that the net dietary protein energy ratio showed potato flour to be moderately balanced in terms of protein and energy and also reported that it would also be a good source of the minerals potassium, phosphorus and magnesium [19].

Table 3: Nutritive value# of value-added products (per/100 g)

Value added products	Protein (g)	Fat (g)	Crude fibre(g)	Carbohydrate (g)	Energy (kcal)	Calcium (mg)	Iron (mg)	Carotene (µg)
Chapati	13.03	1.26	2.03	106	360	63	3.53	53
Upuma	4.80	9.90	0.96	42	275	42	1.26	42
Fruit custard	1.64	1.80	0.50	18	100	71	0.33	153
Vermicelli *kheer*	4.17	4.60	0.28	36	190	93	1.12	21

Computed values

Conclusion

Potatoes can be processed and consumed in a diversified forms. Value-added potato products developed in this study are nutritious and wholesome food which are organoleptically acceptable. Although there are a number of potato products available in the market, pre-gelatinized potato products are not popular. Gelatinized potato has been shown to have health benefits by its higher resistant starch content which would have a pre-biotic effect and also beneficial to diabetics. With the current trend of continuously shifting towards a healthy diet by conscious consumers triggered by the increased income and globalization, the demand for pre-gelatinized potato products will increase thereby increasing the utilization of potatoes commercially.

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