

IMPACTS OF VARIETIES AND FREEZING STORAGE CONDITION ON THE QUALITY OF FRENCH FRIED POTATOES (*SOLANUM TUBEROSUM* L.)

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ABSTRACT

The study reports on processing of potato strips from raw potato which were used for manufacturing of potato French fry. Moisture, vitamin C, reducing sugar, and ash contents of fresh potato of different varieties were determined. Shelf life of potato strips packaged in air tight polyethylene bags was assessed at freezing temperature. The effect of blanching on the shelf life of potato strips was investigated. Colour, and flavour of blanched potato strips were found acceptable up to 70 days and no microbial growth was found during the entire storage period. The potato French fry was tasted organoleptically by a panel of 10 judges, using 1-9 point of Hedonic scale. On the basis of sensory evaluations the potato strips which were blanched, salted, partially fried before storage got the highest score on the Hedonic scale among the other processed samples of the same variety. Among the varieties, Asterix was evaluated as the most preferred sample.

KEYWORDS

KMS, French fry, Potato, Freezing, & Blanching.

1. INTRODUCTION

Potatoes (*Solanum tuberosum*) are the third most important source of starch as it may be successfully grown in a variety of climatic conditions and soil (McComber *et al.*, 1994). In Bangladesh, potato is mainly a vegetable. Potato can either be cooked and consumed directly or processed to a variety of commercial products (Leszczynski, 1989). The most popular form of commercial potato products are potato chips, frozen French fries, canned potatoes, dehydrated potato powders, potato alcohols etc. (Burton, 1989).

The potato is a semi-perishable commodity. The processing suitability of product depends on the prevailing environmental factors during physiological development and post-harvest storage of the tuber (Sadie, 2005). There are about 393 cold storages in Bangladesh with a capacity of 4.0 million tons according to Bangladesh Cold Storage Association (BCSA, 2014). In the year 2010-2011, about 8.3 million tons of potato was produced (BBS, 2011). Only 25-30% of these potatoes were stored in the cold storages including seeds (Islam, 2011). Due to inadequate cold storage facilities to hold the produce for longer periods, large quantities are spoiled before they could be consumed (Hossain, 2009). Cultivation of potatoes in areas of different soil-water qualities results in distinct difference in chemical composition, thereby continually challenging the processor to maintain a uniform product quality (Iritani, 1981; Sadie, 2005).

French fries are appreciated throughout the world because of their pleasant taste and texture (Van Loon *et al.*, 2005). The suitability of potatoes for preparation of French fries varies on the parameters that include tuber size, specific gravity and reducing sugars (Thygesen *et al.*, 2001; Thybo *et al.*, 2003).

The dry matter which is only 25% (m/m) of a potato tuber consists of starch, sugars, proteins, lipids and ash (Leszczynski, 1989). High dry matter content means high starch content, as 60-80% of dry matter is starch that indicated by a specific gravity above 1.080, which is ideal for French fry production (Dalton, 1981; Leszczynski, 1989; Slabber, 2003). Sucrose, glucose and fructose are the main sugars contained within the potato tuber (Leszczynski, 1989).

Fry color and texture are the primary quality characteristics of French fried potatoes (Burton, 1989; Lisinska, 1989). The ideal French fry have a light cream to golden brown crust of 1-2 mm thickness and a firm mealy interior with no separation between the crust and the core (Lisinska, 1989). The general process for French fries production is blanching–drying–frying and each step is important for the final product quality (Lamberg *et al.*, 1990). Blanching in hot water is used mainly to inactivate enzymes, to improve texture, and to obtain a bright, uniform color (Andersson, 1994). Generally, frying is a two-step procedure: par-frying and finish frying. During par-frying, a part of the water is evaporated and crust formation starts. After par-frying, the product is frozen, packaged and distributed. Finish-frying takes place in a restaurant or at home shortly before consumption and results in the final product with the desired flavor and texture (Van Loon *et al.*, 2007).

This study has been conducted to recognize the most suitable potato variety available in Bangladesh for processing of French fry and to assess its sensory attributes. Also it was carried out to identify the shelf life of frozen potato strips for processing French fry.

2. MATERIALS AND METHODS

The investigation was conducted in laboratories of Department of Food Technology and Rural Industries, Bangladesh Agricultural University, Mymensingh, Bangladesh.

2.1 Materials

Good quality potato tubers were collected from suitable suppliers. Mainly Cardinal, Diamond, and Asterix varieties were preferred due to their high dry matter content.

2.2 Chemical Analysis of the Raw Materials

The raw potatoes were analyzed for their moisture, total solid (TS), reducing sugars, starch, ash, and vitamin C contents. The results are expressed as the average of the determined values. Moisture content and total solid (TS) were determined by following the AOAC official method 934.06 (2005). AOAC method 935.42 (2005) was used to determine the total ash content. The vitamin C, reducing sugar, starch and fat content were determined by adopting Ranganna (2011) instructions.

2.3 Processing of Potato Strips

Potatoes were cut into long strips to process potato strips. Then the strips were preserved at freezing temperature (-20°C). The procedure for preparation of frozen potato strips is given below

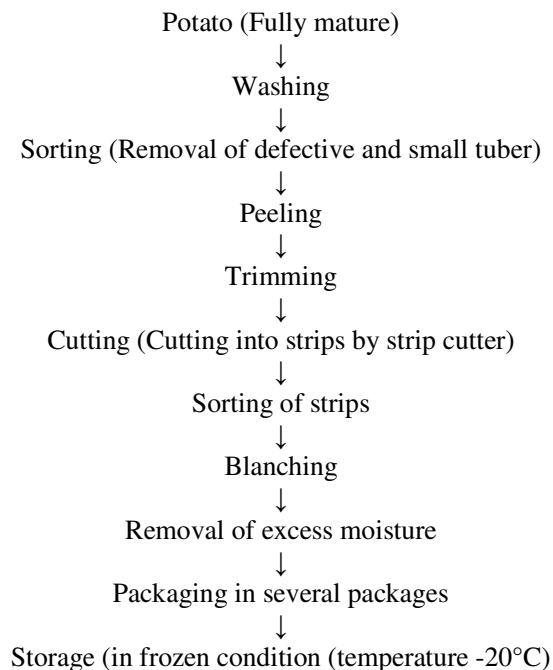


Figure 1. Flow chart for processing of potato strips

Table 1. Different formulations of potato strips

Samples	Different specification
S ₁	Salted only without any treatment
S ₂	Blanched and added KMS
S ₃	Blanched and without added KMS
S ₄	Blanched, salted, slightly fried and without added KMS

2.4 Storage Conditions of Potato Strips

The prepared potato strips were kept into high density polyethylene bags/ low density polyethylene bags and stored at freezing temperature of (-20⁰ C). The polyethylene packaging films were then opened at every 15 days interval up to 60 days to observe colour, flavour, or microbial growth.

2.5 Frying of Frozen Potato Strips

Frozen potato strips were fried after a regular interval to manufacture French fry. The process is shown as a flow chart

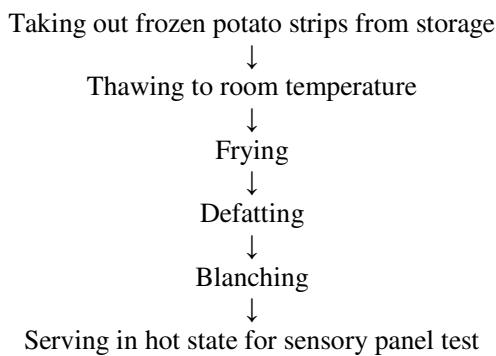


Figure 2. Flow chart for frying of frozen potato strips

2.6 Subjective (Sensory) Evaluation of Potato French Fry

For statistical analysis of sensory data, four different samples of three varieties were evaluated for color, flavor, texture, and overall acceptability by a panel of 10 members. All the judges were the teachers and students of the Department of Food Technology and Rural Industries and were briefed before evaluation. Four reconstituted samples of each variety were presented to 10 panelists who were randomly coded. The test panellist were asked to rate the different parameters presented to them on a 9 point hedonic scale with the ratings of: 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; 9=like extremely. The results were evaluated by Analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT) procedures of the Statistical Analysis System (SAS, 1985).

3. RESULTS AND DISCUSSION

3.1 Chemical Composition of Fresh Potato

Table 2 shows the chemical composition of three varieties (Cardinal, Asterix, and Diamond) of fresh potato tubers.

Table 2. Chemical composition of fresh potatoes

Parameters	Amount in 100g fresh potato varieties		
	Cardinal	Asterix	Diamond
Moisture	80.35 g	81.6 g	81.8 g
Total solid	19.65 g	18.4 g	18.2 g
Reducing sugar	0.70 g	0.50 g	0.65 g
Starch	21.0 g	13.3 g	15.0 g
Ash	1.05 g	0.91 g	0.82 g
Vitamin C	11.7 mg	8.6 mg	11.6 mg

3.2 Chemical Composition of French Fried Potato

The chemical composition of French fried potato for three different varieties (Cardinal, Asterix, and Diamond) are shown in table 3. These data indicates that the moisture content was decreased after frying due to addition of oil. The starch content increases and vitamin C content decreases as heat is applied during frying. But the mineral content remains almost same for fresh and fried product.

Table 3. Chemical composition of French fries

Parameters	Amount in 100g French Fry of Different Varieties		
	Cardinal	Asterix	Diamond
Moisture	37.5 g	34.0 g	44.0 g
Fat	21.9 g	16.8 g	25.0 g
Starch	30.7 g	37.9 g	29.6 g
Ash	1.05 g	0.93 g	0.84 g
Vitamin C	1.01 mg	0.70 mg	1.09 mg

3.3 Effect of Storage on the Quality of Potato Strips

Observation of colour, flavour, and fungal growth is shown in Table 4. Changes of colour and flavour were not remarkable for the blanched samples till 75 days of storage in high density polyethylene at freezing temperature (-18°C). Fungal growth was not noticed in any of the samples within this period of time.

Storage period (days)	Treatment before storage	Colour	Flavour	Microbial growth	Remarks
0	No treatment (Control)	Yellow	Pleasant	Not visible	Acceptable
	Salted only	Yellow	Pleasant	Not visible	Acceptable
	Blanched and added KMS	Yellow	Pleasant	Not visible	Acceptable
	Blanched only (without KMS)	Yellow	Pleasant	Not visible	Acceptable
	Blanched and partially fried	Yellow	Pleasant	Not visible	Acceptable
15	No treatment (Control)	Yellow	Pleasant	Not visible	Acceptable
	Salted only	Yellow	Pleasant	Not visible	Acceptable
	Blanched and added KMS	Yellow	Pleasant	Not visible	Acceptable
	Blanched only (without KMS)	Yellow	Pleasant	Not visible	Acceptable
	Blanched and partially fried	Yellow	Pleasant	Not visible	Acceptable
30	No treatment (Control)	Brownish	Pleasant	Not visible	Not acceptable
	Salted only	Yellow	Pleasant	Not visible	Acceptable
	Blanched and added KMS	Yellow	Pleasant	Not visible	Acceptable
	Blanched only (without KMS)	Yellow	Pleasant	Not visible	Acceptable
	Blanched and partially fried	Yellow	Pleasant	Not visible	Acceptable
45	No treatment (Control)	Deep brownish	Slight off-flavor	Not visible	Not acceptable
	Salted only	Brownish	Pleasant	Not visible	Not acceptable
	Blanched and added KMS	Yellow	Pleasant	Not visible	Acceptable
	Blanched only	Yellow	Pleasant	Not visible	Acceptable
	Blanched and partially fried	Yellow	Pleasant	Not visible	Acceptable

Table 4. Effect of storage on the quality of potato strips

60	No treatment (Control)	Dark brown	Slight off-flavor	Not visible	Not acceptable
	Salted only	Brown	Pleasant	Not visible	Not acceptable
	Blanched and added KMS	Yellow	Pleasant	Not visible	Acceptable
	Blanched only	Yellow	Pleasant	Not visible	Acceptable
	Blanched and partially fried	Yellow	Pleasant	Not visible	Acceptable
75	No treatment (Control)	Black	Off-flavor	Not visible	Not acceptable
	Salted only	Dark brown	Off-flavor	Not visible	Not acceptable
	Blanched and added KMS	Yellow	Pleasant	Not visible	Acceptable
	Blanched only	Yellow	Pleasant	Not visible	Acceptable
	Blanched and partially fried	Yellow	Pleasant	Not visible	Acceptable

3.4 Sensory Evaluation of Potato French Fry

A two way analysis of variance (ANOVA) at 5% level of statistical significance was conducted for scores given by panellists for colour, flavour, texture, and overall acceptability of potato French fries. Mean with same superscript within a column are not significantly different at 5% level of significance.

The mean score for the test parameters of potato French fry from the strips of Cardinal variety are presented in Table 5

Table 5. Mean score of colour, flavour, texture, and overall acceptability of potato French fry (var. Cardinal).

Product Type	Sensory attributes			
	Colour	Flavour	Texture	Overall acceptability
S ₁	4.30 ^c	3.40 ^c	4.80 ^c	2.80 ^c
S ₂	7.70 ^b	7.30 ^b	8.00 ^a	7.60 ^b
S ₃	7.30 ^b	7.60 ^{ab}	7.30 ^b	7.40 ^b
S ₄	8.30 ^a	8.00 ^a	8.10 ^a	8.20 ^a

In case of colour preference, from table 5 (DMRT) of variety Cardinal, it is shown that sample S₄ was the most preferable with a score of 8.3 out of 9 and ranked as “like very much”. But S₂, S₃ samples were equally acceptable at 5% level of significance and both samples were ranked as “like moderately”. Sample S₁ secured score 4.3, can be ranked as “dislike slightly”.

In case of flavour, as shown in the table sample S₄ was most acceptable among the samples securing the highest score 8.0 and ranked as “like very much”. This was followed by the sample S₂ and S₃ securing 7.3 and 7.6 respectively and were equally acceptable which ranked as “like moderately”. The sample S₁ securing 3.4 ranked as “dislike moderately”.

As shown in the table for the texture evaluation, the samples S₄ and S₂ were most acceptable in texture preference among the samples securing the highest score 8.1 and 8.0 respectively and ranked as “like very much”. This was followed by the sample S₃ securing 7.3 ranked as “like moderately”. The sample S₁ secured 4.8 which is ranked as “dislike slightly”.

In case of overall acceptability as shown in the table (DMRT) sample S₄ was most acceptable in overall acceptability preference among the samples securing the highest score 8.2 and ranked as “like very much”. This was followed by the sample S₂ and S₃ securing 7.6 and 7.4 respectively and ranked as “like moderately”. The sample S₁ secured 2.8 which ranked as “dislike very much”.

From the above results it is clearly seen that sample S₄ (blanched, salted, slightly fried before storage) was the most preferred sample with respect to all quality attributes and ranked as “like very much”. Though the other samples S₂ (blanched with KMS) and S₃ (blanched only) could be ranked as “like moderately”.

The mean score for the test parameters of potato French fry from the strips of Asterix variety are presented in Table 6

Table 6. Mean score of colour, flavour, texture and overall acceptability of potato French fry (var. Asterix).

Product Type	Sensory attributes			
	Colour	Flavour	Texture	Overall acceptability
S ₁	4.30 ^c	3.40 ^b	4.60 ^d	3.70 ^b
S ₂	7.70 ^b	8.30 ^a	7.80 ^b	8.30 ^a
S ₃	7.30 ^b	8.40 ^a	7.10 ^c	8.20 ^a
S ₄	8.30 ^a	8.70 ^a	8.80 ^a	8.60 ^a

From the DMRT table, the French fry of potato variety Asterix is similarly discussed here as variety Cardinal. In case of colour preference, the sample S₄ was the most preferable and can be ranked as “like very much”. But S₂, S₃ samples were equally acceptable at 5% level of significance and ranked as “like moderately”. Sample S₁ can be ranked as “dislike slightly”. In case of flavour, the sample S₄ was most acceptable among the samples and ranked as “like very much”. The samples S₂ and S₃ were equally acceptable which ranked as “like very much”. The sample S₁ was ranked as “dislike moderately”.

In case of texture the sample S₄ was most acceptable among the samples and ranked as “like very much”. The samples S₂ and S₃ securing scores 7.8 and 7.1 respectively were equally ranked as “like moderately” but have a significant difference at 5% level of significance as shown by the superscripts. The sample S₁ was ranked as “dislike slightly”.

In case of overall acceptability as shown in the table the sample S₄ was most acceptable in overall acceptability preference among the samples and ranked as “like very much”. The samples S₂ and S₃ were ranked as “like very much” and the sample S₁ was ranked as “dislike slightly”.

From the above results it is clearly seen that sample S₄ was the most preferred sample with respect to all quality attributes and ranked as “like very much”. The other two samples S₂ and S₃ could also be ranked as “like very much”. But sample S₄ was the most preferred than samples S₂ and S₃.

The mean score for the test parameters of potato French fry from the strips of Diamond variety are presented in table 7

Table 7. Mean score of colour, flavour, texture and overall acceptability of potato French fry (var. Diamond).

Product Type	Sensory attributes			
	Colour	Flavour	Texture	Overall acceptability
S ₁	3.90 ^c	3.50 ^c	4.80 ^b	2.70 ^d
S ₂	7.00 ^b	6.50 ^b	7.50 ^a	7.20 ^b
S ₃	7.10 ^b	6.80 ^b	7.10 ^a	6.80 ^c
S ₄	7.70 ^a	7.50 ^a	7.50 ^a	7.80 ^a

From the table (DMRT) it is clear that, for all the parameters i.e. colour, flavour, texture and overall acceptability for potato French fry of variety Diamond, the sample S₄ was the most preferable and ranked as “like moderately”. The S₂ and S₃ samples were comparatively less acceptable securing lower scores but ranked as “like moderately” for colour and texture preferences, and ranked as “like slightly” for flavour preferences. In case of overall acceptability, the sample S₂ was ranked as “like moderately” and the sample S₃ was ranked as “like slightly”. Sample S₁ secured very low scores in all attributes and can be ranked as “dislike moderately”.

From the above discussion it can be said that, the S₄ (blanched, salted, slightly fried before storage) samples of all varieties of potatoes were most preferable to the judges. A two way analysis of variance (ANOVA) at 5% level of statistical significant was conducted for scores given by panellists for overall acceptability of S₄ for all three varieties to find out the best suitable variety for frozen French fry production.

The mean score for the overall acceptability of potato French fry from the strips of sample S₄ from three varieties are presented in Table 8.

Table 8. Mean score of overall acceptability of potato French fry for sample S₄ from three varieties

Variety	Overall acceptability of sample S ₄
Cardinal	8.20 ^{ab}
Asterix	8.60 ^a
Diamond	7.80 ^b

*Mean with same superscript within a column is not significantly different at 5% level of significance.

In case of overall acceptability the results presented in the table showed that there were significant differences in overall acceptability among the varieties. But all the varieties were equally acceptable at 5% level of significance. It can be noted that Asterix and Cardinal both can be ranked as “like very much”, although Asterix secured the highest mark in overall acceptability and was chosen as best preferable to the judges. The S₄ sample of Diamond variety can be ranked as “like moderately”.

Another two way analysis of variance (ANOVA) was conducted to identify the storage impact at 5% level of statistical significance for scores given by panellists for the colour and overall acceptability of S₄ sample of Asterix variety during different period of storage and the mean scores are presented in Table 9.

Table 9. Mean score of colour and overall acceptability of potato French fry for sample S₄ Asterix variety

Day of Observation	Color	Overall Acceptability
D ₁₅	8.60 ^a	8.60 ^a
D ₃₀	8.50 ^{ab}	8.50 ^a
D ₄₅	8.10 ^{bc}	8.10 ^b
D ₆₀	8.00 ^c	8.00 ^b
D ₇₅	7.40 ^d	7.40 ^c

For both parameters, colour preference and overall acceptability for sample S₄ of Asterix variety for 15, 30, 45, 60, and 75 days of storage, the result shows that the suitability decreases slowly with the storage time. At day 15 the sample was most preferable and can be ranked as “like very much” and samples at days 30, 45 and 60 were comparatively less acceptable securing lower scores gradually but still ranked as “like very much”. At day 75, the sample secured the lowest score and ranked as “like moderately”.

From the above results it is clearly seen that the blanched, salted, partially fried and then frozen sample gets highest level of preference after frying. The best potato variety is found as the Asterix for manufacturing frozen French fry. The product has a good storage stability and acceptable after a long storage of 75 days or even more. A slight change occurs in the quality of blanched samples which is not significant in 75 days of storage period. But the deterioration is rapid and significant for unblanched samples.

4. CONCLUSION

The strips were prepared from different varieties of potato to store with different formulation like only salted, blanched, and with added KMS, blanched and without added KMS and blanched, salted then partially fried. The storage stability of these strips was observed up to 75 days and found acceptable regarding the sensory attributes. Fungal growth was not visible during the storage period. The French fry were manufactured by frying the potato strips up to desired colour and crispiness. The strips were then fried at 170°C temperature (oil ratio 1:25) which gave an initial temperature drop of 10°C. The frying time for partially fried sample was found to be minimum (7.5 minutes for 250 g), whereas for blanched sample it needs about 12 minutes and for unblanched sample it takes about 20 minutes. The addition of KMS to the strips enhanced the colour and flavour of the product, while the crispiness was found maximum for the partially fried sample. The unblanched sample had a short storage life due to rapid enzymatic browning and thus not suitable for preservation. Finally the statistical analysis was done for concluding the research to a specific point. The sensory properties of the French fry were analyzed by a panel of 10 judges using 1-9 Hedonic scale by serving the same judge with all the formulations of all varieties at a time. After the test, potatoes of Asterix variety were judged as the best variety for manufacturing frozen French fry by the panellists. The formulation that includes blanching, salting and partial frying before freezing was remarked as the best method of preservation and ranked as “like very much” by the panellists. This product has a storage life of more than 75 days when stored at freezing temperature of -18°C in airtight condition. Therefore it may become a beneficial new commercial food product for the food manufacturers in the near future and may reduce seasonal loss of potato in our country.

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