

Research Article

Moisture loss and oil uptake kinetics in French fries (var. *Kufri Pukhraj*) during frying in different oils and treatments

Ankur M. Arya*, Suresh Chandra, Samsher, Jaivir Singh, Neelash Chauhan, Tarun Kumar, Kapil Kumar and Prince

Department of Agricultural Engineering, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (U.P.)
250110 India

Abstract

In this study relationship between moisture loss and oil uptake at different treatment of sample and time during deep-fat frying of french fries was investigated. The relationship between moisture loss and oil uptake is an important phenomenon in the context of characterizing the physical properties of French fries. French fries samples were diced and fried at different oil (Mustard oil, Soybean refined oil, Sunflower oil,) in a fryer for periods varying from 50 to 200 sec. The relationship between moisture loss and oil uptake during the frying was erratic and appeared to be independent of frying oil. The relationship Oil uptake was positively to moisture loss in the range of frying times 50 sec. to about 200 sec. After 100 sec, oil uptake tended to decrease while moisture loss continued.

Keywords: Potato French fries, Blanching, Frying, Oil absorption, moisture loss, Sunflower oil

***Correspondence**

Author: Ankur M. Arya
Email: tt.king10@gmail.com

Introduction

Potato (*Solanum tuberosum L.*) is grown in more than 100 countries in the world [1]. India ranks third, after China and Russia. It has become an integral part of breakfast, lunch and dinner among the larger population. Being a short duration crop, it produces more quantity of dry matter, edible energy and edible protein in lesser duration of time compared to cereals like rice and wheat. Hence, Potato is considered to be an important crop to achieve nutritional security of the nation. It can be processed into variety of products such as cubes, chips, flakes, granules, powder, French fries and dehydrated dice. In India, Potato processing industry mainly comprises four segments: Potato chips, French fries, Potato flakes/powder and other processed products such as dehydrated chips, Aloo bhujia, Samosa, and Tikkis.

Krokida *et al.* [2] reported that blanching reduces oil absorption of fried potatoes by gelatinizing the surface starch, while air dehydration also leads to reduced oil absorption. Garayo and Moreira [3] found that the final shrinkage in volume of potato slices decreases as oil temperature increases; this behavior is believed to occur since the surface of the potato becomes rigid more rapidly at higher oil temperatures, thus producing increased resistance in volume change. Pedreschi [4] reported that in the deep-fat frying process, water containing foodstuff is immersed into oil or fat at high temperatures, typically between 160 and 180 °C. Santis *et al.* [5] showed that longer soaking time and higher NaCl concentrations improved the texture. Potato slices were darker after frying with increase of blanching temperature from 60°C/5min to 80°C/5min, for NaCl soaked slices against water-soaked slices. Blanching temperatures before frying enhanced the color of the potato chips. Ahmad *et al.* [6] reported that frying is extensively employed in the domestic and industrial sectors due to its ability to create unique sensory characteristics in food. Mir-Bel *et al.* [7] studied that during frying, heat transfer causes protein denaturation, starch gelatinization, water evaporation, crust formation and color development. Mass transfer is characterized by water and some soluble material escaping from the product during the process, combined with oil penetrating the food. Moreira *et al.* [8] determined the internal and structural oil absorption kinetics during vacuum frying of potato chips, and found that 14% of the total oil content was located in the core (internal oil) and the remaining 86% of the oil content was surface oil.

Materials and Methods

Present investigation was carried out to develop potato French fries and to evaluate relationship between moisture loss and oil uptake during frying in different oils; in the Laboratory of the Department of Agricultural Engineering, Sardar

Vallabhbhai Patel university of Agriculture and Technology, Meerut (UP) India, during year 2012-14. Chemicals like NaCl, KMS, CaCl₂ and frying oil viz. mustard oil, refined soybean oil and sunflower oil and other raw materials were procured from the local market. Potatoes (var. *Kufri Pukhraj*) were collected from the farmer, washed with clean water to remove dust and dirt followed by peeling, cutting with the help of french fries cutter then blanching. The samples were fried in different oils (mustard oil, refined oil, sunflower oil) followed by packing. The French fries sample were blanched in control and four different treatments namely, (i) 3% NaCl at 90°C for 3 min, (ii) 0.5% KMS solution at 90°C for 3 min, (iii) 3% NaCl + 0.5% KMS solution at 90°C for 3 min, and (iv) 0.5% CaCl₂ solution at 90°C for 3 min. After blanching, the samples were cooled for 30 min in ceiling fan. Deep frying process is followed in which heat is transferred from the oil to the food, water is evaporated from the food and oil is absorbed in it.

Frying conditions

The potatoes cut into rectangular pieces and samples of the same mass were selected. The samples were washed in distilled water and excess surface water was removed using tissue paper. The potato to oil ratio was kept at 1:5. The samples were blanched with different treatments and frying was performed for four different times of 50, 100, 150, 200 sec. After each frying experiment, the level of oil was measured.

Moisture content

Moisture content of samples was determined by method as recommended by AOAC [9].

Oil uptake

Oil uptake is measured as difference in mass of oil in pan during frying.

Results and Discussions

Moisture loss during frying

The moisture content of the samples decreased during frying time increase. As expected, water evaporation took place quicker when the higher temperatures are applied. There are important differences between 50 to 200 sec., while increase has additional effect on moisture reduction when it is compared with 50 sec.

Effect of mustard oil

The experimental result for moisture content or moisture loss during frying in mustard oil represents that moisture loss was increased with increasing the frying period among the entire samples (**Table 1**). The pretreatment also affect the moisture loss during frying. Initial moisture content of sample was found 355 % db. The highest moisture loss was observed at first 50 sec. in KPM T₅ (355 - 122.58% db) and lowest in sample KPMT₂ (355 - 276.19% db). Frying for 100 sec. highest moisture loss was observed in sample KPMT₃ (355 - 62.71% db) and lowest in control sample KPM T₁ (355 - 197.72% db). Frying at 150 sec. highest moisture loss was observed in sample KPM T₃ (355 - 23.72% db) and lowest in sample KPMT₁ (355 - 109.09% db). Frying at 200 sec. highest moisture loss was observed in sample KPMT₅ (355 - 4.83% db) and lowest in sample KPM T₂ (355 - 44.73% db). The study was noticed that moisture loss was lost rapidly in first 50 sec of frying. The moisture was lost from 355 % (db) to 4.83% (db) during frying.

Table 1 Effect of mustard oil on moisture content (% db) of potato French fries.

Time (sec.)	KPM T ₁	KPM T ₂	KPM T ₃	KPM T ₄	KPM T ₅
0	355	355	355	355	355
50	254.45	276.19	138.98	216.66	122.58
100	197.72	192.85	62.71	152.68	66.12
150	109.09	123.80	23.72	93.75	25.80
200	40.54	44.73	10.16	41.66	4.83

Effect of refined oil

The experimental result for moisture content loss during frying in refined oil is given in (**Table 2**) represents the highest moisture loss was observed in first 50 sec. in KPR T₃ (355 - 98.50% db) and lowest in KPRT₄ (355 - 184.61% db). Frying at 100 sec highest moisture loss was observed in KPRT₃ (355 - 52.23% db) and lowest in KPR

T₄ (355 – 148.07% db). Frying at 150 sec highest moisture loss was observed in KPRT₃ (355 – 13.43% db) and lowest moisture loss in sample KPRT₄ (355 – 73.07% db). Frying at 200 sec highest moisture loss was observed in sample KPRT₃ (355 – 1.49% db) and lowest moisture loss in sample KPR T₄ (355 – 26.92% db). The moisture was lost during frying from 355 % (db) to 1.49% (db).

Table 2 Effect of refined oil on moisture content (% , db) of potato French fries.

Time (sec.)	KPR T ₁	KPR T ₂	KPR T ₃	KPR T ₄	KPR T ₅
0	355	355	355	355	355
50	127.86	138.90	98.50	184.61	150.87
100	90.16	74.57	52.23	148.07	110.52
150	36.06	35.59	13.43	73.07	66.66
200	6.55	6.77	1.49	26.92	16.17

Effect of sunflower oil

The experimental result for moisture loss during frying in sunflower oil is given in (Table 3) represents the highest moisture loss was observed in first 50 sec. in KPST₂ (355 – 122.58% db) and lowest in control sample KPST₁ (355 – 234.70% db). Frying at 100 s highest moisture loss was observed in KPST₂ (355 – 66.12% db) and lowest in control sample KPST₁ (355 – 178.26% db). frying at 150 sec highest moisture loss was observed in KPST₂ (355– 25.80% db) and lowest moisture loss by control sample KPST₁ (355 – 95.65% db). Frying at 200 sec highest moisture loss was observed in sample KPST₃ (355 – 5.08% db) and lowest moisture loss in control sample KPST₁ (355 – 60.86% db). It was noticed that the moisture was lost during frying from 355 % (db) to 5.08% (db).

Table 3 Effect of sunflower oil on moisture content of potato French fries.

Time (sec.)	KPS T ₁	KPS T ₂	KPS T ₃	KPS T ₄	KPS T ₅
0	355	355	355	355	355
50	234.70	122.58	133.33	192.15	157.14
100	178.26	66.12	96.66	113.72	82.14
150	95.65	25.80	43.33	45.09	28.57
200	60.86	8.06	5.08	19.60	23.21

Oil absorption during frying

Effect of mustard oil

The experimental data for change in oil uptake of potato french fries fried in mustard oil are shown in (Table 4). It is clear that french fries oil uptake first increase then decrease with increase in time. Frying at 50 sec highest oil uptake by control sample KPMT₁ (40.90 g) and lowest in KPMT₅ (24.19 g). Frying at 100 sec highest oil uptake by KPMT₄ (18.75 g), and lowest oil uptake by sample KPMT₅ (9.67 g). Frying at 150 sec highest oil uptake by KPMT₂ (16.66 g) and lowest oil uptake by sample KPMT₅ (6.45 g). Frying at 200 sec highest oil uptake by sample KPMT₂ (9.52 g) and lowest oil uptake by sample KPMT₅ (4.83 g). Frying for 50-200 sec highest oil uptake was by control sample KPMT₁ (40.90 g) and lowest oil uptake by sample KPMT₅ (4.83 g).

Table 4 Effect of mustard oil on oil uptake of potato French fries.

Time (sec.)	KPM T ₁	KPM T ₂	KPM T ₃	KPM T ₄	KPM T ₅
50	40.90	34.00	30.50	33.33	24.19
100	13.63	14.28	13.55	18.75	9.67
150	11.36	16.66	10.16	12.50	6.45
200	9.09	9.52	6.77	8.33	4.83

Effect of refined oil

The experimental data for change in oil uptake of potato french fries fried in refined oil are shown in (Table 5). Frying at 50 sec highest oil uptake by pretreated sample KPRT₂ (30.50 g) and lowest oil uptake by control sample KPRT₁ (22.95 g). Frying at 100 sec highest oil uptake by KPRT₃ (19.40 g) and lowest oil uptake by control sample KPRT₁ (8.19 g). Frying at 150 sec highest oil uptake by KPRT₃ (9.83 g) and lowest oil uptake by control sample KPRT₁ (6.55 g). Frying at 200 sec highest oil uptake by KPRT₄ (7.69 g) and lowest oil uptake by control sample

KPRT₁ (4.91 g). Frying at 50-200 sec highest oil uptake by sample KPRT₂ (30.50 g) and lowest oil uptake by sample KPRT₃ (4.47 g).

Table 5 Effect of refined oil on oil uptake of potato French fries.

Time (sec.)	KPR T ₁	KPR T ₂	KPR T ₃	KPR T ₄	KPR T ₅
50	22.95	30.50	26.86	26.92	28.07
100	8.19	10.16	19.40	15.38	14.03
150	6.55	8.47	9.83	9.61	8.77
200	4.91	5.08	4.47	7.69	7.01

Effect of sunflower oil

The experimental data for change in oil uptake of potato French fries fried in Sunflower oil are shown in (Table 6). Frying at 50 sec highest oil uptake was by control sample KPST₁ (39.13 g) and lowest oil uptake by KPST₃ (23.33 g). Frying at 100 sec highest oil uptake by sample control sample KPST₁ (15.12 g) and lowest oil uptake by sample KPST₂ (9.67 g). Frying at 150 sec highest oil uptake by control sample KPST₁ (13.04 g) and lowest by sample KPST₂ (8.06 g). Frying at 200 sec highest oil uptake by control sample KPST₁ (8.69 g) and lowest oil uptake by sample KPST₅ (5.35 g). Frying during 50-200 sec highest oil uptake was by controlled sample KPST₁ (39.13 g) and lowest was by sample KPST₅ (5.35 g).

Table 6 Effect of sunflower oil on oil uptake of potato French fries.

Time (sec.)	KPS T ₁	KPS T ₂	KPS T ₃	KPS T ₄	KPS T ₅
50	39.13	25.80	23.33	29.41	26.78
100	15.12	9.67	11.66	11.76	10.71
150	13.04	8.06	10.00	7.84	8.92
200	8.69	6.45	6.66	5.88	5.35

Conclusion

This study shows relationship between oil uptake and moisture loss during deep-fat frying of French fries. The relationship between moisture loss and oil uptake is an important phenomenon in the context of characterizing the physical properties of fried product. Highest moisture loss in case of French fries fried in mustard oil was observed in samples pre-treated with 3% NaCl at 90 °C for 3 min and than the other pre-treated samples; oil uptake was found highest in controlled sample. Effect of refined oil on moisture content of French fries blanching with CaCl₂ at 90 °C for 3 min highest moisture loss and oil uptake was found in controlled sample. Effect of sunflower oil on moisture content of French fries was highest found in blanching with 3%NaCl + 0.5% KMS at 90 °C for 3 min and oil uptake was highest found in controlled sample

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