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Effect of intermittent frying and frying medium on the quality of potato chips

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Potato chips deep fried in refined soya bean oil were compared with those fried in refined groundnut oil and hydrogenated vegetable oil (Dalda) during intermittent frying. The fried product was evaluated for chemical and sensory changes during intermittent frying. The potato chips fried in hydrogenated oil had the lowest value for breaking strength and a greater amount of fat absorption when compared to refined soya bean and groundnut oils. Overall acceptance of the potato chips varied ($P < 0.05$) with reference to intermittent frying only in refined groundnut and soya bean oils but not in hydrogenated vegetable oil (Dalda).

INTRODUCTION

Frying of foods is one of the most common processing techniques throughout the world. Most foods and vegetables are fried in oils; some of them are fried in small quantities whereas others are deep fried. The quality of fried foods depends upon the quality of the frying oil and thus it is of prime importance to maintain and protect the quality of the frying medium. The necessity of using good frying oil and maintaining it in that state as long as possible becomes clear when one considers that all fried food absorbs a certain amount of fat. To maintain and to protect the fat quality certain options are available. However, it is necessary to examine some major changes which occur during deep fat frying. Dobbs *et al.* (1978) reported that canola oil and soya bean oil develop an unpleasant odour when heated to frying temperature. Niewiadomaski (1985) also reported the same phenomenon in soya bean and canola oils due to frying. Coll Hellin *et al.* (1985) conducted a comparative study to evaluate the changes in physicochemical properties of soya bean and olive oil during intermittent frying. Eskin *et al.* (1989) studied the stability of low linolenic acid canola oil to frying temperatures and found less development of oxidation. Meenakshi Rani *et al.* (1993) showed that intermittent frying induced changes in refractive index, viscosity, peroxide value, fatty acids composition and thiobarbituric acid number of frying oils.

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Soya bean is the major oil seed crop in the USA but it is gaining popularity in some developing countries, particularly in India, where it is replacing groundnut oil as a cooking and frying medium. Therefore, it is necessary to know the advantage of refined soya bean oil for potato chips frying compared to refined groundnut oil and hydrogenated vegetable oil (Dalda).

MATERIALS AND METHODS

Potatoes of uniform size were procured from a local market and thoroughly washed. The washed potatoes were peeled using a mechanical peeler (M/s. B. Sen Berry and Co., New Delhi, India). Then peeled potatoes were sliced (2 mm thickness) and blanched in a boiling solution of potassium metasulphite (0·05%) for 3 min to prevent browning. Blanched slices were then dried using a tray dryer.

Frying

Dried potato chips were fried in refined soya bean oil, refined groundnut oil and hydrogenated vegetable oil (Dalda) separately at a temperature of 180°C for 0·5 min (based on preliminary trials). The frying in the same oil was repeated at intervals of 12 h until 60 h and, after each frying, a sample of potato chips was analysed.

Proximate composition of potatoes

Moisture fat and ash contents were determined using standard methods of AOAC (1975). The protein

content was estimated by the macro-Kjeldahl method. Carbohydrate content was arrived at by subtracting the sum of the percentage of moisture, protein, fat and ash from 100.

Fat absorption

Fat content absorbed by potato chips was estimated using the AOAC method (1975) in triplicate.

Texture

Texture of the potato chips was determined using an Instron machine (model 1111). Ten potato chips of uniform diameter and thickness were taken from each sample. Each chip was placed on a loading cell and compressed using the following conditions.

Full-scale load range	= 50 kg
Cross-head speed	= 5 cm/min
Chart speed	= 20 cm/min
Deformation	= 1·5 mm

During the compression, the changes in the force required to break the sample were recorded on the chart in the form of peaks and breaking strength (kg) for each sample was obtained by calculating the maximum force required to break the potato chips. The average of ten values is reported.

Sensory evaluation

Organoleptic evaluation of potato chips was conducted by presenting the potato chips sample to a taste panel comprised of nine members. The members were asked to record their degree of preference on an evaluation card using a hedonic scale as given below:

Liked extremely	9
Liked very much	8
Liked moderately	7
Liked slightly	6
Neither liked nor disliked	5
Disliked slightly	4
Disliked moderately	3
Disliked very much	2
Disliked extremely	1

The data thus obtained for sensory characteristics were subjected to statistical analysis by using a two way technique of variance described by Snedecor and Cochran (1967).

RESULTS AND DISCUSSION

Proximate composition of potatoes

Potatoes used in the present work had a moisture content 80·1%, protein 2·6%, fat 0·8%, total ash 1·22% and carbohydrate 15·4% on a fresh weight basis. Watt and Merile (1963) reported a range of 63·2–86·9% moisture and 0·7–4·6% protein in different varieties of potatoes. Gopalan *et al.* (1971) estimated fat content to be in the range 0·1–1·0% in Indian potatoes, whereas Toma *et al.* (1978) reported a range of 3·41–5·55% total ash content on a dry weight basis.

Potato chips

Fat absorption

The effects of intermittent frying and frying oils on the fat absorption of potato chips are presented in Table 1. The quantity of fat absorbed did not vary much due to intermittent frying. But the frying medium altered the fat absorption by potato chips.

Samples fried in hydrogenated vegetable oil (Dalda) absorbed greater amounts of fat as compared to the potato chips fried in unsaturated oils. However, the samples fried in refined groundnut oil exhibited higher fat absorption than those fried in refined soya bean oil. The higher absorption of fat by the samples of potato chips fried in hydrogenated vegetable oil (Dalda) (followed by refined groundnut oil) might be due to the presence of high concentrations of saturated fatty acids (Swern, 1964). During intermittent frying long-chain fatty acids will be converted into short-chain fatty acids (Kilogore & Bailey, 1970).

Breaking strength

The effects of intermittent frying on the breaking strength of potato chips are presented in Table 1. The breaking strength of potato chips decreased with the increase in numbers of intermittent fryings.

Among the frying media, the breaking strength of potato chips fried in hydrogenated vegetable oil (Dalda) was lowest which ranged from 25·9 to 21·1 kg, respectively, after the first and sixth frying. This was followed by refined soybean oil and refined groundnut oil. This

Table 1. Effect of intermittent frying and frying medium on the fat absorption and breaking strength of potato chips

Frying interval (h)	Frying media[a]		
	A	B	C
Fat absorption (%, mean ± SD)			
0	26·47 ± 0·11	25·67 ± 0·10	30·60 ± 0·11
12	28·43 ± 0·12	27·07 ± 0·11	30·50 ± 0·12
24	26·50 ± 0·11	29·09 ± 0·12	33·71 ± 0·13
36	22·74 ± 0·09	28·31 ± 0·11	35·62 ± 0·14
48	23·10 ± 0·09	30·69 ± 0·12	33·48 ± 0·14
60	23·37 ± 0·09	28·13 ± 0·11	30·92 ± 0·12
Breaking strength (force in kg, ± SD)			
0	26·50 ± 0·11	36·60 ± 0·15	25·90 ± 0·10
12	25·50 ± 0·11	34·20 ± 0·14	24·00 ± 0·10
24	25·00 ± 0·10	32·20 ± 0·13	23·80 ± 0·09
36	23·50 ± 0·09	31·00 ± 0·12	22·80 ± 0·09
48	23·00 ± 0·09	31·80 ± 0·13	21·10 ± 0·08
60	21·00 ± 0·08	29·80 ± 0·12	19·00 ± 0·07

[a]A, Refined soya bean oil; B, refined groundnut oil; C, hydrogenated vegetable oil (Dalda).

decrease in breaking strength of potato chips might possibly be due to the low viscosity of oils at high temperatures with subsequent frying because of thermal decomposition of polyunsaturated fatty acids into short-chain units.

The potato chips were fried in different media at a time and were measured for breaking strength (Table 1). It is clear that the potato chips fried in Dalda had the lowest value for breaking strength, followed by refined soya bean and groundnut oils. However, the values for breaking strength are quite low as compared with the values shown for the effect of frying intervals.

The potato slices were dried in a tray dryer (moisture content of 6 ± 0·5%). Further, in the frying process water is removed to the extent that finished chips contain 1·5–2·0% moisture (Rasmussen, 1958).

Sensory quality

It can be seen from Tables 2–4 that the differences in mean scores for overall acceptability due to intermittent frying were significant in the potato chips fried in unsaturated oils and non-significant in those fried in hydrogenated vegetable oil (Dalda). These differences might be attributed to the fact that the composition of unsaturated fatty acids changes with subsequent heating and cooling. Furthermore, the differences in the mean overall organoleptic scores reported for the potato chip samples after first and second fryings in refined soya bean and groundnut oils were significant ($P < 0.05$). It can also be seen from the Table 2 that the sensory properties of potato chips fried in refined soya bean oil after intervals of 12 and 24 h, 36 and 48 h and 48 and 60 h interval did not differ significantly ($P > 0.05$). In the case of samples fried in refined groundnut oil, the differences in mean organoleptic scores between the samples obtained after 12 and 24 h, 12 and 36 h, 24 and 36 h and 48 and 60 h were non-significant. However, all the samples of potato chips were rated from good to very good by panellists and thus intermittent frying did not affect the overall acceptability of potato chips.

From Table 3, it is clear that potato chips fried in refined groundnut oil achieved the highest mean overall organoleptic score and differed significantly from those potato chips fried in other frying media. This was followed by those fried in hydrogenated vegetable oil (Dalda) and these also differed significantly from other samples fried in soya bean oils. However, it was interesting to note that the highest score for the attribute

Table 2. Effect of intermittent frying on overall organoleptic score of potato chips fried in refined soya bean oil

	Samples (frying interval, h)					
Panellist	$R_1(0)$	$R_2(12)$	$R_3(24)$	$R_4(36)$	$R_5(48)$	$R_6(60)$
1	8·00	8·00	8·25	7·75	7·25	7·00
2	8·50	8·00	8·50	7·50	7·25	6·75
3	8·50	8·00	7·50	7·50	7·00	7·00
4	8·00	7·00	6·75	6·50	5·50	5·00
5	8·00	6·00	6·00	7·00	7·50	6·25
6	7·50	8·00	7·50	7·75	7·75	8·00
7	8·00	8·00	8·50	7·50	7·25	7·50
8	8·00	8·00	8·00	7·50	6·50	7·00
9	8·00	8·00	7·00	6·00	6·00	5·00
Mean	8·056	7·666	7·601	7·222	6·888	6·611

Statistical analysis[a]	
Treatment pairs	Actual mean difference
R_1R_2	0·390*
R_1R_3	0·455*
R_1R_4	0·834*
R_1R_5	1·050
R_1R_6	1·168*
R_2R_3	0·065
R_2R_4	0·444*
R_2R_5	0·772*
R_2R_6	0·055
R_3R_4	0·378*
R_3R_5	0·713*
R_3R_6	0·990*
R_4R_5	0·334
R_4R_6	0·661*
R_5R_6	0·277

[a]Critical difference = 0·337.
*Differ significantly at the 5% level.

Table 3. Effect of intermittent frying on overall organoleptic score of potato chips fried in refined groundnut oil

	Samples (frying interval, h)					
Panellist	$R_1(0)$	$R_2(12)$	$R_3(24)$	$R_4(36)$	$R_5(48)$	$R_6(60)$
1	9·00	7·00	7·50	6·75	7·00	7·25
2	7·00	6·50	7·00	6·75	7·25	7·00
3	7·25	7·00	7·25	7·25	7·00	6·50
4	8·50	7·50	6·75	7·00	6·50	7·00
5	8·75	8·00	7·00	7·25	6·25	7·00
6	7·75	7·75	7·00	6·75	6·00	7·00
7	8·25	7·25	7·00	7·50	6·00	6·75
8	8·00	7·00	6·50	5·50	5·50	5·50
9	7·50	7·50	7·50	7·25	6·50	6·00
Mean	8·000	7·278	7·111	7·000	6·444	6·667

Statistical analysis[a]	
Treatment pairs	Actual mean difference
R_1R_2	0·722*
R_1R_3	0·899*
R_1R_4	1·000*
R_1R_5	1·556*
R_1R_6	1·333*
R_2R_3	0·167
R_2R_4	0·278
R_2R_5	0·834*
R_2R_6	0·611*
R_3R_4	0·111
R_3R_5	0·667*
R_3R_6	0·444*
R_4R_5	0·556*
R_4R_6	0·333
R_5R_6	0·223

[a]Critical difference = 0·395.
*Differ significantly at the 5% level.

Table 4. Effect of intermittent frying on overall organoleptic score of potato chips fried in hydrogenated vegetable oil (Dalda)

	Samples (frying interval, h)					
Panellist	R_1(01)	R_2(12)	R_3(24)	R_4(36)	R_5(48)	R_6(60)
1	8·00	8·00	7·75	7·50	7·25	7·50
2	8·00	7·00	6·50	6·00	6·25	6·00
3	7·50	7·50	6·50	7·00	6·50	6·50
4	8·00	8·00	7·50	7·50	7·75	7·25
5	8·00	7·00	6·75	7·50	7·50	7·25
6	8·00	8·00	7·50	6·75	7·25	6·50
7	8·00	7·50	6·50	6·75	5·75	7·75
8	8·00	7·50	7·50	6·50	7·50	7·25
9	9·00	7·00	7·50	7·50	7·75	7·50
Mean	8·056	7·500	7·111	7·000	6·944	7·056

Analysis of variance for overall organoleptic score of potato chips fried in hydrogenated vegetable oil (Dalda)[a]

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	$F_{calculated}$
Treatments	5	8·277	1·655	1·766
Panellists	8	31·583	3·948	4·213
Errors	40	37·473	0·937	—
Total	53	77·333	—	—

[a] $F_{tabulated}$ (5,40) = 2·45.
$F_{tabulated}$ (8,40) = 2·18.
Treatments (frying interval) effects differ non-significantly at 5% level.

texture was obtained by the samples of potato chips fried in hydrogenated vegetable oil (Dalda) followed by refined soya bean oil. These observations were in accordance with the results obtained for breaking strength (Table 1) where breaking strength was lowest for the potato chips fried in hydrogenated vegetable oil (Dalda) followed by those fried in refined soya bean oil.

Thus the results of this investigation indicate that intermittent frying did not affect the overall acceptability of potato chips. Also, refined soya bean oil can be used as an alternative frying medium in the preparation of potato chips.

REFERENCES

AOAC (1975). *Official Methods of Analysis* (12th edn). Association of Official Analytical Chemists, Washington, DC.

Coll Hellin, L., Clawell, M. & Del, P. R. (1985). Effect of frying on the lipid composition of snacks commonly consumed in Spain. II. Deep fat frying experiment. *An. Bramatol.*, 36–40.

Dobbs, J. E., Vaisey-Genser, M. & Diamant, R. (1978). Unpleasant odours of rape seed oil heated to frying temperatures. *Can. Inst. Food Sci. Technol. J.*, **11**, 66–9.

Eskin, N. A. M., Vaisey-Genser, M., Durance-Todd, S. & Przybylski, P. (1989). Stability of low linoleic acid canola oil to frying temperatures. *J. Am. Oil Chem. Soc.*, **66**, 1081–4.

Gopalan, C., Ram Sastri, B. V. & Balasubramaniam, S. C. (1971). *Nutritive Value of Indian Foods*. National Institute of Nutrition, ICAR, Hyderabad, India.

Kilogore, L. & Bailey, M. (1970). Degradation of linoleic acid during potato chips frying. *J. Am. Dietetics Assoc.*, **56**, 130–2.

Meenakshi Rani, Chauhan, G. S. & Dheer Singh (1993). Comparative changes in the quality of refined soybean oil and groundnut oil during intermittent frying of potato chips. *Bev. Food World*, **20**, 18–19.

Niewiadomaski, H. (1985). Progress in the technology of rape seed oil for edible purposes. *Chem. Ind.*, **4**, 883–6.

Rasmussen, N. C. (1958). Some evaluations of surface water removal on raw slices. National Potato Chip Institute, Proc. Prod. Technol. Div. Meeting, 1958, p. 23.

Snedecor, G. W. & Cochran, W. G. (1967). *Statistical Methods* (6th edn), The Iowa State University Press, IA, USA.

Swern, D. (1964). *Bailey's Industrial Oil and Fats* (3rd edn). Interscience Publishers, New York, USA.

Toma, R. B., Angustin, J. Shar, R. L. True, R. H. & Hogan, J. M. (1978). Proximate composition of freshly harvested and stored potatoes (*Solanum tuberosum*). *J. Food Sci. Technol.*, **43**, 1702–4.

Watt, B. K. & Merile, A. L. (1963). *Composition of Foods—Raw, Processed and Prepared* (Handbook No. 8). US Dept. of Agriculture.