FRYING PERFORMANCE OF CANOLA FATS FOR FRENCH FRIED POTATOES

Z.J. Hawrysh(1), M.K. Erin(1), C. Lin(1), R.T. Hardin(2)

(1) Department of Foods & Nutrition, University of Alberta
308 Home Economics Building, Edmonton, AB CANADA T6G 2M8
(2) Department of Animal Science, University of Alberta
310 Agriculture Forestry Centre, Edmonton, AB CANADA T6G 2P5

INTRODUCTION

Current use of canola fats for frying convenience foods (french fries, chicken and fish pieces) is limited. Solid and liquid canola frying fats may enhance the quality attributes of these foods and offer advantages in terms of frying performance. However, comparisons of canola fats with other frying fats on the sensory properties of convenience foods, in conjunction with fat frying performance and oxidative stability, are lacking.

The objective of this study was to evaluate the effect of canola fats and commonly used frying fats on the quality attributes of french fried potatoes using sensory, chemical and instrumental methods. The frying performance of each of the fats was also assessed.

MATERIALS AND METHODS

The following commercially available fats were used: partially hydrogenated canola (PHC) oil, from Canbra Foods, Lethbridge, Alberta and hydrogenated (solid) canola (HC), partially hydrogenated soy (PHS) oil, hydrogenated (solid) soybean (HS) and tallow (T), all from Canada Packers, Edmonton, Alberta. All fats contained dimethylpolysiloxane (2ppm) and monoglyceride citrate (50ppm). The T also had butylated hydroxyanisole and butylated hydroxytoluene. Initial quality of the fats was defined via fatty acid composition (Bannon et al., 1982), peroxide (Cd 8-53) and iodine (Cd 1-25) values (AOCS, 1989) and % free fatty acids (as given in Stevenson et al., 1984).

Regular cut (1 cm), frozen parfried french fried potatoes (FF), from I & S Foods, Edmonton, Alberta were fried in each of the frying fat treatments (PHC, HC, PHS, HS and T). Five home-style deep fat fryers (Seb Tefal^R, Model 8215) sprayed with Pam^R were used for frying. Fresh fat (2800 g) was weighed into each fryer. Fats were heated to 180° ±5°C, equilibrated for 1/2 hr, and held at 180°C for 6 h/d. For each fat tested, five 450 g batches of FF were fried (8 min) intermittently throughout the d and two 140 g batches were fried (4 1/4 min) for sensory/instrumental analyses. Additional FF (140 g fried for 4 1/4 min) fried in T served as reference (R) and hidden reference (HR) samples for sensory evaluation. The FF for chemical, sensory and objective analyses were cooked within a 75 min period during the middle of the d. Each frying fat was filtered daily, sampled (ca. 350 mL) for analyses, returned to the cleaned fryers and fresh fat was added to replace fat sampling/cooking losses. Fats were held at 22°C overnight. Frying was conducted for 4 d (24 h). Fresh T was used to fry R FF each d. Three replications were completed.

After frying, FF were drained and transferred to paper towel lined trays. French fries for sensory analysis were portioned and served within 10 min of frying. The FF for instrumental analyses were cooled (1 h), covered with saran^R wrap and held until all measurements were completed. For chemical analyses cooled (1 h) FF were placed in plastic bags, nitrogen flushed, rebagged and frozen (-30°C) for later analysis.

Sensory data were obtained from eight trained (6 wks) panelists that had been screened and selected according to the procedures of Cross et al., 1978. During the experimental sessions, panelists evaluated six randomly presented FF samples (one from each frying fat treatment and a HR) in comparison to an identified R FF. Warm FF were presented on a white plate placed on a Salton[R] hot tray. Six FF quality attributes were evaluated by panelists using (15 cm) unstructured line scales. In judging the FF, panelists were instructed to place a vertical line across a 15 cm horizontal line at a point which best described their impression of each FF characteristic. The characteristics were potato flavor intensity, oil flavor intensity, crust crispness, oily mouthcoating and interior texture. Panelists evaluated the FF using a standardized tasting procedure. Evaluations were conducted in individual booths under red fluorescent lighting in an atmospherically controlled sensory panel room. Visual evaluations (color evenness and intensity) of each FF treatment, in a Macbeth Skylight (northern daylight, 7500°K) were also obtained from four panelists. Color evenness was rated on a 15 cm line scale where values of 15 and 0 represented a FF that was extremely even and extremely uneven (blotchy), respectively. Color intensity was measured, as per USDA Color Standards for Frozen French Fried Potatoes (Munsell Color, Baltimore, Maryland), on an intensity scale of 1 (no shading of brown due to frying) to 7 (dark golden brown).

Standardized instrumental measurements made on FF included shear force and color. Shear determinations were made using an Instron Food Testing System (Model 4201) equipped with a Kramer cell and a 50 kg load cell (crosshead speed = 100 mm/min). A Hunterlab Color/Difference Meter (Model D25-2) was used to record FF 'L', 'a' and 'b' values.

Chemical tests used to monitor fat quality included anisidine values (IUPAC, 1987), % free fatty acids, color (Gwo et al., 1985) and capillary gas chromatographic (GC) analyses (Snyder et al., 1985) for pentane, 2,4-decadienals and total volatiles. Physical measurements of frying fats included viscosity (Stevenson et al., 1984) and smoke point (AOCS, 1989).

A strip-plot experimental design (Milliken and Johnson, 1984), involving fat treatments (n=5) and heating time (n=4), was used for the experiment. Three replicates were completed. For sensory data panelists (n=8) were included. All data were subjected to analyses of variance. Where appropriate Student-Newman Keul's Multiple Range test was used to identify significant ($P<0.05$) differences among treatment means. For this paper results will focus on the effect of fat treatments with only minor emphasis on the effect of heating time.

RESULTS AND DISCUSSION

Data (Table 1) for peroxide and iodine values and % free fatty acids indicated that all fresh fats were of good initial quality.

Table 1. Chemical properties of fats upon receipt

Characteristic	Frying Fat Treatment				
	PHC	HC	PHS	HS	T
PV (meq/kg)	0.29	0.51	0.54	0.60	0.28
IV	99.19	72.94	103.36	68.96	47.63
% FFA	0.00	0.02	0.00	0.01	0.00

For each heating time, sensory data (Table 2) showed that all FF were similar in potato flavor intensity, although FF cooked in PHS tended to have lower potato flavor intensity scores. The means for FF potato flavor intensity also indicated that FF from all fats were similar, except for FF fried in PHS which were significantly less intense in potato flavor.

Table 2. French fry flavor attributes

Attribute	Heating Time (d)	Frying Fat Treatment PHC	HC	PHS	HS	T	HR	SEM[(1)]
Potato Flavor Intensity[(2)]								
	1	8.4	8.6	6.7	8.3	8.6	8.5	0.40
	2	8.7	8.3	7.2	8.0	7.8	8.7	0.36
	3	8.5	8.3	7.3	7.6	8.0	8.1	0.42
	4	8.0	8.8	6.6	8.2	8.1	8.4	0.49
	Average ($\bar{x}$)	8.4[a]	8.5[a]	7.0[b]	8.0[a]	8.1[a]	8.4[a]	0.21***
Oil Flavor Intensity[(2)]								
	1	8.9[a]	9.7[a]	6.9[b]	8.2[ab]	8.5[ab]	8.4[ab]	0.43*
	2	9.0[a]	9.4[a]	7.4[b]	8.8[a]	8.3[a]	8.6[a]	0.25**
	3	8.5[ab]	9.4[a]	6.9[b]	8.0[ab]	8.0[ab]	8.5[ab]	0.41*
	4	7.8	8.8	6.8	7.9	8.3	8.0	0.53
	Average ($\bar{x}$)	8.5[b]	9.3[a]	7.0[c]	8.2[b]	8.3[b]	8.4[b]	0.20***

(1)Standard error of the mean.
(2)15 cm line scale where 15 = extremely intense potato flavor, bland oil flavor, and 0 = extremely weak potato flavor, strong oil flavor.
abcMeans within the same row sharing a common letter are not significantly different at $P<0.05$.
*,**,***, Significant at $p<0.05$, $p<0.01$ and $p<0.001$, respectively.

Panelists detected significant differences in oil flavor intensity among FF. After 1 d of heating, FF fried in PHS had a more intense oil flavor than those cooked in PHC and HC, which were the same. The HS and T FF were similar to FF from all fats. Following 2 d of use, PHS FF were more intense ($P<0.01$) in oil flavor than FF from the other treatments which were similar. After 3 d of frying, only the HC FF were less intense in oil flavor than the PHS FF. All FF were similar in oil flavor intensity at 4 d, although the PHS FF tended to be more intense than the others. The means showed that HC FF had the least intense oil flavor, followed by FF cooked in PHC, T, and HS which were similar, while PHS FF were most intense in oil flavor.

Panel data (Table 3) for FF showed no significant differences in crust crispness, oily mouthcoating and interior texture due to frying fat. However, the Instron Kramer shear force values (Table 4) indicated that PHC FF required a greater ($P<0.05$) shearing force than FF cooked in HC and HS, which were similar to each other and to FF from PHS and T. Except for differences in FF shear values at 2 d, which were the same as the treatment means (Table 4), no other significant differences in FF shear data were found among the fat treatments at other heating times.

Panelists did not detect any visual differences in FF color evenness or intensity (Table 3) due to frying fat. However, Hunter 'L' values (Table 4) indicated that FF fried in PHC and PHS were similar and darker in color than the FF cooked in HC, HS and T, which did not differ. No significant differences in FF 'a' values were found. The Hunter 'b' values showed that the PHS FF were less yellow than FF fried in HC, HS and

T, which were similar. The PHC FF were similar in yellowness to FF from all fats.

Table 3. French fry sensory textural and color attributes

Attribute	Frying Fat Treatment						
	PHC	HC	PHS	HS	T	HR	SEM[(1)]
Crust Crispness[(2)]	6.9	7.1	7.0	7.3	6.8	7.7	0.26
Oily Mouthcoating[(2)]	7.2	7.5	6.8	7.1	6.8	7.1	0.26
Interior Texture[(2)]	7.8	7.5	7.9	7.5	7.5	7.5	0.25
Color Evenness[(2)]	9.8	10.2	10.8	11.3	11.7	-	0.71
Color Intensity[(3)]	3.4	3.4	3.2	3.1	3.0	-	0.10

[(1)]Standard error of the mean.
[(2)]15cm line scale where 15 = crisp crust, dry mouthcoat, dry interior texture and extremely even color and 0 = limp crust, oily mouthcoat, moist interior texture and extremely uneven (blotchy) color.
[(3)]USDA color standard for frozen french fried potatoes where 1 = no browning and 7 = dark golden brown.

Table 4. Instron Kramer shear force values and Hunterlab 'L', 'a' and 'b' values of french fries

Trait	Frying Fat Treatment					
	PHC	HC	PHS	HS	T	SEM[(1)]
Force (kg)	3.2^{a}	2.6^{b}	3.0^{ab}	2.6^{b}	2.8^{ab}	0.16*
'L' value	53.1^{b}	58.0^{a}	53.2^{b}	58.3^{a}	56.6^{a}	1.00***
'a' value	1.8	2.8	2.0	2.8	2.6	0.40
'b' value	16.2^{ab}	17.7^{a}	15.5^{b}	17.4^{a}	17.4^{a}	0.46**

[(1)]Standard error of the mean.
[ab]Means within the same row sharing a common letter are not significantly different at $p<0.05$.
*,**,*** Significant at $p<0.05$, $p<0.01$ and $p<0.001$, respectively.

The initial (0 d) peroxide values (PV) of the fats (Table 5) differed significantly; however differences of this magnitude are not of practical importance. After 1 d of heating, the PV of all fats increased markedly (0.81-1.33 meq/kg) but remained relatively constant over the remaining 3 d of heating, and over 4 d were indicative of good quality fats (0.85-1.35 meq/kg). Initially (0 d) the anisidine values (AV) of the fresh fats also differed slightly. The AV means revealed significant ($P<0.001$) differences among each of the fats; the AV for PHS was highest followed by PHC, T, HC and HS. Slight differences in the color of the fresh fats were determined and as expected all fats darkened upon heating. The means for color showed small but significant differences among the fats; these small differences appear to be related to the initial color of each fat. The % free fatty acids (FFA) in the fresh fats (Table 1) showed small differences at time 0, but no significant differences were determined among the fat treatments at any of the heating times (data not shown). After frying, data for % FFA ranged from 0.46-0.51, well below 1%, a common level recommended for discarding fats (Billek et al., 1978). Thus these chemical data show that all of the fats remained relatively and equally stable over the 4 d frying period.

Table 5. Chemical and GC data of frying fat treatments

Trait	Heating Time (d)	Frying Fat Treatment					
		PHC	HC	PHS	HS	T	SEM[(1)]
Peroxide Values							
	0	0.29^{b}	0.51^{a}	0.54^{a}	0.60^{a}	0.28^{b}	0.02***
	Average ($\bar{x}$)[(2)]	0.85^{d}	1.25^{ab}	1.03^{c}	1.18^{bc}	1.35^{a}	0.05***
Anisidine Values							
	0	0.77^{b}	0.44^{cd}	0.33^{d}	0.52^{c}	0.95^{a}	0.04***
	Average ($\bar{x}$)	16.56^{b}	11.68^{d}	22.01^{a}	9.88^{e}	14.26^{c}	0.16***
Color							
	0	0.04^{c}	0.07^{a}	0.03^{d}	0.05^{b}	0.03^{b}	0.00***
	Average ($\bar{x}$)	0.19^{c}	0.23^{a}	0.18^{d}	0.21^{b}	0.17^{e}	0.00***
Pentane							
	0	0.22	0.38	0.29	0.34	0.29	0.08
	Average ($\bar{x}$)	0.58^{b}	0.39^{c}	1.30^{a}	0.36^{c}	0.55^{b}	0.05***
2,4-Decadienals							
	0	0.00	0.01	0.00	0.01	0.00	0.00
	Average ($\bar{x}$)	6.74^{b}	3.15^{d}	16.94^{a}	1.89^{e}	4.22^{c}	0.29***
Total Volatiles							
	0	13.58^{a}	2.29^{b}	1.35^{b}	1.98^{b}	4.93^{b}	1.18***
	Average ($\bar{x}$)	37.19^{a}	32.68^{b}	39.39^{a}	26.34^{c}	39.96^{a}	1.14***

(1) Standard error of the mean.
(2) Average computed across 1-4 d heating.
a-e Means in the same row sharing a common letter are not significantly different at $p<0.05$.
***Significant at $p<0.001$.

Capillary gas chromatography data (Table 5) showed that the pentane and 2,4-decadienal content of each of the fresh fats were similar. Except for PHC which was significantly higher, the total volatiles determined in each of the fresh fats did not differ. After heating the pentane level in PHS was highest, followed by PHC and T which were similar and different than HC and HS which were the same. The 2,4-decadienals in the heated fats differed significantly; PHS was highest followed by PHC, T, HC and HS. The data for pentane and 2,4-decadienal levels in heated PHS support findings of the trained panel (Table 2) which indicated that oil flavor of FF fried in PHS was most intense. Levels of total volatiles in heated fats differed significantly; the means for T, PHS and PHC were similar and significantly higher than HC which also differed from HS.

Small but significant differences in viscosity (data not shown) were found among the fresh frying fats. However, the viscosity of each fat was stable and for each fat no differences in viscosity were noted over the 4 d of heating. Data for smoke points (not presented) for fresh fats were similar. As expected, the smoke point for each of the fats decreased with heating time and small but significant differences in smoke points were noted among the fats after 2 d (176-189°C) and 4 d (151-159°C) of frying. After 3 d the smoke points for all fats were below 170°C, the temperature used as a criteria for discarding used frying fats in Germany (Billek et al., 1978)

CONCLUSIONS

Findings from this study showed few differences among the fat treatments for either FF quality attributes or frying fat performance. Sensory data indicated that FF fried in both HC and PHC were similar to FF fried in T and HS for the flavor, texture and color attributes measured. However, trained panelists scored PHS FF lower in potato flavor intensity and higher in oil flavor intensity than FF fried in canola fats. All frying fats evaluated were stable to the frying conditions used in this study. Averages for the 4 d of frying showed that the PV, color, % FFA and viscosity of each fat were indicative of good quality. Analyses of the heated fats showed that PHS had a higher AV and pentane and 2,4-decadienals levels than the other fats. The pentane and total volatile content of heated canola frying fats were similar or lower than the levels in heated T. Thus, in this study, evaluations of FF quality and fat performance indicated that both canola frying fats, the soy frying fats and T were similar.

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