

## Sensory properties during storage of crisps and French fries prepared with sunflower oil and high oleic sunflower oil

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### SUMMARY

#### Sensory properties during storage of crisps and French fries prepared with sunflower oil and high oleic sunflower oil

A selected and trained descriptive sensory panel has assessed samples of crisps and French fries prepared on an industrial scale with either sunflower oil (SO) or high oleic sunflower oil (HOSO). Furthermore, crisps have been fried in these oils with or without dimethyl polysiloxane (DMPS). Reference samples were prepared using palm olein (PO) or hydrogenated rapeseed/palm oil mixture (RP). Crisps were stored at ambient temperature for six months and French fries at -20°C for 12 months. At regular intervals the samples were assessed.

Crisps prepared in SO have a lower sensory quality than those prepared in PO. Frying in HOSO resulted in crisps comparable with those fried in PO. The differences found in this study concerning the mouthfeel or texture were thought not to be caused by the application of different oils. The addition of DMPS did not have any positive effect on the storage quality of crisps fried in SO or HOSO.

Frying of French fries in HOSO and especially in SO, in comparison with RP, resulted in a product with a typical sweet fruits odour and flavour. During storage these sensory attributes decreased in intensity. As this finding might be an artefact of this study, further research is needed.

**KEY-WORDS:** *Crisps – French fries – High oleic sunflower oil – Sensory assessment – Storage – Sunflower oil*

### 1. INTRODUCTION

Application of sunflower oil for frying, in comparison with other oils, has been reported a few times in the literature. Theunissen et al. (1977) investigated the effect of five different vegetable oils (with a high content of polyunsaturated fatty acids), including sunflower oil, on the preferences of a consumer panel for five common fried foodstuffs. It was concluded that the differences observed were so small that practical consequences could not be expected. Robertson et al. (1978) evaluated potato crisps fried in, amongst others sunflower oil, during storage for 10 weeks at 31°C. Sensory scores did not differ markedly among crisps fried in different oils. The sensory properties of meat croquettes and French

fries fried in four different oils, viz. sunflower oil, corn oil, partly hydrogenated soybean oil and hydrogenated palm oil, were compared by Van Gemert and Hoekman (1986). They used a descriptive and a consumer panel. It was concluded that from a sensory point of view there are no objections against use of frying oils with a high level of linoleic acid. Keijbets et al. (1986) compared different soybean oils and sunflower oil for finish-frying of up to 100 batches of pre-fried French fries. Analysis of the hydrolysis, oxidation and polymerization of the oils and sensory quality of the French fries established that the sunflower oil deteriorated more rapidly than the soybean oils. Recently, Gustafsson et al. (1993) tested two liquid margarines, one based on rapeseed oil and the other on sunflower oil, for frying and baking. They concluded that rapeseed oil margarine seems more resistant to heating than sunflower oil margarine.

In the context of the AIR Project CT92 - 0687 'Utilisation of sunflower oils in industrial frying operations' crisps and French fries have been produced on an industrial scale by Raisio, Finland. Four different oils have been used for frying, i.e. sunflower oil (SO), high oleic sunflower oil (HOSO), palm olein (PO) and hydrogenated rapeseed/palm oil mixture (RP). The products prepared in PO and RP were considered to be reference samples, as till now these oils, or other partially hydrogenated oils, are mainly used as frying medium. In the trials with crisps the application of dimethyl polysiloxane (DMPS) was also tested. After production samples of crisps were stored at ambient temperature for six months and samples of the deep frozen French fries were stored at -20 °C for 12 months.

Information about the oils and the products is given by Niemelä et al. (1996). Here the sensory analysis is reported, using a descriptive panel, of the crisps and French fries at regular intervals during the storage periods.

The objective of the present study is to establish whether or not the application of SO or HOSO as a frying medium results in products with different sensory properties in comparison with reference samples prepared in PO or RP. If there are

differences, the consumer might consider the products less acceptable. Especially, when the intensity and character of these differences indicates off-odours or off-flavours caused by SO or HOSO.

## 2. EXPERIMENTAL

### 2.1 Panel

The eight panel members, all female, had been specially selected previously with a view to sensitivity to taste, capacity to recognise smells, odour and flavour memory and the ability to verbalise sensory impressions. In addition, they were experienced in using descriptive techniques for profiling various foods and beverages, but they had no experience with crisps or French fries.

### 2.2 Crisps

The training existed of six sessions lasting two hours each, during which fresh and aged samples of crisps prepared in different oils (sunflower and palm oil) were served for developing a list of potentially usable attributes (odour, flavour, mouthfeel and after-flavour; not appearance). This list, 78 attributes, was tested in three measurement sessions. Based on the analysis of the results of these measurements and discussions a definitive list of 60 attributes (see Table I) was made during the tenth and final session.

The samples of crisps (bags of 175 g) had been prepared in three different groups, each consisting of three different samples. Group 1 consisted of crisps fried in PO, SO and HOSO, group 2 of those fried in PO, SO and SO+DMPS and group 3 of crisps fried in PO, HOSO and HOSO+DMPS. Thus, comparison of SO and PO was done in groups 1 and 2, comparison of HOSO and PO in groups 1 and 3 and the effect of DMPS was measured in groups 2 and 3.

The sensory assessments were performed after storage periods (at ambient temperature) of approximately 1/2, 1, 4 and 6 months. At each storage period samples were assessed four times by each panel member in random order.

The results of every attribute were per group subjected to a three-way analysis of variance, with the factor panel members being regarded as stochastic and the factors storage period and sample as fixed. Principal components analysis (PCA), based on the covariance matrix of the mean scores per sample, was used to construct biplots of the first two principal components for each aspect - odour, (after-)flavour and mouthfeel - and for each group. The plot of the loadings of the attributes is superimposed on the plot of the scores.

Table I  
Overview of the 60 attributes with anchors  
used for profiling the crisps; anchors are  
*little...much* unless stated otherwise

ODOUR	FLAVOUR
odour strength	salt
odour <i>fresh...old</i>	burnt
burnt	potato
fried	fried potato
potato	sweet
raw potato/fish	fishy
peanut	flavours <i>fresh...old</i>
vegetable oil/fat	deep-frying fat
beef fat/lard/solidified fat	old oil
rancid	vegetable oil
bread-bin	rancid
stale/earthy	herby
herby/peppery/spicy	cardboard/paper
plastic	floury
soft soap	stale/earthy
sweet/vanilla	acid
salty	perfumed/gassy/4711 (eau de cologne)
putty	
sourish/fresh	
MOUTHFEEL	AFTER-FLAVOUR
breakable/crusty	encourages salivation
<i>airy...compact</i>	arouses thirst
<i>thin...thick</i>	burnt
<i>soft...firm</i>	sweet
crispy/crunchy	fishy
tough	stale/earthy
<i>mushy/smooth...lumpy</i>	oily/grease layer
<i>vanishes quickly/dissolves</i>	sticky/tacky
<i>...long in the mouth</i>	<i>fresh...old</i>
sticky/tacky	paper
mealy	rancid
greasy/oily layer	salt
	<i>brief...lasting</i>

### 2.3 French fries

The same panel (now seven instead of eight panel members) applied in the study of crisps was used for the French fries. This time nine sessions of two hours were devoted to train the panel and to obtain a list of 43 descriptors for the French fries (see Table II) in the same way as described for crisps.

The samples of deep-frozen French fries (bags of 500 g) were prepared during four successive weeks. There were two reference samples (frying oil: RP - potato varieties: Sabina or Record) and two experimental samples (frying oils: SO or HOSO - potato variety: Record).

Table II  
Overview of the 43 attributes with anchors used for profiling the French fries; anchors are *little...much* unless stated otherwise

ODOUR	MOUTHFEEL
odour	outside <i>weak/soft...hard</i>
raw potato	outside tough
frying/old oil	inside dry/mealy
warm new oil	inside soft
butter	inside peppery
sweet fruits	crumbling
sweet	fatty
boiled potato	granular/sandy
acid	smooth
earthy	sticky
smoked	chewing <i>short...long</i>
FLAVOUR	AFTER-FLAVOUR
burnt	oily
baked potato	sweet
watery	burnt
acid	acid
raw potato	earthy
nuts	rough/tart
sweet fruits	need to drink
sweet potato	after-flavour <i>short...long</i>
mealy	
oily	
bitter	
earthy	
flavour	

French fries were prepared by heating (Juno Convectomat) for 10 min in a hot air oven at 230°C. The sensory assessments were performed after storage periods (at approximately -20°C) of about 2, 4, 6, 8, 10 and 12 months. At each storage period samples were assessed twice by each panel member in random order.

Results were subjected to analysis of variance as described above.

### 3. RESULTS AND DISCUSSION

#### 3.1 Crisps

##### Group 1: PO, SO and HOSO

The analysis of variance resulted in a large number of statistically significant effects. For the periods and the samples the number of significant attributes are 16 and 29, respectively. Four attributes showed a statistically significant interaction. Mean scores of the SO samples increased for the attributes putty odour, fishy flavour and old oil flavour more than the PO and HOSO samples during storage. The herby flavour shows a decrease in time for the PO and SO samples and a stable level for the HOSO samples from the beginning.

From Figure 1 (PC 1 and 2 of 19 odour attributes; variance explained 80 %) it can be seen directly that the SO samples are different from the PO and HOSO samples. The SO samples had a higher odour intensity, a more old, rancid, bread-bin, stale/earthy, sweet/vanilla and putty odour and a less fried and salty odour than the other two samples. Besides,

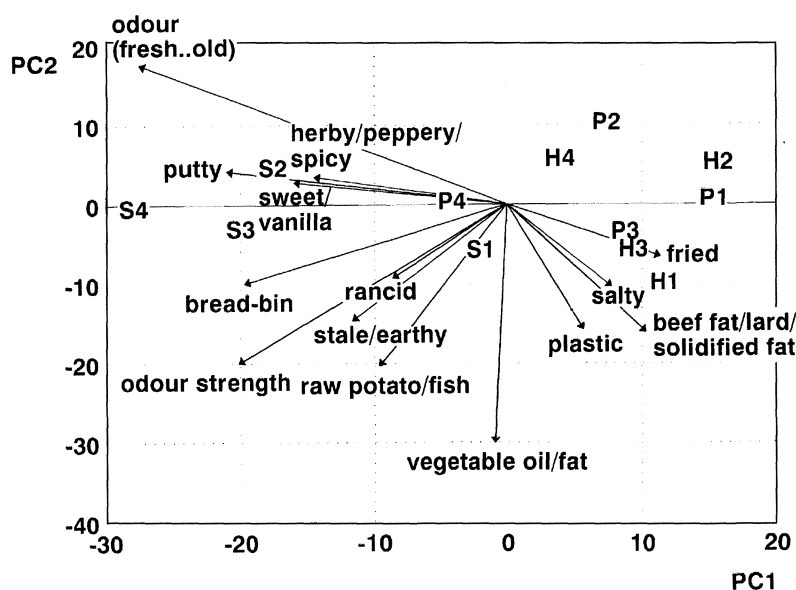


Figure 1

Principal component 1 and 2 of the 19 odour attributes of crisps fried in different oils and stored for up to six months; attributes with relatively small loadings have been omitted. P = palm olein, S = sunflower oil, H = high oleic sunflower oil; 1 = 1/2 month, 2 = 1 month, 3 = 4 months, 4 = 6 months

during storage the odour became more old and putty for all samples and the plastic odour decreased. In general, it can be said that, due to the nature of the differences, the odour quality of the SO samples is worse than the PO and HOSO samples. It is therefore very likely that at least part of the consumers will prefer crisps fried in PO above those fried in SO.

Figure 2 (PC 1 and 2 of 30 (after-)flavour attributes; variance explained 66 %) shows that the effect of storage was more or less the same for the PO

and HOSO samples, but different for the SO samples. The latter developed a higher intensity for the attributes old oil, old, rancid and stale/earthy (both flavour and after-flavour) and the former became less floury and more salty (both flavour and after-flavour). Here, it looks like the starting point is the same for all three samples, but that the changes during storage are different. Again, the SO samples are worse than the PO and HOSO ones. The same reasoning can be done for the flavour as for the odour.

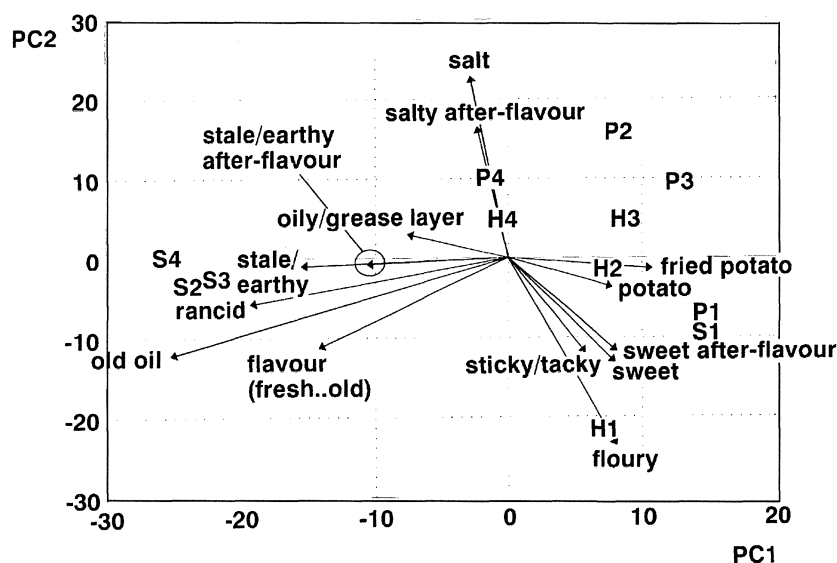


Figure 2

Principal component 1 and 2 of the 30 (after-)flavour attributes of crisps fried in different oils and stored for up to six months; attributes with relatively small loadings have been omitted. P = palm olein, S = sunflower oil, H = high oleic sunflower oil; 1 = 1/2 month, 2 = 1 month, 3 = 4 months, 4 = 6 months

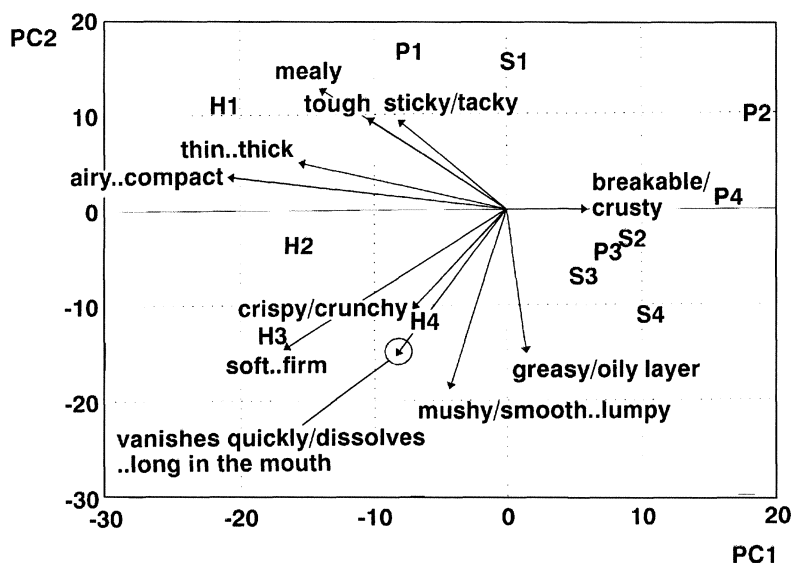


Figure 3

Principal component 1 and 2 of the 11 mouthfeel attributes of crisps fried in different oils and stored for up to six months; attributes with relatively small loadings have been omitted. P = palm olein, S = sunflower oil, H = high oleic sunflower oil; 1 = 1/2 month, 2 = 1 month, 3 = 4 months, 4 = 6 months

In the biplot of the first two PCs (see Figure 3; variance explained 81 %) of the 11 mouthfeel attributes, the HOSO samples were clearly different from the PO and SO samples. The former were more compact, thick, firm, lumpy, crispy/crunchy and were dissolving longer in the mouth. It can be questioned whether these differences are caused by the differences in the oils. Differences in the batches of sliced potatoes used for the preparation of the fried crisps are more likely. Furthermore, in contrast with the remarks made concerning the quality of the odour and flavour of the SO samples, it is not directly clear what the influence of these differences in texture on the perception of quality by the consumer will be.

During the storage the perceptibility of the greasy/oily layer increased and the samples become less floury.

#### *Group 2: PO, SO and SO+DMPS*

This time the number of statistically significant effects in the analysis of variance is much lower. For the periods and the samples the number of significant attributes is 6 and 4, respectively.

The main difference between the PO and the SO and SO+DMPS samples is that the latter had a more salty flavour and after-flavour. In order to check this result, chemical measurements of the salt content were performed. It appeared that the salt content of the PO samples (0.8 %) is indeed lower than of the SO and SO+DMPS samples (1.2 %), and also lower when compared to all other samples (range 1.0 - 1.3 %).

In this group the differences between the SO and PO samples are much smaller than those in group 1. Comparison of the SO and SO+DMPS samples did not reveal any positive effect of the addition of DMPS.

During the storage all samples become less floury and mealy and more lumpy and have a more perceptible oily/grease and greasy/oily layer.

In group 1 the SO samples had a lower sensory quality than the PO samples, in group 2 the sensory quality of these two samples was about the same. It was decided therefore to repeat the comparison of SO and PO with new samples. This time the samples were assessed after five storage times, i.e. 0.5, 1, 2, 4 and 6 months. For this purpose the panel was trained again during four sessions of two hours, during which the list of 60 attributes was somewhat changed.

It appeared that the SO crisps, in comparison with the PO ones, have higher scores for the odour attributes odour strength, old, beef fat/lard/solidified fat and plastic, and the flavour attributes old, deep-frying fat, rancid and old oil. Especially attributes like old odour, old flavour, rancid and old oil flavour can be considered as typical off-odours or off-flavours. Thus, SO crisps have a lower sensory quality than the PO ones.

#### *Group 3: PO, HOSO and HOSO+DMPS*

The number of statistically significant effects in the analysis of variance is of the same magnitude as for group 2. For the periods and the samples the number of significant effects is 8 and 7, respectively.

Only the mouthfeel of the HOSO samples was clearly different from the PO and HOSO+DMPS samples. The HOSO samples were more thick, compact and firm and took more time to dissolve in the mouth. The same comments can be made as for the results obtained for group 1. Differences for odour and flavour attributes were, if present, small and not important. Thus, again the application of DMPS did not improve the storage quality of the crisps. During storage the flavour of all samples showed decreasing scores for potato and fried potato and increasing ones for old oil and rancid. In addition, storage results in a more perceptible greasy/oily layer.

### **3.2 French fries**

In Table III the results of the analysis of variance are presented. This overview only contains the attributes with statistically significant effects. Four attributes showed a statistically significant interaction between storage period and product (sweet fruits odour, sweet fruits flavour, earthy after-flavour and need to drink). Nine and 12 attributes showed statistically significant differences between respectively the storage periods and the products.

The results of the analysis of variance have been examined in combination with the original mean scores. It appeared that, especially in the beginning of the storage period of 12 months, the sample prepared in SO had a different odour and (after-)flavour in comparison with the reference samples. French fries prefried in SO had higher scores for the odour attribute sweet fruits, the flavour attributes sweet fruits, sweet potato and oily and the after-flavour attributes sweet and oily. The sample prepared in HOSO showed this effect to a (much) lesser extent. It is likely that consumers will perceive these differences as negative, as they do not expect these sensory properties.

In the experiment with the crisps (see above) and in the literature (Theunissen et al. 1977, Robertson et al. 1978, Van Gemert and Hoekman 1986, Keijbets et al. 1986, Gustafsson et al. 1993) this sweet fruits odour and flavour is not mentioned. Neither was it discussed by Pokorny et al. (1982a, b) who compared chicken muscle and fish filet fried in fresh and oxidized or used sunflower seed oil. The possibility that this typical sweet fruits odour and flavour is an artefact of these experiments can not be excluded. Further research will be needed to establish whether this finding is an artefact or not.

The reference sample of the potato variety Record had higher scores for the odour attributes warm new oil and butter (especially in comparison with the HOSO samples) and a lower score for the flavour attribute earthy, and had, specifically at the end of the storage period of 12 months higher scores for the mouthfeel attribute hard outside.

Table III  
French fries; overview of attributes with statistically significant F-values of the analysis of variance

	Per1)	Prod	Per.Prod
<b>ODOUR</b>			
odour	1.01	3.90*	0.74
warm new oil	2.29	3.35*	0.48
butter	1.12	4.96*	0.88
sweet fruits	4.00**	2.49	1.86*
<b>MOUTHFEEL</b>			
outside ( <i>weak/soft...hard</i> )	2.41	7.51**	1.57
outside tough	2.97*	0.55	0.93
inside dry/mealy	2.66*	4.01*	0.83
crumbling	4.31**	0.78	0.78
smooth	1.77	4.13*	1.00
<b>FLAVOUR</b>			
baked potato	4.08**	1.48	0.71
watery	3.69**	3.58*	0.54
sweet fruits	11.81***	19.15***	3.53***
sweet potato	4.88**	0.85	1.23
oily	1.22	6.69**	0.55
earthy	1.32	4.20*	1.02
<b>AFTER-FLAVOUR</b>			
oily	0.53	5.53**	1.48
sweet	5.26***	1.97	1.67
earthy	2.16	2.47	2.12*
need to drink	0.38	4.19*	1.79*

1) Per = storage periods; Prod = products; Per.Prod = their interaction

\*)  $P < 0.05$ ; \*\*)  $P < 0.01$ ; \*\*\*)  $P < 0.001$

During the storage period the mouthfeel attributes outside tough, inside dry/mealy and crumbling got higher scores for all samples. This is also true for the flavour attribute baked potatoes; the flavour attribute watery decreases during storage.

#### 4. CONCLUSIONS

Crisps prepared in SO had a lower sensory quality than the ones prepared in PO. Frying in HOSO

resulted in crisps comparable with those fried in PO. The differences found in this study concerning the mouthfeel or texture are thought not to be caused by the application of different oils. The addition of DMPS does not have any positive effect on the storage quality of crisps fried in SO or HOSO.

Frying of French fries in HOSO and especially in SO results, in comparison with RP, in a product with a typical sweet fruits odour and flavour. During storage these sensory attributes decrease in intensity. As this finding might be an artefact of this study, further research is needed.

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