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Comparative study of frying to other cooking techniques influence on the nutritive value

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SUMMARY

Comparative study of frying to other cooking techniques influence on the nutritive value.

Frying is one of the oldest methods of food preparation. It improves the sensory quality of food by formation of aroma compounds, attractive colour, crust and texture. Undesirable changes involved are loss of nutritive quality e.g. due to degradation of heat – susceptible vitamins.

The influence of common frying methods (frying in an oven, in a pan deep frying) on cooking time and nutritive value of vegetables, potatoes, meat, poultry and fish is described and compared to other cooking methods (boiling, steaming, stewing).

Frying of vegetables, potatoes and breaded meat, poultry and fish, no matter whether in a pan or by deep – frying, is associated with fat uptake (2 – 14 g per 100 g of raw food) while non – breaded high fat food of animal origin loses fat during frying (2 – 30%). Data suggest that the fat quantity absorbed during frying increases up to a saturation limit which depends on the kind of food and on the amount of panade. Deep – fried meat, poultry and fish usually absorb less fat than meat, poultry and fish fried in a pan. The kind of fat had no essential influence on fat uptake.

After frying of vegetable food and of breaded meat, poultry and fish, the content of protein, carbohydrates and minerals was nearly fully retained while boiling and steaming reduced the mineral content by 25-50%.

In the majority of cases frying including deep frying also retained the vitamins B_1, B_2, B_6 and C better than boiling, steaming and stewing.

KEY-WORDS: Cooking methods – Food stuffs – Frying process – Nutritive value.

1. INTRODUCTION

Frying is one of the oldest methods of food preparation. It improves the sensory quality of food by formation of aroma compounds, attractive colour, crust and texture. Cooking, moreover, improves the hygienic quality of the food by inactivation of pathogenic microorganisms and enhances digestibility and bio-availability of nutrient in the digestive tract. Undesirable changes involved are loss of heat- and oxidation susceptible vitamins and of water soluble minerals.

The most important methods to fry food are:

deep frying:	cooking of food in enough hot fat or oil for the food to float on it
shallow frying:	frying of food in little fat or oil in a pan
roasting:	frying of mostly protein containing food with or without fat in an oven

This paper will be devoted to the following subjects which will be discussed on the basis of own experimental results and literature data:

- Influence of cooking medium and temperature on cooking time during frying of vegetable and animal food.
- Influence of various frying methods, as compared to other cooking methods such as boiling, steaming, stewing and braising, on nutrient content (protein, fat, carbohydrates, minerals, vitamins).

2. MATERIAL AND METHODS

2.1 Food

Potatoes and potato products, pork (fat and lean), hamburgers (mixture of pork and beef), meat loaves, fried sausage, chicken and turkey breast meat, plaice fillets and pollack fingers were used, i.e. food which is frequently deep fried, roasted or fried in a pan, either breaded or unbreaded.

The food was prepared according to household recipes. Industrial convenience food including deep frozen French potatoes, potato pan cake and breaded fish were used as well.

2.2 Cooking methods, equipment

Household and industrial deep fryers (max. volume: 2-15 l), household frying pans and convection ovens were used (Piekarski [22]).

2.3 Determination of the cooking endpoint

The cooking endpoint depends on the cooking degree of a food; it is usually characterized by the sensory quality attributes colour, shape, odour and texture. For the cooking endpoint, or cooking time, resp., of fried food, two items are essential:

- formation of attractive and typical surface browning and crust, and of aroma compounds, and
- a certain «inner» cooking degree, reflected by colour, taste and texture of the food, e.g. tender texture of meat and fish.

Both external appearance and «inner cooking degree» should be optimal when the cooking process is completed.

Various studies have shown that there is a relation between central temperature and colour during frying of beef and pork (Bognár [7 - 9], Piekarski [23], Tilgner [24]). At a temperature of about 75 °C, the colour turns grey-beige, due to denaturation of the meat pigments myoglobin, oximyoglobin and methmyoglobin. Browning of the food surface and crust formation is described as consequence of many complex reactions including non-enzymatic browning reactions among amino groups of proteins and carbonyl groups of carbohydrates, pyrolysis and carmellization of protein and carbohydrates (Tilgner [24]).

The degree of browning, i.e. surface browning and crust formation of a food during frying, cannot be described by physical data alone. For deep frying e.g. there is only one certain point, i.e. a certain temperature of the heating medium at which both internal cooking and external browning are reached at one and the same time (Skjöldebrand [25]). Perfect cooking means to find out this optimal point.

In the present studies, browning during cooking was evaluated visually by five to seven trained assessors according to a ranking tests including five classes (Table I). The inner cooking degree was evaluated by measurement of the internal temperature of the food.

Table I
Assignment of classes and descriptions when judging degree of browning the frying process

class	colour degree of the surface
A	no browning
B	partly browning, too thin crust
C	optimal browning, golden-brownish, shiny as uniform as possible due to product components
D	partly dark brown, a little bit non uniform, some brown-black parts
E	burnt, too dark brown towards the black-brown colour

2.4 Evaluation of sensory quality

Sensory quality of fried foods was evaluated by means of the 9-point scale [1.1] by at least six trained test persons on the basis of colour shape odour, taste and texture (Bognár, Zacharias [9]).

The scores of 9 - 1 corresponded to the following general descriptions which apply to any of the attributes of colour, shape, odour, taste and texture.

9 = perfect, optimal
8 = typical, without defects
7 = typical, with slight deviations
6 = noticable deviations
5 = noticable defractions, slight defects
4 = distinct defects
3 = strong defects
2 = very strong defects
1 = completely changed

The sensory quality was calculated by using following equation:

$$\text{Sensory quality} = \frac{2\,F_1 + F_2 + 4\,G + 2\,T}{9}$$

where:
F_1 = colour (browning)
F_2 = shape
G = odour + taste
T = texture

2.5 Determination of nutrient content

The content of water (moisture), protein, fat, carbohydrates, minerals (ash), vitamin C, B_1, B_2, B_6 were determined according to standard analytical methods ([1.2 - 1.6], Bognár [3 - 6, 12]). Changes in the weight and in nutrient content of cooked food were compared with the raw material by using following equations:

$$\text{weight yield \%} = \frac{V_{(p)}}{U_{(p)}} \bullet 100 = d_{(p)} \qquad (1)$$

$$\text{weight loss \%} = 100 - d_{(g)} \qquad (2)$$

$$\text{nutrient retention in \%} = \frac{Z_{(i,\,g)} \bullet d_{(g)}}{X_{(i,\,g)}} = d_{(i,\,p)} \qquad (3)$$

$$\text{nutrient loss in \%} = 100 - d_{(i,\,p)}$$

where:

$U_{(g)}$ = weight of food or recipe (9) before cooking in g
$V_{(g)}$ = weight of food or dishes after cooking in g
$X_{(i,\,p)}$ = content of nutrient i per 100 g of raw food or recipe before cooking
$Z_{(i,\,p)}$ = content of nutrient i per 100 g of cooked food or dish p after cooking

Analytical results and literature dates were evaluated according to the usual statistical procedure.

3. RESULTS AND DISCUSSION

3.1 Cooking time and sensory quality

Frying time is influenced by
— temperature of the heating medium
— layer thickness and geometric dimensions of the food
— initial temperature of the food
— desired cooking degree

Cooking time for selected foods and the cooking conditions are shown in Figure 1.

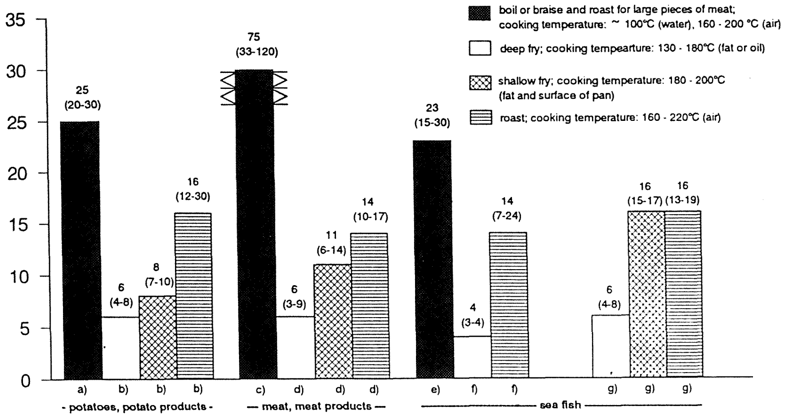

Figure 1
Cooking time of selected foods depending on cooking condition –mean values and variauons–
(Bognár, Zacharias [9], Bognár [11, 14], Gall [16])

a) potatoes, peeled;
b) potato chips, fresh and deep frozen products, potato croquettes, fresh and dry products, potato pan cake, fresh and deep frozen products;
c) beef, pork, chicken, turkey, small and large pieces (for roast only large pieces > 500 g);
d) pork chop, nature and breaded, meat ball (from pork and beef), meat loaf, pork sausage, chicken breast chop, nature and breaded, turkey breast chop, nature and breaded;
e) species not known (Bognár [11]);
f) fillet of Florida pompano, grouper, mackerel, red snapper (Gall [16]);
g) filet of plaice, fish fingers (Alaska pollack), breaded, deep frozen products;

Comparative studies have shown that 190 °C are the maximum fat temperature necessary for both deep frying and frying in a pan, and that below 130 °C browning is insufficient. The temperature of the medium should be adapted to food size, i.e. the larger the diameter of the food to be fried, the lower the temperature. Otherwise surface browning is too fast, while the inner parts are still raw. Optimal temperature, depending on the food and calibration, are between 140 and 190 °C; the quantity of fat in relation to the quantity of food, and fryer capacity must be known (Bognár [7 - 9], Piekarski [22], Tilgner [24]).

The results of sensory analyses listed in Figures 2 and 3 show that good to very good sensory quality can be achieved when potatoes, breaded meat, poultry and fish are deep fried or fried in a pan. Medium quality only is achieved from frying in a convection oven, even when the food surface was sprayed with fat; this was due to uneven surface browning and crust formation and to a less pronounced odour and taste.

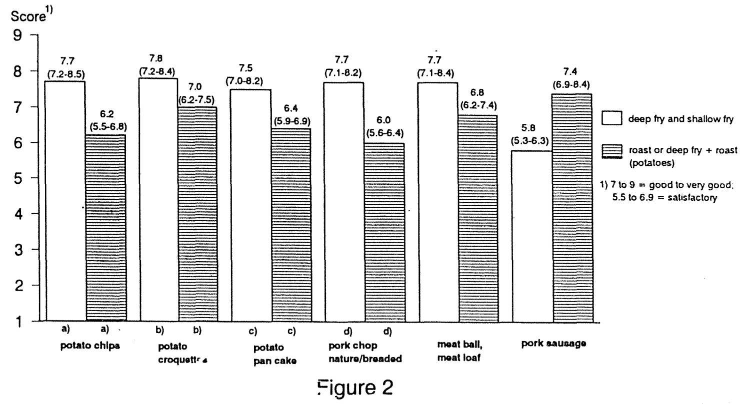

Figure 2
Sensory quality of potato and meat dishes depending on the cooking methoa –mean values and variations– (Bognár, Zacharias [9])
a) fresh and deep frozen products; b) fresh and dry products; c) fresh and deep frozen products; d) lean and fat, small pieces;

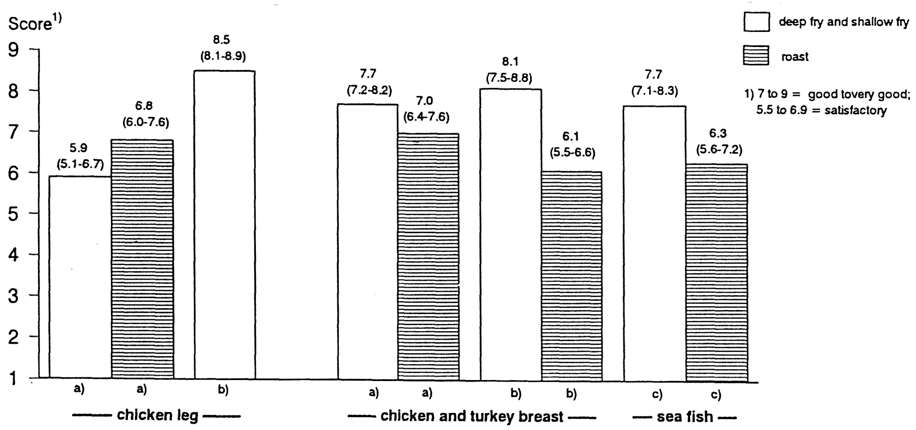

Figure 3
Sensory quality of poultry and fish dishes depending on the cooking method –mean values and variations– (Bognár, Zacharias [9])
a) nature; b) breaded; c) fish fillet (plaice) and fish fingers (Alaska pollack), breaded;

Not all foods are suitable for deep frying. The surface of deep fried chicken legs –unbreaded– is blistered and hard. Deep fried sausages of pork crack. Repeated use of fat for deep frying of potatoes, meat and fish is possible without loss in quality of the food fried; this is in agreement with findings of Moreiras-Varela [20, 21] and Varela [25, 26]. Fat used 20 times did not influence the sensory quality of the potatoes significantly.

3.2 Changes of weight and nutrient content

Weight changes during cooking usually relate to the changes of water and fat content of food (Bergström [2], Gall [16], Moreiras-Varela [20, 21], Varela [25, 26]). The relation between weight yield and change of water and fat content for selected foods using different cooking methods are presented in Table II.

Table II
Influence of certain cooking methods on the weight and on the content of water and fat of selected food (Bognár [9], Gall *et. al.,* [16])

Food	Cooking method	Weight		Water		Fat	
		Yield G (F)	Change g[a]	Content g[b]	Change g[c]	Content g[b]	Change g[c]
Potatoes, peeled	raw	100		80.0		0.2	
	boil	97	-3	78.2	-1.8	0.2	±0
	deep fry	52	-48	28.0	-52.0	4.5	+4.3
Pork chop, lean	raw	100		73.9		2.5	
	boil	60	-40	36.9	-37.0	1.8	-0.6
	deep fry	64	-36	37.4	-36.5	3.8	+1.3
Pork chop, fat	raw	100		66.4		13.2	
	boil	63	-37	33.2	-33.2	10.0	-3.2
	deep fry	67	-33	35.4	-31.0	12.0	-1.2
Pork chop, breaded (lean and fat)	raw	100		66.8		6.2	
	deep fry	79	-21	42.5	-24.3	10.2	+4.0
	shallow fry	79	-21	41.0	-25.8	12.5	+6.2
Grouper, fillet	raw	100		78.0		0.9	
	broil	77	-23	56.0	-22.0	0.9	±0
	deep fry	73	-27	49.8	-28.2	2.7	+1.8
Spanish mackerel, fillet	raw	100		62.9		13.8	
	broil	80	-20	49.8	-13.1	10.6	-3.2
	deep fry	81	-19	47.8	-15.1	10.1	-3.7
Plaice, fillet, breaded (deep frozen product)	raw	100		70.8		1.9	
	deep fry	87	-13	50.1	-20.7	9.7	+7.8
	shallow fry	92	-8	49.6	-21.2	15.2	+13.3

a) Weight of raw food – yield

$$\text{b) Change in g} = \frac{\text{Content per 100 g of cooked food}}{100} \qquad \text{* F = C}$$

c) Content per 100 g raw food – C
– = loss; + = absorption

These values are always related to 100 g raw food. According to our experimental results and the literature data the following types of weight changes resulted from cooking:

— water and carbohydrate losses in potatoes by boiling
— water, fat and protein losses in meat and fish by boiling, braising and roasting
— water and fat losses in meat and fish with high fat content (> 5 %) by deep frying and shallow frying
— water losses and fat absorptions in potatoes, meat and fish with low fat content (< 5 %) and breaded meat and fish by deep frying and shallow frying.

Figure 4 shows the mean weight losses during cooking of selected foods. The highest losses were found in potato chips after deep frying and meat after boiling and braising. The different frying processes had only a little influence on the weight yield in case of potato products and breaded fish, while significantly lower losses were noted for shallow fried breaded meat chops (pork, chicken and turkey breast). Boiling of meat occured significant lower weight yield than deep frying and shallow frying of small pieces of meat.

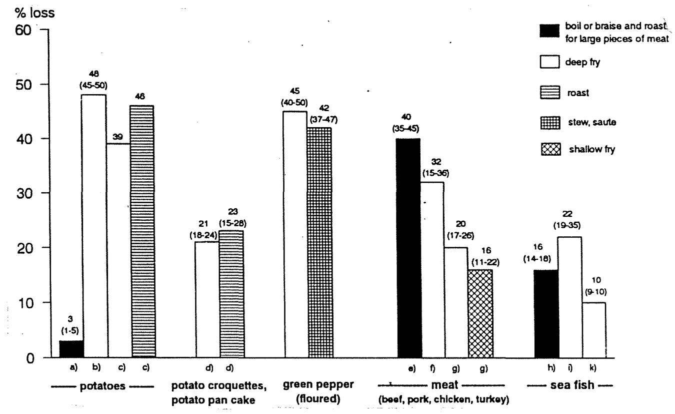

Figure 4
Effect of certain cooking methods on the weight of selected foods –mean values and variations–
(Bergström [2], Bognár [11, 14], Bognár, Zacharias [9], Gall *et al.* [16], Moreiras - Varela *et al.* [21], Varela [26],

a) potatoes, peeled; b) potato chips, fresh (deep fry and deep fry + roast); c) potato chips, deep frozen products;
d) fresh, dry and deep frozen products; e) small and large pieces;
f) small pieces (deep fry, shallow fry, roast); g) small pieces, breaded; h) fillet of grouper, pompano, red snapper, mackerel;
i) anchovy, hake, fillet of grouper, pompano, red snapper, mackerel (deep fry, shallow fry, roast);
k) fish fillet (plaice) and fish fingers (Alaska pollack), breaded, (deep fry, shallow fry, roast);

Gall *et al.* [16] found that the mean weight yield for deep fried grouper, red snapper and pompano fillet were significantly lower than the yield with other cooking methods. No significant differences were found between the weight losses of mackerel fillets prepared by any of these cooking methods. The presented data suggest that the weight yield are related to the type and the dimension and also to the coating of food with flour or bread crumbs.

There was an apparent net increasing in the nutrient content of fried food, when compared to the raw food on the wet weight basis. However the content of these nutrients in all fried foods cooking by deep frying, shallow frying and roasting, was, with exception of fat, more or less lower if it would have been calculated on the 100 g raw food basis.

The retention of protein in cooked food investigated varied from 90 % in boiled meat and 96 % to 100 % in deep fried potatoes, meat and fish (figure 5). The lower retention after boiling and roasting of meat and fish occured mainly due to leaching and dripping (Bognár [11 - 16]). Our investigation shows results similar to those of Gall [16] and Moreiras-Varela [21]. In the study conducted by Moreiras-Varela *et al.* [21] it was found that the deep frying of hake, beef, pork and sword fish did not change the digestibility of protein (Table III).

Table III

Protein digestibility coeffizient of raw and deep fried food (Moreiras-Varela *et al.* [21])

State	Beef	Pork	Meat balls	Hake	Fish	Fish balls
Raw	0.93	0.92	0.90	0.92	0.94	0.92
Deep fried	0.93	0.92	0.88	0.92	0.96	0.89

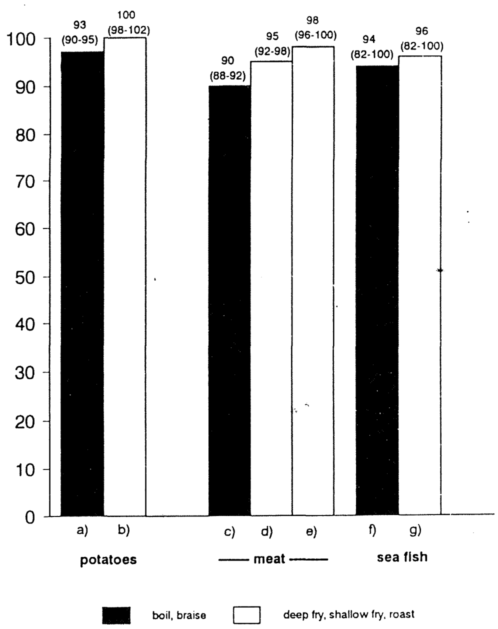

Figure 5
Effect of certain cooking methods on the protein content of selected foods –mean values and variations–
Bognár, Zacharias [9], Bognár [7, 8, 10, 11, 14], Gall [16], Moreiras – Varela [21], Varela [26]

a) potatoes, peeled; b) potato chips, fresh and deep frozen products, potato croquettes, fresh and dry products, potato pan cake, fresh and deep frozen products (deep fry, deep fry+roast);
c) beef, pork, small and large pieces; d) beef, pork chop, chicken and turkey breast, small pieces;
e) beef, pork chop, chicken and turkey breast, small pieces, breaded;
f) fillet of grouper, pompano, red snapper and mackerel;
g) anchovy, hake, fillet of grouper, pompano, red snapper and mackerel, fillet of plaice and fish fingers (Alaska pollack), breaded;

The change of carbohydrate content was investigated only in potatoes, potato products and breaded meat and fish. The results showed that the retention of carbohydrates varied from 95 % to 100 % depending on the kind of food. No influence of frying methods was found.

The results of our investigations and of the literature reviewed about changes of mineral (ash) content in food during cooking are compiled in Figure 6.

Minerals are especially of water soluble potassium easily lost in cooking water by boiling of plant and animal food and dropping by roasting of meat (Bognár [7 - 8, 10 - 11]). The losses of minerals (ash) in deep fried foods varied –as the figure 6 shows– from 1 % in potatoes and 26 % in beef and were significantly lower than in boiled foods from the same type. The mineral losses in breaded meat and fish varied after deep frying from 2 % and 8 % and were significantly lower than in deep fried meat and fish fillet without coating. The bread crumbs seems to be absorbed the minerals solved in gravy of meat.

Our findings and literature data about change of fat content in food during cooking are shown, that the fat in food may be lost, gained or remain unchanged after cooking (Figure 7 and 8).

No significant changes was found in boiled and steamed potatoes and vegetables (Bognár [9, 14]). The quantity of fat absorption in deep fried potato chips, croquettes and potato pan cakes varied between 4.5 and 10g per 100 g of raw food. No fat absorption was occured during roasting of deep frozen potato chips. The highest fat absorption was found in shallow fried potato pan cakes.

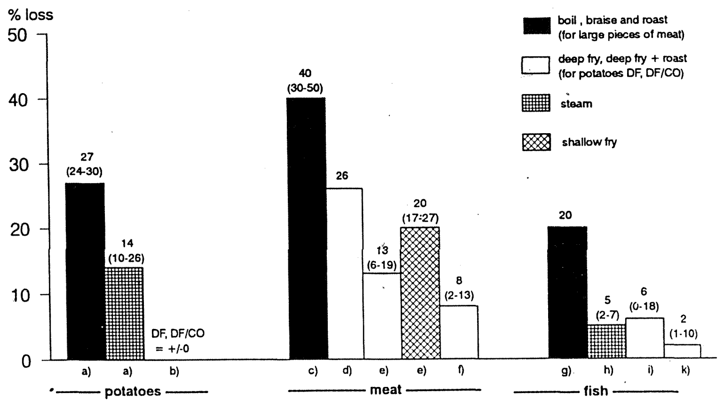

Figure 6
Effect of certain cooking methods on the mineral (ash) content of selected foods –mean values and variations–
(Bognár, Zacharias [9], Bognár [11, 14], Moreiras – Varela [21], Gall *et al.* [16])

a) potatoes, peeled;
b) potato chips, fresh and deep frozen products, potato croquettes, fresh and dry products, potato pan cake, fresh and deep frozen products (deep fry, deep fry+roast);
c) beef, pork, small and large pieces; d) beef, small pieces; e) pork chop, lean and fat, chicken and turkey breast, small pieces;
f) pork chop, lean and fat, chicken and turkey breast, breaded, meat ball, meat loaf, pork sausage (deep fry, shallow fry, roast);
g) sea fish (species not known); h) fresh water fish (trout, carp);
i) anchovy, hake, grouper, pompano, red snapper, mackerel (deep fry, roast);
k) fish fillet (plaice) and fish fingers (Alaska pollack), breaded (deep fry, shallow fry, roast);

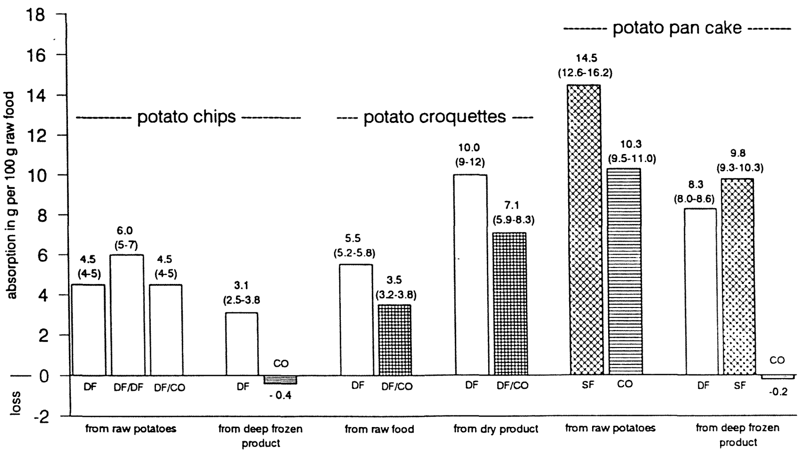

Figure 7
Changes of fat content in potatoes and potato products as a function of cooking methods –mean values and variations– (Bognár, Zacharias [9], Bognár [11, 14])

DF = deep fry; DF/CO = deep fry+roast; CO = roast; SF = shallow fry

Frying of breaded meat, poultry and fish, no matter wether in a pan or deep fat fried was associated with a fat uptake of 2 to 13.3 g per 100 g of raw food, while meat, and fish, with a fat content of 5 to 20 g per 100 g raw food, lost during boiling or roasting 0.4 to 5 g fat per 100 g raw food (Figure 8).

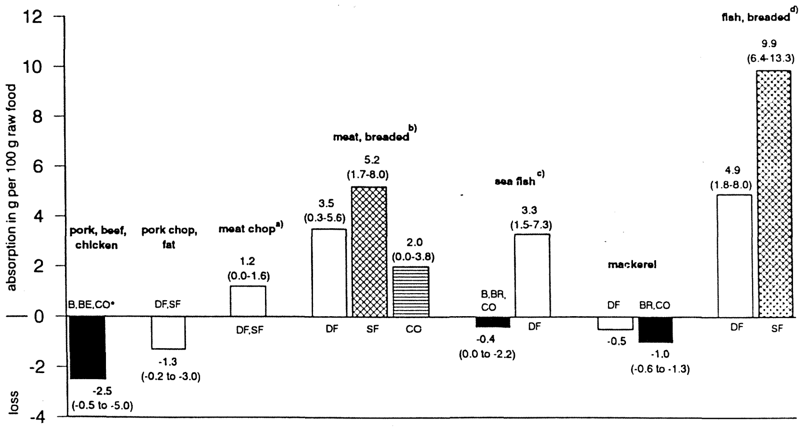

Figure 8
Changes of fat content in meat and fish as a function of cooking methods –mean values and variations– (Bognár, Zacharias [9], Bognár, [7, 8, 10, 11], Gall *et al.* [16], Moreiras – Varela *et al.* [21])

a) pork lean, chicken and turkey breast, small pieces; b) pork lean and fat, chicken and turkey breast, small pieces; c) anchovy, hake and fillet of grouper, pompano; d) fillet of plaice and fish fingers (Alaska pollack)
B = boil; BR = braise; CO = roast; CO* = roast of large pieces (> 500 g); DF = deep fry; SF = shallow fry;

Significant amounts of fat was absorbed from frying fat by the chops of lean pork, chicken and turkey breast and by the fillets of fish with low fat content (grouper, red snapper and pompano).

Our findings and literature data (Gall [16] and Moreiras-Varela [21], Varela [26]) indicate that the gain or loss of lipid from meat and fish is related to the lipid content in raw food and to the quantity of the coating flour or bread crumbs on the food surface. Deep fried, breaded meat, poultry and fish usually absorb less fat than meat, poultry and fish fried in a pan. The kind of fat had no essential influence on fat uptake.

As known, cooked foods are important sources of **vitamins** in the diet. Research regarding losses during cooking of foods was concentrated especially on the retention of vitamin C and vitamin B_1. Ascorbic acid and thiamine are the nutrient most susceptible to the thermal degradation and leaching from food.

Experimental data concerning changes in the vitamin C-content of potatoes, potato products and green pepper during cooking by different methods have been reported by several authors; they are compiled in Figure 9. The most investigations of deep frying have been done with potatoes since for more than fifty years the preparation of french fried potatoes or chips is common praxis in most countries in the western world (Brubacher [15]).

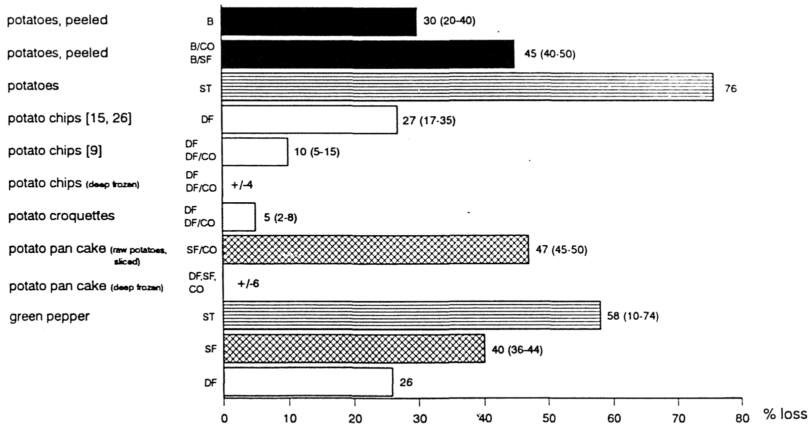

Figure 9
Effect of certain cooking methods on the vitamin C content in potatoes and potato products –mean values and variations–
(Bognár, Zacharias [9], Bognár [10, 11, 14], Brubacher [15], Miucclo [19], Varela [26])

B = boil; B/CO = boil + roast; B/SF = boil + shallow fry; CO = roast; DF = deep fry; SF = shallow fry; ST = stew, saute

Cooking of potatoes under different conditions shows less vitamin C-loss for deep frying (5 - 35 %) and deep frying + roasting followed by boiling (30 %) and stewing (76 %). Nearly the same relations could be shown in green pepper. The high variation of the vitamin C loss during deep frying of potato chips could be occured from the used analytical method. Our own investigations on potato dishes, prepared from different raw products like as fresh or deep frozen, let us conclude that the decomposition of ascorbic acid is depending also on the activity of the peroxida-seenzym in the raw product. Vitamin C-retention in potato chips, pan cakes and croquettes, prepared from deep frozen and dry products resp. was nearly 100 % since these products did not contain any peroxidase activity.

The losses of vitamin B_1 during cooking of food ranged from 0 % to 10 % in potatoes and vegetables, 10 to 70 % in meat and fish (Figure 10). According to the cooking methods, meat and fish suffered quite several losses by boiling, braising and roasting, while after deep frying and shallow frying the losses were significantly lower in meat, breaded meat and fish respectively. Coating of meat and fish with bread crumbs effected also for thiamine a better retention during deep frying and shallow frying.

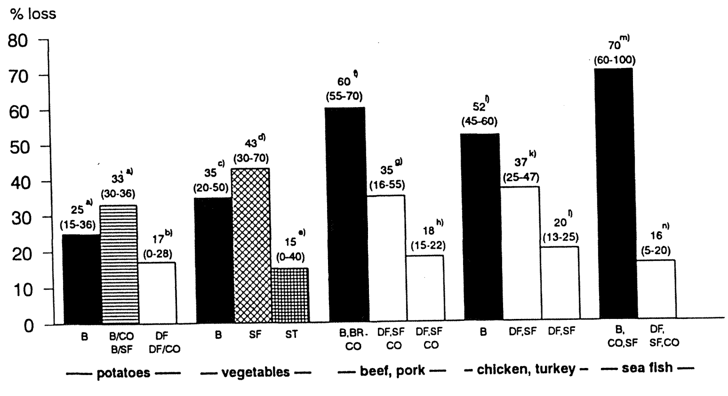

Figure 10
Effect of certain cooking methods on the vitamin B1 content of selected foods –mean values and variations–
(Bognár, Zacharias [9], Bognár [10, 11, 13, 14], Brubacher [15], Miucclo [19])

a) potatoes, peeled; b) potato chips, (fresh and deep frozen products, potato croquettes (fresh and dry products), potato pan cake (fresh and deep frozen products); c) all varieties; d) green pepper, egg plants, veg.marrow; e) green pepper, egg plants, squash summer;
f) small and large pieces; g) beef, beef ball, pork chop lean and fat; h) pork chop lean and fat, breaded, meat ball, meat loaf, pork sausage;
i) chicken whole; k) chicken leg, chicken and turkey breast, small pieces;
l) chicken leg, chicken and turkey breast, small pieces, breaded;
m) mackerel, octopus, tinca, tuna; n) fish fillet (plaice) and fish fingers (Alaska pollack), breaded;

B = boil; B/CO = boil + roast; DF/CO = deep fry + roast; SF = shallow fry; B/SF = boil + shallow fry;

The changes of vitamin B_2 content during cooking of food ranged between 70 % losses and 240 % increases (Figure 11). The losses during boiling of potatoes, vegetables, meat and fish were occured mainly by leaching (Bognár [7 - 8, 10 - 11]). The increases of riboflavine content during deep frying, shallow frying and roasting of potatoes, breaded meat and fish were significant. The gain of riboflavine is caused probably by generation of riboflavine from riboflavine precoursors during cooking. The kind of precoursors are not yet known and has to be elucidated in further research. Brubacher [15] found in sea pike also a gain of riboflavine during frying. He described it as probably sampling errors.

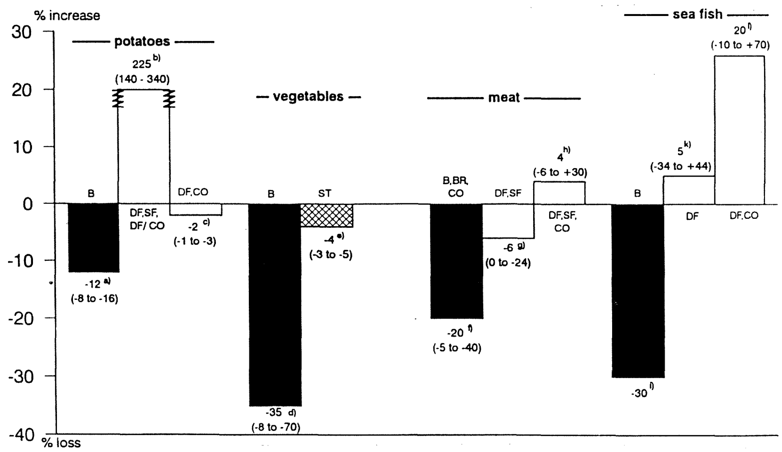

Figure 11

Changes of vitamin B2 content of selected foods as a function of cooking methods –mean values and variations– (Bognár, Zacharias [9], Bognár [7, 8, 11, 13, 14], Brubacher [15])

a) potatoes, peeled; b) potato chips, potato pan cake (fresh and deep frozen products), potato croquettes (fresh);

c) potato croquettes from dry product (enriched with 3-5 mg riboflavine per 100 g); d) all variety; e) green pepper, egg plants, squash summer;

f) beef, pork, small and large pieces; g) beef, pork, lean and fat, chicken and turkey breast, small pieces; h) pork, lean and fat, chicken and turkey breast, small pieces, breaded, meat ball, meat loaf, pork sausage; i) species unknown; k) sardines (-34%), sea pike (+44%); l) fish fillet (plaice), fish fingers (Alaska pollack), breaded, balls of sea pike;

B = boil; BR = braise; CO = fry in oven; DF = deep fry; DF/CO = deep fry + roast; SF = shallow fry;

In natural food vitamin B_6 is present as pyridoxamine (PM), Pyridoxal (PL) and pyridoxin (PN) either free or bound to phosphate, proteins, aminoacids and glucosids (Bognár [12]). Data about the influence of cooking on the content of individual vitamin B_6 compound are rare. In the present work the effect of different cooking methods on the individual vitamin B_6 derivates and the total vitamin B_6 in selected food were investigated by using a HPLC analytical method (Bognár [12, 14]).

The total content of vitamin B_6 was on average 350µg in potatoes, 306 µg in green pepper, 67 µg in egg plants and 119 µg in squash summer (Bognár [14]). Potatoes and vegetables contained besides PM and PL also a high level of pyridoxine. Cooking of potatoes and vegetables under different conditions have shown less vitamin B_6-loss by deep frying and stewing followed by boiling (Figure 12). Our findings confirm with literature date (Zobel [30]) according to which leaching loss due to the high water solubility of the vitamin B_6 derivates is high. Due to degradation, but also conversion into pyridoxamine, pyridoxal has been found to be the least stable vitamin B_6 compound in plant foods.

Raw pork contained on average 400 µg vitamin B_6 per 100 g, chicken breast 790 µg and turkey breast 640 µg respectively. 25 % to 50 % of total vitamin B_6 were PM, 40 % to 60 % were PL and 5% to 10 % PN. Boiling and braising reduced the content of vitamin B_6 by 50 % in pork and by 30 % in poultry and fish, while deep frying caused losses of 25 % in breaded pork and 25 % in breaded fish only.

Part of pyridoxal which was degraded nearly completely under the heat influence was transaminated into pyridoxamine. Of pyridoxine nearly 100 % were retained. A relation seems to be exist between the extent of the vitamin B_6-loss and pyridoxal content of the raw food; the higher the PL content, the higher the thermal loss.

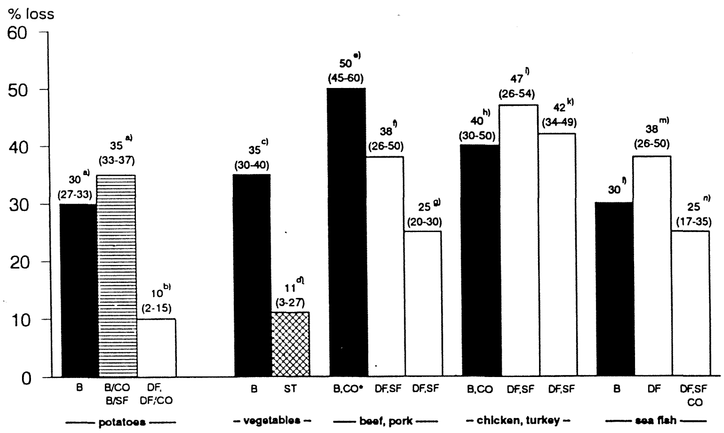

Figure 12
Effect of certain cooking methods on the vitamin B6 content of selected foods –mean values and variations–
(Bognár, Zacharias [9], Bognár [11, 14], Brubacher [15])

a) potatoes, peeled; b) potato chips (fresh and deep frozen products), potato croquettes (fresh and dry products), potato pan cake (fresh and deep frozen products); c) all varieties; d) green pepper, egg plants, squash summer; e) beef, pork, small and large pieces; f) beef, beef ball, pork chop, lean and fat, small pieces; g) pork chop, lean and fat, breaded, meat ball, meat loaf, pork sausage; h) chicken whole; i) chicken leg, chicken and turkey breast, small pieces; k) chicken leg, chicken and turkey breast, breaded; l) species unknown; m) sea pike and sardines; n) balls of sea pike and fish fingers (Alaska pollack), breaded;

B = boil; CO = roast in oven; DF = deep fry; DF/CO = deep fry + roast; SF = shallow fry; ST = stew, saute;

4. CONCLUSION

After frying of potatoes, vegetables and of breaded meat, poultry and fish, the content of protein, carbohydrates and minerals was nearly fully retained while boiling and steaming reduced the protein content by 5 - 10 % and the mineral content by 25- 50 %.

Frying of vegetables, potatoes and breaded meat, poultry and fish, no matter whether in a pan or by deep fat frying, is associated with fat uptake (2 - 13 g per 100 g of raw food) while non-breaded high fat food of animal origin loses fat during frying (2 - 30 %). Data suggest that the fat quantity absorbed during frying increases up to a saturation limit which depends on the kind of food and on the amount of panade. Deep fried breaded meat, poultry and fish usually absorb less fat than shallow fried breaded meat, poultry and fish. The kind of fat had no essential influence on fat uptake.

In the majority of cases deep frying and shallow frying also retained the vitamins B_1, B_2, B_6 and C better than boiling, steaming and stewing.

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