EVALUATION OF OIL SEED BY-PRODUCTS AS POTENTIAL FOOD INGREDIENTS

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ABSTRACT

The objective of our research work was to study the application of by-product of cold-pressed sunflower seed and cold-pressed pumpkin seed as ingredients of bakery and coatings. We made detailed chemical analysis to evaluate the nutritional value and made microbiological tests to know the safety of these materials. Food development trials were made. The pumpkin and sunflower seed by-products were found to be rich in nutritive and physiologically important compounds. High protein, dietary fibre and fat ratio. They had very high ratio of the unsaturated fatty acids, especially the essential linol acid (~60%/total fat). The by-products were found microbially safety. Application as food ingredients can be unique, because of the product's new look and claim of healthy product. For bread making, using of dough improvers are proposed, because of by-products' dough weakening effect. As coating (batter) ingredients for deep-fat frying, the pumpkin seed by-product was less effective to decrease the oil uptake, than the sunflower seed by-product.

1. INTRODUCTION

The by-products of cold-pressed sunflower-seed and pumpkin seed are rich in bioactive compounds e.g. protein, fiber, unsaturated fatty acids, phytosteroids, etc., which have many positive physiological effects. (Moure, 2006).These can reduce the risk of different diseases e.g. colon cancer, osteoporosis. So these materials can be suitable as functional ingredients in foodstuff.

The utilization possibilities are limited by not only the physiologically important chemical composition of the by-products, but also the compliance to the food safety rules. The ingredient used in the further food development also can not be harmful to the consumers' health. Microbial contamination (e.g. *Salmonella, mould number)* and chemical residue (e.g. mycotoxins, pesticides) have to be below the allowed limit values.

Nowadays these by-products are used in animal feeding. It is real challenge to make detailed evaluation for find the new utilization possibilities, and determined the economically fitting product prototype.

Inasmuch as the oil seed by-products are dry materials, plausible to use them in dry mixes, such can be for making breads, and the other one can be the coatings for fried foods. Bread is staple foodstuff. Different sorts of bread are consumed all around the world. Can we increase the nutritional value without changing the organoleptical properties of the product type, or can we develop new, unusual look? (Cauvain, 2003).

Deep-fat fried (DFF) battered products are very popular, but they adsorb significant amount of fat. The oil used in DFF not only increase the caloric content of the food and contribute nutritional and physiological elements, such as fat-soluble vitamins, but also increase the quantity of the oxidative derivates in the fried product. So it increases the risk of different diseases e.g. cardiovascular diseases, colon cancer etc. It is important to study different coating formulas to reduce the oil uptake and possibly to increase the nutritional and physiological element ratio in the end product. (Gennadios et al. 1997)

The objective of our research work was to study the application of by-products of cold-pressed sunflower and pumpkin seed as functional ingredients in flour formulas for bakery and in fried products. We measured the chemical composition of these by-products, checked the microbiological contamination, and studied the application in mixed flours: determined the rheological properties, measured techno-functional properties e.g. coating adhesion and the oil content of deep-fried products.

2. MATERIALS AND METHODS

The by-products of cold-pressed sunflower and pumpkin seeds were brought from a Hungarian agricultural company. The hulled oil seeds were cold pressed. The extruded by-product were milled, then packed in opaque plastic bags, and stored in cool place to avoid from the degradation (e.g. oxidation, putrefaction).

Chemical analysis:
Water content: MSZ 6369-4:1987.
Protein: MSZ 6830-4:1981.
Total dietary fibre: MSZ 6884-3:1985, MSZ 6369-12:1979.
Fat: MSZ 6369-15:1982.
Fatty acids composition (SFA=saturated fatty acids, MUFA=monounsaturated fatty acids, PUFA=polyunsaturated fatty acids): Perkin Elmer Clarus 500; splitless PTV t=250°C; He 5.0(1ml/min); 70°(2')→(2°/p) →250°C(1')→(8°/p)→280°C(60'); FID (300°C).
Macro-and microelement composition: Sample extraction were made with the mixture of HNO_3:H_2SO_4:H_2O_2=4:1:1 (v/v) in microwave extractor. Perkin Elmer Optima 5300DV; RF:40MHz; RF power: 1300 W; torch injector diameter: 2 mm; Ar gas: 0,85 l/min; Ar flow rates: Aux: 1,5 l/ min, plasma: 15 l/min; sign: 3 pointed area; resolution: 0,006 at 200 nm.

Microbiological evaluation:
Total plate count determination: we incubated PCA (Merck) plates for 48 h at 30°C according to the MSZ ISO 4833:1999.
Mould number: YGC agar (Merck) was used for mould enumeration. Plates were incubated at 25°C for 5 days according to the MSZ ISO 7954:1999.
Coliform: BPLS agar was used for *Coliform* enumeration. Plates were incubated for 24 h at 37°C.

Measurements for food application:
As bread ingredients:
Mixed flour formulas' preparation: We mixed 4 basic flour formulas which were wheat flour (BL-80) and by-products in two ratios less than 10%, respectively (notation: P as pumpkin, S as sunflower; addition units: 1 Unit as 1U, 2 Units as 2U). We supplemented the basic flour formulas with inulin (BeneoHPX) or guar gum in 1 and 2%.
Rheological measurements: the formulas' humid gluten ratio, the stretching of humid gluten, the water absorption, degree of softening with Farinograph, the extensibility, the energy (breaking force), resistance to extension with Brabender Extensograph were determined.

As batter ingredients:

Batter (coating) preparation: We mixed wheat flour (BL-55) and by-product one-by one in the ratio of 7:3. The pre-blended dry ingredients were mixed with distilled water in a container by using a domestic Braun mixer for 30 sec. The dry/water mix proportion was 3:4 and 3:5.

Coating adhesion: The batter adhering to the sample during dipping was considered as the batter-pick up and was calculated as the mass of the coated samples divided by the uncoated one multiplied with 100, in triplicate.

Deep-fat frying process: Formed (1x1x4cm), coated pieces of celery were deep fat-fried in sunflower-seed oil at 180 °C for 4 minutes.

Measurement of oil absorption (uptake): Fried samples were extracted with 50 ml n-hexane in ultrasound for 15 min, in triplicate. After evaporating of n-hexane we measured the oil content gravimetrically.

3. RESULTS AND DISCUSSION

The application possibilities of oil seed by-products are influenced partly by the chemical composition and on the other hand the adequacy for the regulation of food safety. We measured these by-products' inside-values, shown in Table 1, determined the fatty acid composition (Table 2) and the distribution of different sorts of fatty acids (Table 3), the macro-and microelement composition (Table 4), and furthermore the vitamin content, shown in Table 5.

Table 1. Chemical content of oil seed by-products (g/100g).

Sample name	Water	Protein	Total dietary fibre	Soluble fibre	Fat	Ash	Carbo-hydrates
Pumpkin seed by-product	7,2	50,4	6,3	4,4	8,1	7,2	27,3
Sunflower seed by-product	7,6	48,5	15,3	12,7	9,2	7,0	22,4

Table 2. Fatty acid composition (%) of oil seed by-products.

Sample name	Total SFA (%)	Total MUFA (%)	Total PUFA (%)
Pumpkin seed by-product	16,0	22,2	61,7
Sunflower seed by-product	15,4	27,5	57,1

Table 3. Distribution of different sorts of fatty acids in oil seed by-products (%).

Fatty acid ratio / Sample name	SFA		MUFA		PUFA
	Palmitic acid 16:0	Stearic acid 18:0	Palmitoleic acid 16:1 (9)	Oleic acid 18:1 (9)	Linol acid 18:2 (9,12)
Pumpkin seed by-product	61,5	38,5	5,6	94,4	100
Sunflower seed by-product	64,3	28,6	4,0	96,0	100

Table 4. Macro and microelement content (mg/100g) of oil seed by-products.

Sample name	Na	K	Ca	Mg	Fe	Mn	Zn	Cu	P	Se
Pumpkin seed by-product	37,3	1810,2	95,4	1317,2	35,4	6,2	17,5	3	2510,9	0,008
Sunflower seed by-product	6,7	1522,1	253,6	893,5	14,7	4,7	12,1	3,9	1422,5	0,005

Table 5. Vitamin content of oil seed by-products (mg/100 g).

Sample name	C	B1	B2	B6	Niacin	Panthotenic acid	K	E
Pumpkin seed by-product	0,23	0,47	0,68	0,44	11,52	0,68	0,039	13,45
Sunflower seed by-product	0,06	3,66	0,67	1,52	13,71	17,65	0,13	22,08

Based on our results we stated the water content is very low which influences the further microbial propagation during the storage, thus the safety shelf-life.

These by-products are good for protein enrichment in food development because of their high protein content. The soluble fibre content increases not only the nutritional value, but also can have technological effect.

The ash content of this by-products is also very high, in comparison with the cereals' ones. Only the ash content of wheat bran approximates to be so high, we measured (Varga et al., 2008).

The oil residue of these by-products may have technological effect on the dough, we analyse below. We stated furthermore, that the high poly-and monounsaturated fatty acid content contribute to increase the nutritional value of the prospective food prototype development. The SFA content can give the representative aroma characters which can enhance the popularity of the developed prototype. The ratio of PUFA is 3-folds more, than the MUFA in the pumpkin seed by-product, while in the case of sunflower seed by-product PUFA ratio is 2-folds more. The PUFA content is represented by the essential linol acid, in both of the by-products.

The examined by-products are very rich in both water- and fat-soluble vitamins. In general we can say, that in comparison, the by-products' vitamin content is of an order higher, than the wheat germ's one. (Varga et al., 2008).

We summarized that the by-product of both the pumpkin seed and sunflower seed are rich in nutritive and functional components, so that they can be applicable as functional food ingredients.

Food processing, the raw materials and other food components e.g. ingredients used in food production are required the compliance to the food safety regulations. The oil-seed by-products must have to be safety for the consumer health. For this reason we made microbiological evaluation, to know the microbial safety of these raw materials at the beginning of any food application. We determined the total mesophyl microbe count, the number and the species of mould, and *Coliforms*.

Table 5. Initial microbial contamination of oil seed by-products.

Origin of by-product	Total plate count cfu/g	Mould number cfu/g	Coliforms cfu/g
Pumpkin seed	$3,5 \times 10^3$	$2,33 \times 10^2$	$7,0 \times 10^2$
Sunflower seed	$1,2 \times 10^3$	$4,66 \times 10^2$	-

We can see that the total mesophyl microbe count is higher in the case of pumpkin seed by-product, but acceptable low in the case of sunflower seed by-products. The mould number of the samples is relatively low. We identified *Mucor sp.* and *Penicillium sp.* in the pumpkin seed samples, and *Penicillium sp.* in the sunflower seed samples. According to the *Coliforms*' propagation we concluded that the sunflower seed by-product is adequate, but the pumpkin seed by-product can be infected.
From January 1st 2006 any food producing technology and process have to be adequate to the 2073/2005/EK, where is stated a regulation of hygiene for ready to eat fruits and vegetables. So the food sample has to be *Salmonella*-free. The *E. coli* number upper limit is 1000cfu/g. In the Hungarian regulation of 4/1998 EüM the maximum limit value for mould count is 10.000cfu/g, too.
Summing our results up, the microbial safety of the samples is adequate for the above mentioned legislations in force. But due to growing conditions the contamination of pumpkin seed by-product must be checked more regularly for *E.coli* and *Salmonella sp.*

We studied these oil seed by-products' applicability as ingredients in bread flour and in coating formula, the latter for deep-fat frying process. We measured rheological parameters, as below can be seen.

Table 6. Physical-chemical parameters of different flour formulas for bread making.

Sample name	Humid gluten (%)	Stretching (mm)	Industrial quality value	Water binding capacity (ml)
Control (BL-80)	31,20	1,0	A2	62,00
Pumpkin seed by-product 1U	30,50	3,0	B1	64,40
Pumpkin seed by-product 2U	30,60	4,5	B1	63,60
Sunflower seed by-product 1U	30,75	3,0	B1	63,00
Sunflower seed by-product 2U	30,65	3,5	B2	64,00

Replacement 1U or 2U of wheat flour with any of these by-products decreased the humid gluten ratio. The stretching numbers are increased in all cases. The industrial quality numbers and the stretching data harmonize, the dough softens. By the addition of oil seed by-products these mixed flours need to be supplemented with additives.

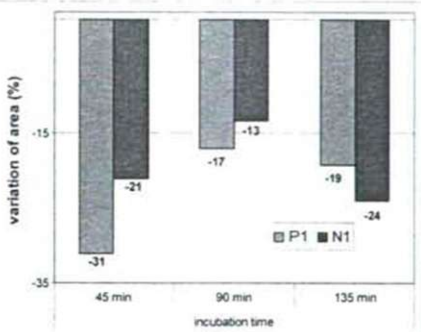

Figure 1. Changing of breaking force (area) in case of 1U wheat flour replacement with by-product.

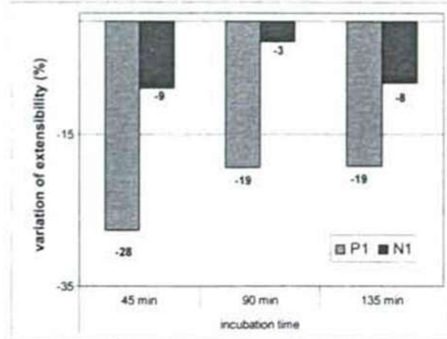

Figure 2. Changing of dough extensibility in case of 1U wheat flour replacement with by-product.

Addition of any by-product to the wheat flour, they soften the dough in every case. The dough extensibility changing values are better in case of sunflower seed by-product addition during the whole incubation time, compared with the pumpkin seed by-product addition.

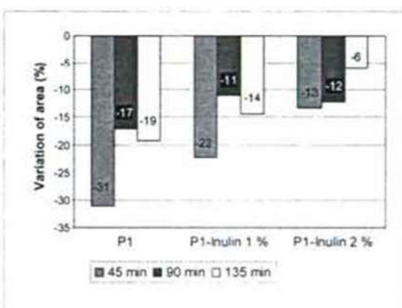

Figure 3. Effect of inulin addition on the change of breaking force in case of pumpkin seed by-product replacement

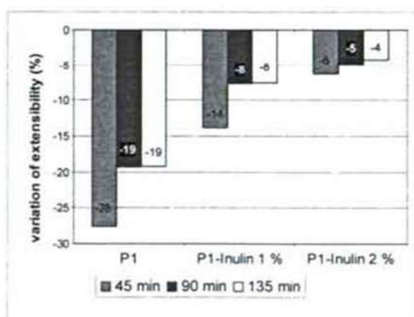

Figure 4. Effect of inulin addition on the change of dough extensibility in case of pumpkin seed by-product replacement

In short incubation period (45 min) every 1% inulin addition enhances the dough force. The dough softens after maximum incubation time on the effect of 1% inulin addition into the mixed flour replaced with pumpkin seed by-product. Increasing inulin ratios decrease the dough extensibility changing, so the mixed dough force converges to the wheat flour dough.

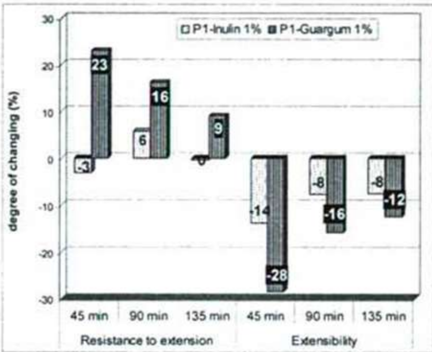

Figure 5. Effect of different additives on the characteristics of dough made with pumpkin seed by-product.

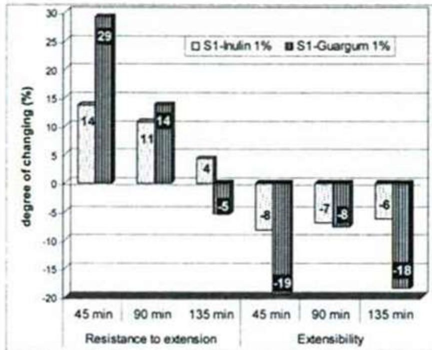

Figure 6. Effect of different additives on the characteristics of dough made with sunflower seed by-product.

The value of resistance to extension indicate the tolerance of dough kneading, in practice we can conclude the dough mashinability. Resistance to extension is better in case of oil-seed by-product addition than the wheat flour dough in both case of inulin or guar gum addition. Guar gum has more significant texture improver effect as compared with inulin in both dough supplemented with pumpkin seed or sunflower seed by-product. Strong dough is more knead able, but less extensible, the bread volume may be less.
Summing our results we concluded that the addition of oil seed by-products soften the dough. The pumpkin seed by-product addition makes bigger ratio of softening, than the sunflower seed by-product addition. So texture improvers need to be added into this dough or flour formulas. The examined, the inulin and the guar gum are good for using as improvers.

The oil seed by-products in coating formula for deep-fat frying were tried. The most important industrial and physiological parameters were determined, shown in Table 7. Coating adhesion is necessary to the making of uniform product; the knowledge of mass of oil absorption is necessary to healthy product preparation.

Table 7. Techno-functional parameters of different flour formulas as coatings.

Measured parameter	Coating adhesion (%)		Oil absorption (%)	
Dilution ratio (mixed flour:DW)	*3:4*	*3:5*	*3:4*	*3:5*
Coating with pumpkin seed by-product	141,2	56,3	7,94	22,98
Coating with sunflower seed by-product	178,0	89,5	7,73	13,67

Growing ratio of dilution affect significantly the coating pick up, in negative correlation. The sunflower seed by-product has higher total dietary fibre content, so it can bind more water, this coating is thicker. The thicker is the coating the bigger the adhesion. The ratio of oil absorption depends on the dilution. The weak is the coating the more fried the product. The weak is the coating on the food surface the more oil absorbs into the product.
Summarized, although the new look of a coating, the green colour of the pumpkin seed by-product coating might be amazing and popular, it looks it is physiologically less functional

than the other one which is added with sunflower seed by-product, because of the higher oil absorption values. In case of green coating (with pumpkin seed by-product, not with artificial colorants) using of thickening agents (e.g. bran) is proposed to increase coating adhesion and to reduce oil uptake.

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