Development of production systems and processing technology for high quality of edible pumpkin seed oil

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Temperate and mediterranean climate (10%)

Agricultural land 508.759 ha: arable land 176.314 ha;
Cereals for grains more 54% of arable land;
permanent grassland 304.906 ha;
permanent crops 27.539 ha: **Orchards 9.997 ha, Vineyards 16.428 ha, Olive groves 820 ha, Nurseries 294 ha**

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Arable land - production systems:

- Conventional
- Integrated (20% of fields)
- Organic (1.6 %)

Diference between integrated and organic?

New: Council ***Regulation*** (EC) No ***834/2007*** of 28 June 2007

Oil (seed) pumpkin, oil squash, oilmarrow,oilbearing gourd

(*Cucurbita pepo* L. convar. *citrullina* (L.) Greb. var. *styriaca* Greb.),

(Syn.: *C. pepo* L. convar. *giromontiina* (L.) Greb. var. *oleifera* Pietsch.);

Taxanomy

Oil (seed) pumpkin belong to the family of *Cucurbitaceae*, which includes approximately 90 orders and 750 species. The species of squash pumpkin (*Cucurbita pepo* L.) is one of 5 cultivated and about 10 wild species of the genus *Cucurbita* L. of family 'Cucurbits' *Cucurbitaceae*.

For oil pumpkin in USA botanical classification not exist.

- Oil from pumpkin seeds is a common salad oil in Austria and Slovenia (in Styria region) and parts of Hungary, and still very popular due to rich healthy value over the world.

WHY PRODUCED IT?

- The traditionally processed oil (oil content in seeds is 40 to 50%) is dark green and contains free fatty acids.
- The contain of antioxidants, especially gamma-tocopherol is very high.
- From nutritive point of view the seeds are a good source of zinc and lechythin.

Palmitinic, stearic, oleic and linoleic fatty acids represent up to 98% of fatty acids.

Tocopherol (particularly gamma tocopherol) content is about 617 mg/kg dry seeds

- Consumption of pumpkin oil was recommended over a long-term period in alternative medical therapy of small disorders of the prostate gland and the urinary bladder, especially due to the beneficiary effect on hypertrophy, because it can influence hormone regulation. Seeds and oil can be used in pharmacology, cosmetics and alternative medicine, especially when organically produced.

Pumpkin seeds are also an effective fermifuge for stomach parasits

Seeds and oil - organically produced appreciated product in gastronomy

- Hull-less – naked-seeds are edible and easily crushed to extract edible oil, oil is used for salad dressing.

The roasted seeds can be consumed in combination with salt, coated with

caramel, chocolate, cinnamon, etc.

Planting – sowing systems

The follows system can be implemented: sowing of non-germinated seed, sowing of germinated seed and sowing of transplants.

Table 2. Effects of direct seeding (non-germinated and germinated) and transplanting on seed yield and yield characteristics of oil pumpkin

Treatment	**Fruit weight (t/ha)**	No. harvested (unripe/decayed) fruits/ha	Fruit diameter (cm)	Seed yield[z] (t/ha) (Average)
Non-germinated seed	**9.6-44.0**	4350-11100/ 0-2500	17.1-21.6	0.44-1.50 (1.03)
Germinated seed	**11.2-51.0**	3750-12750/ 150-5250	19.0-21.5	0.80-1.77 (1.27)
Transplants	**30.6-72.6**	8150-17150/ 0-5500	21.9-22.3	**1.30-2.36 (1.68)**

Seedlings of oil pumpkins as an alternative to seed sowing: yield and production costs

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Ölkürbis-Jungpflanzen als Alternative zur Aussaat: Ertrag und Produktionskosten

Summary

The effects of direct sowing, sowing pre-germinated seeds, and transplantations of seedlings of oil pumpkins (cv. Gleisdorfer Öilkurbis) on growth, yield and production costs were compared in three years of field experiments. Seeds were sown in plug trays on April 29 and May 1 and then the seedlings were transplanted on the sowing date of experiment (May 16). Plants that developed from transplanted seedlings were luxuriant and produced more and larger fruits than those grown from direct sowing. The seed yield obtained from transplants was significantly higher (3.35 kg 20 m^{-2}) than that obtained from direct sowing (2.06 kg 20 m^{-2}) and pre-germinated seeds (2.54 kg 20 m^{-2}). The break-even price per kg seed yield from direct sowing (0.98 EUR kg^{-1} seed yield) was lower than the costs from transplanted seedlings (1.20 EUR kg^{-1}) where the profit ha^{-1} was higher.

Key words: oil pumpkin, seed, sowing, seedling, yield, costs.

Harvesting, handling and storage

Mature fruits are yellow with exception of the shady side where they have yellow and green stripes.

It takes the longest to clean the seeds out pumpkins fruits, which can be done by hand or mechanically with special machines.

Especially with mechanical cleaning and drying of a larger quantity of cucurbits it is necessary to wash them with a lot of water under low pressure or the gentle skin and the grin part of rind can be damaged and consequently the quality of yield reduced.

Seed is dried at 40 to 60° C to the final moisture content from 8 to 10%.

Oil processing

- For the production of the oil from seeds, traditional “hot” and new “cold” pressing procedures are used.
- In traditional pressing method the pumpkin seeds were milled in a stone mill. After milling and homogenization of milled seeds with water and salt (cca. 50 kg seeds, 6 l water, 250 g salt), the milled seeds were heated in a pan to a temperature up 100 to 130° C, which led to the formation of the dark green to red ochre color of oil and typical spicy, roasty, nutty aroma.
- It was first known that pyrazines contribute significantly to the formation of the aroma, but also several volatile and non-volatile compounds have been undertaken to elucidate the temperature levels to achieve the typical aroma of the product, such as beneficial antioxidants, but also carcinogenic polycyclic aromatic hydrocarbons (PAHs), etc.
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Oil contains numerous beneficial compounds like gamma-tocopherols, omega-3-fatty acids, etc. But in contradiction to the natural healthy value of oil, some unhealthy compounds can be influenced by production and processing technology.

Intensive, integrated, organic production?

- Comparing organic, integrated and intensive production systems the results showed that this kind of production can avoid chemicals, due to the rest of chemicals in the seeds and oil. On the other hand, traditional ‘hot’ and new ‘cold’ pressing procedures are used.

Actual research in pumkin oil – traditional v.s. cold pressing oil

- Optimization of the processing based on 12 different treatments of oil processing (temperatures from 60-70° C to 150° C with temperatures from 45 to 120 min.) in comparison with samples of cold pressed oil and oil mixtures – all were analysed by different methods.

Treatment (roasting temperature – °C, combinations)	Require time for roasting (min.)	No. of oil sample
60-70	100	11
90	75	6
95	70	1
100	65	12
105	65	2
110	60	10
115	60	9
120	55	3
125	55	8
130	50	4
150	45	7
90 and 130	30 and 30	5
0 - cold press		13
Oil mixtures: ½ cold press and ½ 150		14 (13 + 4)

Antioxidants

- However, antioxidants content in oil from non-roasted seeds was different from those produced by the traditional method. In this case the higher temperatures seemed to be compensated by the shorter roasting times required to extract the oil.

Table 1: Tocopherols content of pumpkin see oils obtained with different processing conditions

			α-tocopherol (mg/kg)			γ-tocopherol (mg/kg)			A-tocopherol + γ-tocopherol (mg/kg)
Treatment (roasting temperature – °C, combinations)	Required time for roasting (min.)	No. of oil sample	average	stdev	%	average	stdev	%	
60-70	100	11	45,77	2,27	7,31	580,45	10,40	92,69	626,22
90	75	6	37,73	0,92	6,33	558,44	3,20	93,67	596,17
95	70	1	55,36	8,73	8,06	631,61	34,20	91,94	686,97
100	65	12	32,60	6,18	5,58	551,94	27,63	94,42	584,54
105	65	2	48,08	8,65	7,76	571,29	33,21	92,24	619,37
110	60	10	27,81	1,70	4,51	588,38	0,91	95,49	616,19
115	60	9	51,52	6,40	7,86	603,88	7,39	92,14	655,40
120	55	3	46,35	0,67	7,37	582,89	8,31	92,63	629,25
125	55	8	37,18	2,70	6,36	547,24	20,04	93,64	584,42
130	50	4	41,94	7,82	6,72	582,23	7,68	93,28	624,17
150	45	7	39,61	0,87	6,60	560,70	1,98	93,40	600,31
90+130	30+30	5	37,87	1,05	6,26	567,22	15,85	93,74	605,08
0 (cold press)	-	13	32,85	4,45	5,60	553,52	14,74	94,40	586,37
0+150	45	14 (13 + 7)	52,41	5,46	8,06	597,47	18,59	91,94	649,88

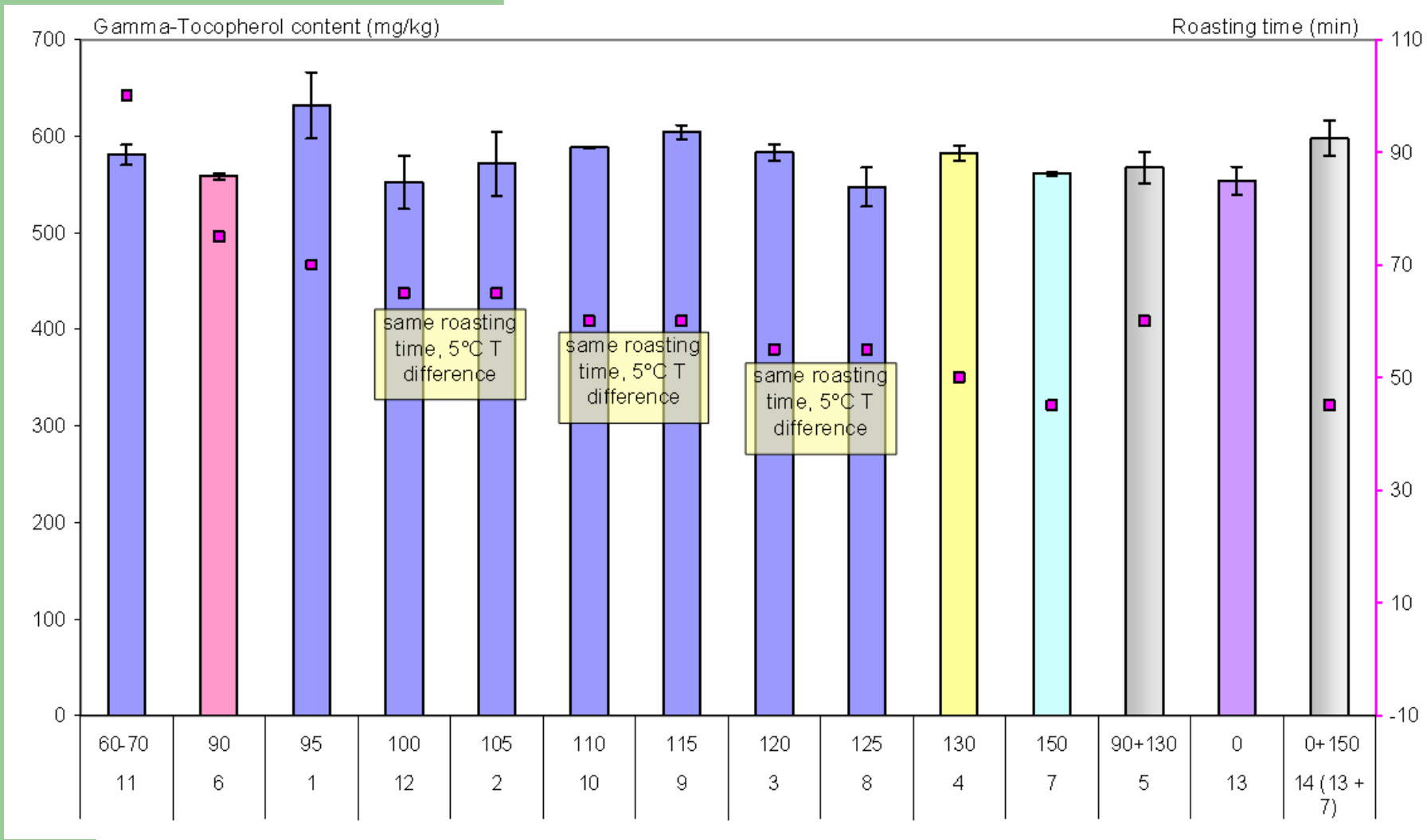

Figure 1: Influence of roasting temperature and time on γ-tocopherol content

Carotenoids

- The total carotenoids content in pumpkin seed oil, measured by a colorimetric method, ranged from 125.78 to 393.06µg-carotene per g of oil, where the lowest value was observed in the cold pressed oil (from non roasted seeds).

PAHs

- Optimal processing procedure for avoiding the critical level of polycyclic aromatic hydrocarbons (PAHs) are follows according to our results:

One gram oil was extracted and purified according to Veyran et al (2007)[1] and analyzed using HPLC-FLD according to Brasseur et al (2007)[2] and Danyi et al (2009)[3]

[1] Veyran B., Brosseaud A., Sarcher L., Varlet V., Monteau F., Marchand P., Andre F., Le Bizec B. Innovative method for determination of 19 polycyclic aromatic hydrocarbons in food and oil samples using gas chromatography coupled to tandem mass spectrometry based on an isotope dilution approach. *J. Chrom A.*, 1149 (2007) 333-344.

[2] Brasseur C, Brose F, Pirlot A, Douny C, Eppe G, Maghuin-Rogister G, Scippo ML. Validation of the analytical procedure for the determination of PolyAromatic Hydrocarbons (PAH) in smoke flavourings using High Performance Liquid Chromatography (HPLC) coupled to a UV, Diode Array or Fluorescence Detector (UV/DAD/FLD). *Accredit. Qual. Assur.,* 12 (2007) 535-542.

[3] Danyi S, Brose F, Brasseur C, SchneiderYJ, Larondelle Y, Pussemier L, Robbens J, De Saeger S, Maghuin-Rogister G , Scippo ML. Analysis of EU priority polycyclic aromatic hydrocarbons in food supplements using high performance liquid chromatography coupled to an ultraviolet, diode array or fluorescence detector. *Anal. Chim. Acta* 633 (2009) 293-299.

		LOD (µg/Kg)	LOQ (µg/Kg)	Analysis of 16 EU PAHs in pumpkin seed oil (µg/Kg) Sample n° "PSO Bavec						
				1	2	3	4	5	6	7
Benzo[*b*]fluoranthene	BbF	0.5	1.0	< LOQ	<LOD	< LOD	<LOD	< LOQ	< LOQ	1.1
Dibenzo[*a,l*]pyrene	DlP	0.5	1.0	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Dibenzo[*a,h*]anthracene	DhA	0.5	1.0	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Benzo[*ghi*]perylene	BgP	0.5	1.0	< LOD	<LOD	< LOD	< LOD	< LOD	< LOD	< LOD
Dibenzo[a,e]pyrene	DeP	0.5	1.0	Nd	Nd	Nd	Nd	Nd	Nd	< LOD
Benzo[j]fluoranthene	BjF	2.0	4.0	Nd	Nd	Nd	Nd	Nd	Nd	< LOD
Benzo[c]fluorene	BcL	0.5	1.0	2.3	1.2	< LOD	<LOD	< LOQ	< LOQ	1.7
Benzo[a]anthracene	BaA	0.5	1.0	2.3	1.6	< LOQ	<LOD	1.9	2.3	3.8
Chrysene	CHR	0.5	1.0	1.2	<LOQ	< LOQ	<LOQ	1.1	1.2	2.2
5-methylchrysene	5MC	0.5	1.0	3.3	1.9	1.1	<LOQ	2.0	3.0	6.1
Benzo[k]fluoranthene	BkF	0.5	1.0	< LOD	<LOD	< LOD	< LOD	< LOD	< LOD	< LOQ
Benzo[a]pyrene	BaP	0.5	1.0	<LOQ	< LOD	< LOD	< LOD	<LOD	< LOQ	1.0
Indeno[1,2,3-cd]pyrene	IcP	2.0	4.0	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Dibenzo[a,i]pyrene	DiP	0.5	1.0	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Dibenzo[a,h]pyrene	DhP	0.5	1.0	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Cyclopenta[cd]pyrene	CPP	10.0	20.0	Nd	Nd	Nd	Nd	Nd	Nd	Nd

LOD : limit of detection (< LOD : a peak was detected and quantified by the HPLC software, but below the calibration working range).

LOQ : limit of quantification (< LOQ : a peak was detected and quantified by the HPLC software, but below the limit of quantification of our method).

Nd : Not detected (no peak at all was detected).

		LOD (µg/Kg)	LOQ (µg/Kg)	" 8	9	10	11	12	13	14
Benzo[*b*]fluoranthene	BbF	0.5	1.0	< LOQ	< LOQ	< LOQ	< LOQ	< LOQ	< LOD	< LOQ
Dibenzo[*a,l*]pyrene	DlP	0.5	1.0	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Dibenzo[*a,h*]anthracene	DhA	0.5	1.0	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Benzo[*ghi*]perylene	BgP	0.5	1.0	< LOD	< LOD	< LOD	< LOD	< LOD	Nd	< LOD
Dibenzo[a,e]pyrene	DeP	0.5	1.0	< LOD	< LOD	< LOD	< LOD	< LOD	Nd	Nd
Benzo[j]fluoranthene	BjF	2.0	4.0	< LOD	Nd	Nd	Nd	Nd	Nd	Nd
Benzo[c]fluorene	BcL	0.5	1.0	1.5	1.4	1.7	2.0	1.7	< LOQ	<LOD
Benzo[a]anthracene	BaA	0.5	1.0	3.3	3.1	3.2	3.8	3.2	Nd	2.0
Chrysene	CHR	0.5	1.0	1.9	1.7	1.9	2.1	1.9	< LOD	1.0
5-methylchrysene	5MC	0.5	1.0	5.5	4.7	5.1	5.4	5.3	< LOQ	3.8
Benzo[k]fluoranthene	BkF	0.5	1.0	<LOD	< LOD	<LOD	< LOQ	<LOD	<LOD	< LOD
Benzo[a]pyrene	BaP	0.5	1.0	< LOQ	< LOQ	< LOQ	< LOQ	< LOQ	<LOD	< LOD
Indeno[1,2,3-cd]pyrene	IcP	2.0	4.0	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Dibenzo[a,i]pyrene	DiP	0.5	1.0	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Dibenzo[a,h]pyrene	DhP	0.5	1.0	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Cyclopenta[cd]pyrene	CPP	10.0	20.0	Nd	Nd	Nd	Nd	Nd	Nd	Nd

LOD : limit of detection (< LOD : a peak was detected and quantified by the HPLC software, but below the calibration working range).

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CONCLUSSIONS

- Based on literature and our experiences we can conclude that optimisation of production systems and processing technology are the main keys for sustainable development, such as for quality and safe consumption of pumpkin oil.
- Few main keys are: no pesticides and their by-products in nature, seeds and oil, high level of antoxidative compounds and low level of PAHs, especially by traditionall produced oil with special aroma.