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CADMIUM AND FATTY ACID CONTENTS OF LINSEED IN FINLAND

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LINSEED AS FUNCTIONAL FOOD

- Linseed (*Linum usitatissimum* L.) has several properties with positive effects on human health, e.g.

- Favourable fatty acids
- Proteins
- Dietary fibre



- Linseed has industrial interest and applications

- As a functional food
- As an ingredient of functional foods e.g. in the form of oil and seed crush



- Despite its numerous advantageous components promoting human health, linseed may also contain some compounds not beneficial to health, including cadmium (Cd) taken up from soil



QUALITY DEVELOPMENT



- Several Finnish linseed companies intensified their cooperation during the “Agro fibre network” project during the years 2002-2005
- Examples of this cooperation include
 - **Networking between companies, farmers and universities**
 - **Studies of the cadmium content**
 - **Studies of the fatty acid composition of linseed**



AIMS OF THE STUDY

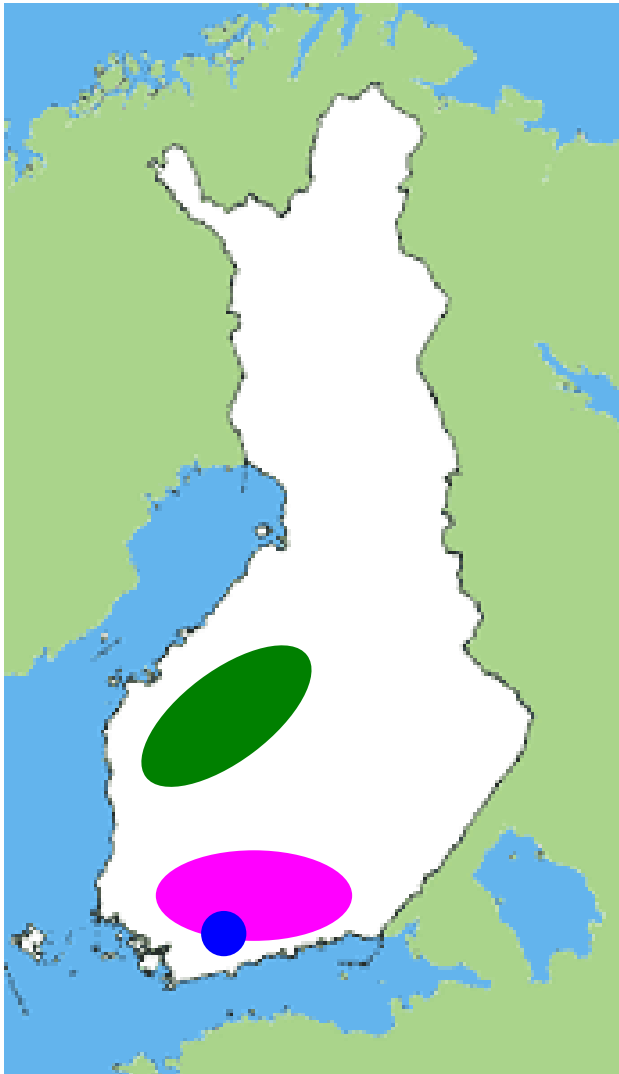
- 1. To evaluate**
 - **The cadmium contents of seed and seed crush of linseed**
 - **The acceptable daily dose of cadmium**

- 2. To illustrate the possible positive substances**
 - **The fatty acid composition of Finnish linseed samples was screened**

- 3. To compare the Finnish results with results of international studies**



MATERIALS AND METHODS



Cadmium determination

- Seed samples (N=85) collected in different locations in Finland in 2002-2004
 - Southern Finland (Siuntio)
 - Ostrobothnia
- In addition, 15 samples of linseed crush were examined
- AAS method (Atomic absorption spectroscopy)

Fatty acid composition

- 6 samples collected in 2003
- Gas chromatography and mass spectrometry



RESULTS OF CADMIUM CONTENT

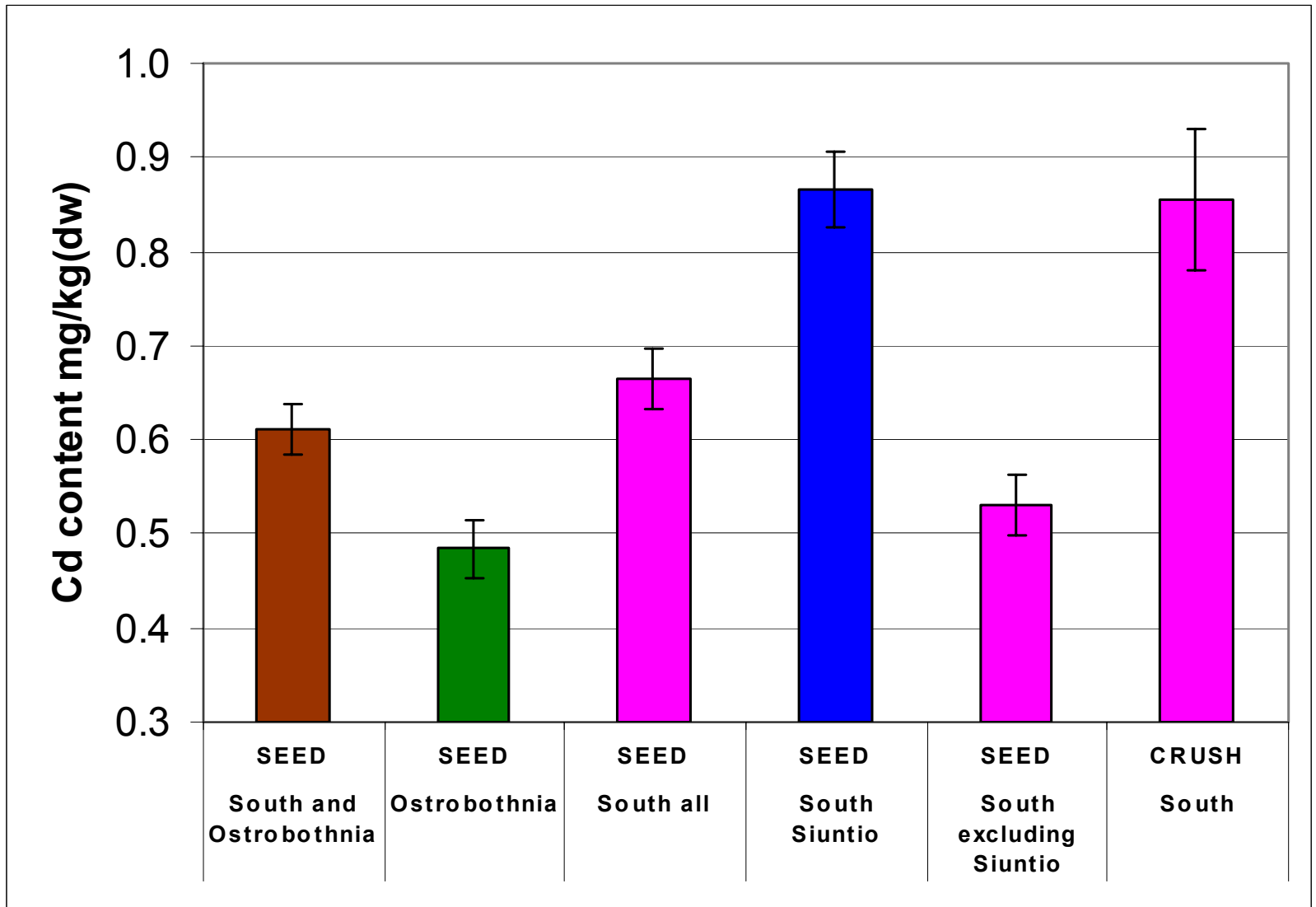
- The Cd content of the seed samples varied between 0.27 and 1.3 mg kg⁻¹ dry matter
- The Cd contents of the crush samples were 56% higher on average than those of the corresponding seeds

Table 1. Cadmium content of linseed and linseed crush samples in the Finnish study

| Sample (N) | Mean (mg kg⁻¹ dry matter) | Variation range (mg kg⁻¹ dry matter) |
|-----------------------------|---|--|
| Seed, all (85) | 0.62 | 0.27 - 1.3 |
| Seed, Ostrobothnia (25) | 0.48 | 0.27 - 0.96 |
| Seed, southern Finland (36) | 0.67 | 0.27 - 1.3 |
| Crush (15) | 0.85 | 0.47 - 1.5 |

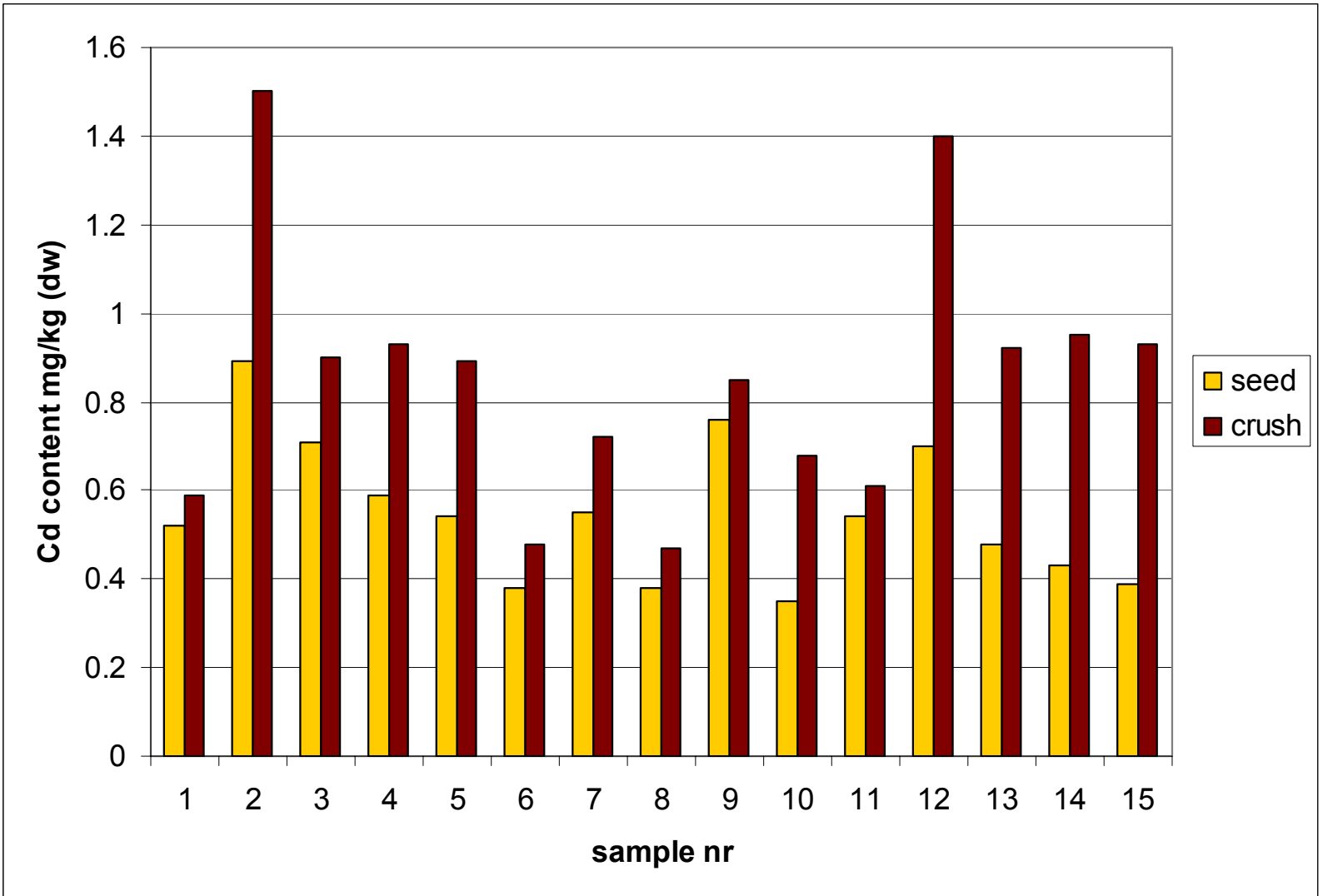


AREAL VARIATION IN THE CADMIUM CONTENT OF LINSEED



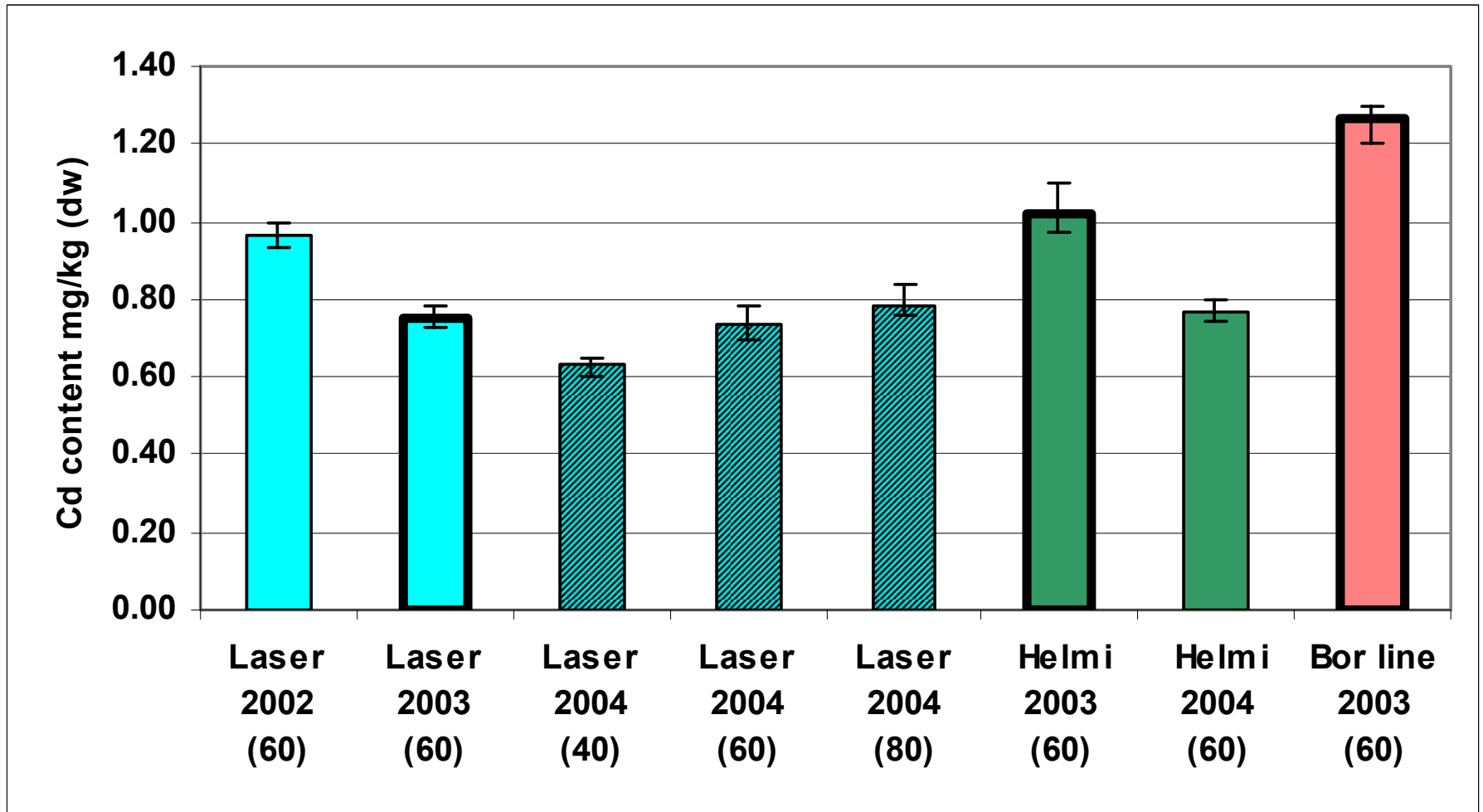


COMPARISON OF SEED AND CRUSH





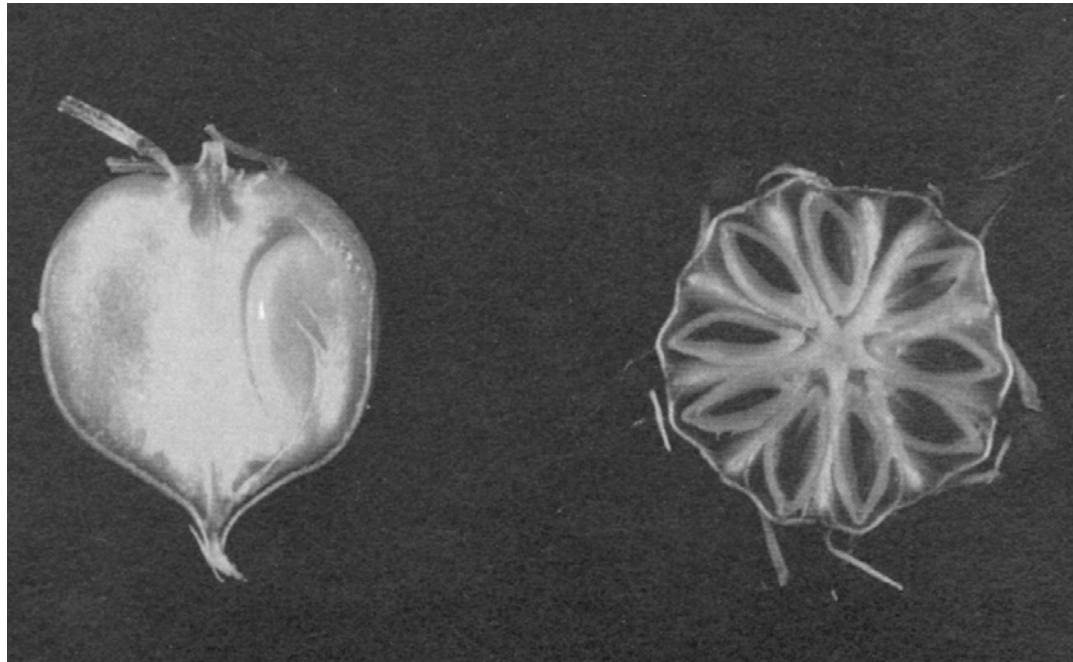
VARIATION BETWEEN VARIETIES, YEARS AND LEVELS OF FERTILIZATION





EVALUATION OF THE CADMIUM RESULTS

- The cadmium content of Finnish linseed was in general similar to that reported in previous international studies, although there was marked variation both in the present and previous studies





COMPARISON OF FINNISH AND INTERNATIONAL Cd VALUES OF LINSEED

| Examined linseed samples | Cd content (dw = dry weight, fw = fresh weight) | Reference |
|--|--|--------------------------------------|
| Yellow | mean 0.23 mg kg ⁻¹ | Klein&Weigert (1987) |
| Brown | mean 0.38 mg kg ⁻¹ | Klein&Weigert (1987) |
| 118 seed samples and 16 genotypes | 0.10 - 1.70 mg kg ⁻¹ (dw) | Marquard et al. (1990) |
| 14 commercial varieties | 0.02 mg kg ⁻¹ - 0.10 mg kg ⁻¹ (fw) | Li et al. (1997) |
| 60 plant introduction lines | 0.14–1.37 mg kg ⁻¹ (fw) | Li et al. (1997) |
| Cultivars grown under experimental conditions | 0.23 and 0.55 mg kg ⁻¹ (dw) | Hocking&McLaughlin (2000) |
| <i>Own study: Finnish linseed grown at different locations</i> | <i>0.27-1.30 mg/kg⁻¹ (dw)</i> | <i>Kymäläinen&Sjöberg (2006)</i> |



ESTIMATED CADMIUM INTAKE

- The dietary recommendation of linseed for adults is a daily dose of 24–30 g (Morris 2003, Tarpila et al. 2004)

 - By comparing the Cd values from the present study with the reference values, the estimated daily intake (EDI) of Cd is
 - 6.5–39 μg Cd (seed)
 - 11–45 μg Cd (crush)

 - These values are
 - 9.3–55% (seed)
 - 14–63% (crush)
- of the provisional tolerable daily intake (PTDI) value (70 $\mu\text{g}/\text{d}$) presented by WHO and FAO (1993)



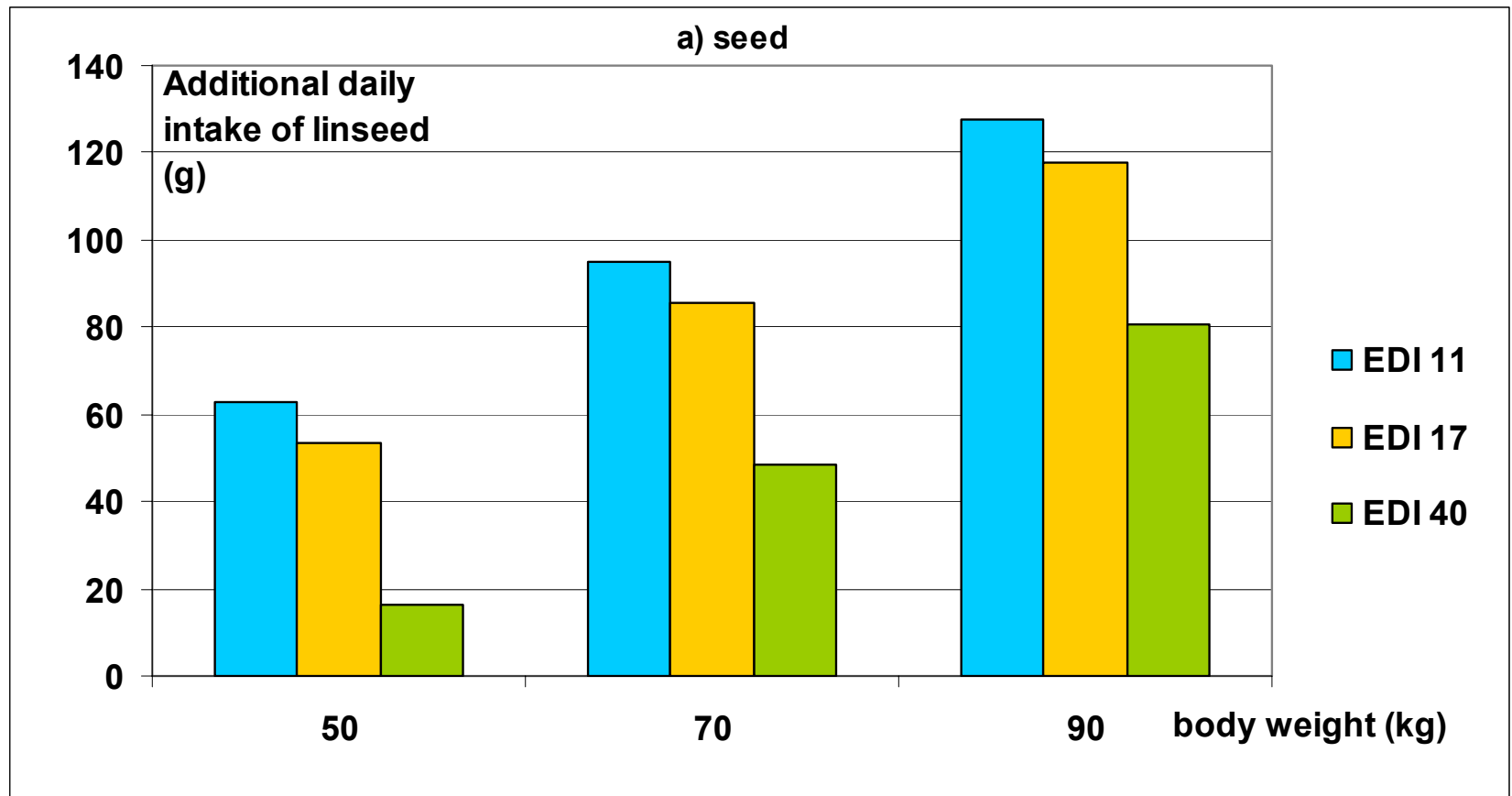
PERMITTED CADMIUM INTAKE

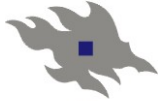
- Examples of estimated daily intakes (EDI) of Cd in food
 - **Finnish maximum: 11 μg (Tahvonen 1995)**
 - **French: 17 μg (Leblanc et al. 2000)**
 - **High (polluted area): 40 μg (Skibniewska 2003)**
- Taking into account the provisional tolerable daily intake (PTDI) value (70 $\mu\text{g}/\text{d}$) of Cd presented by WHO and FAO (1993), if we ingest Cd from linseed in addition to this basal EDI in food (11–40 μg), **the possible additional daily intake of Cd (from other sources than food) would be 30–60 μg**
- **The permitted intake of linseed depends on body weight and on the Cd content of the product**



Estimated average intake of linseed for persons with different body masses, when linseed is considered as an additional source of cadmium

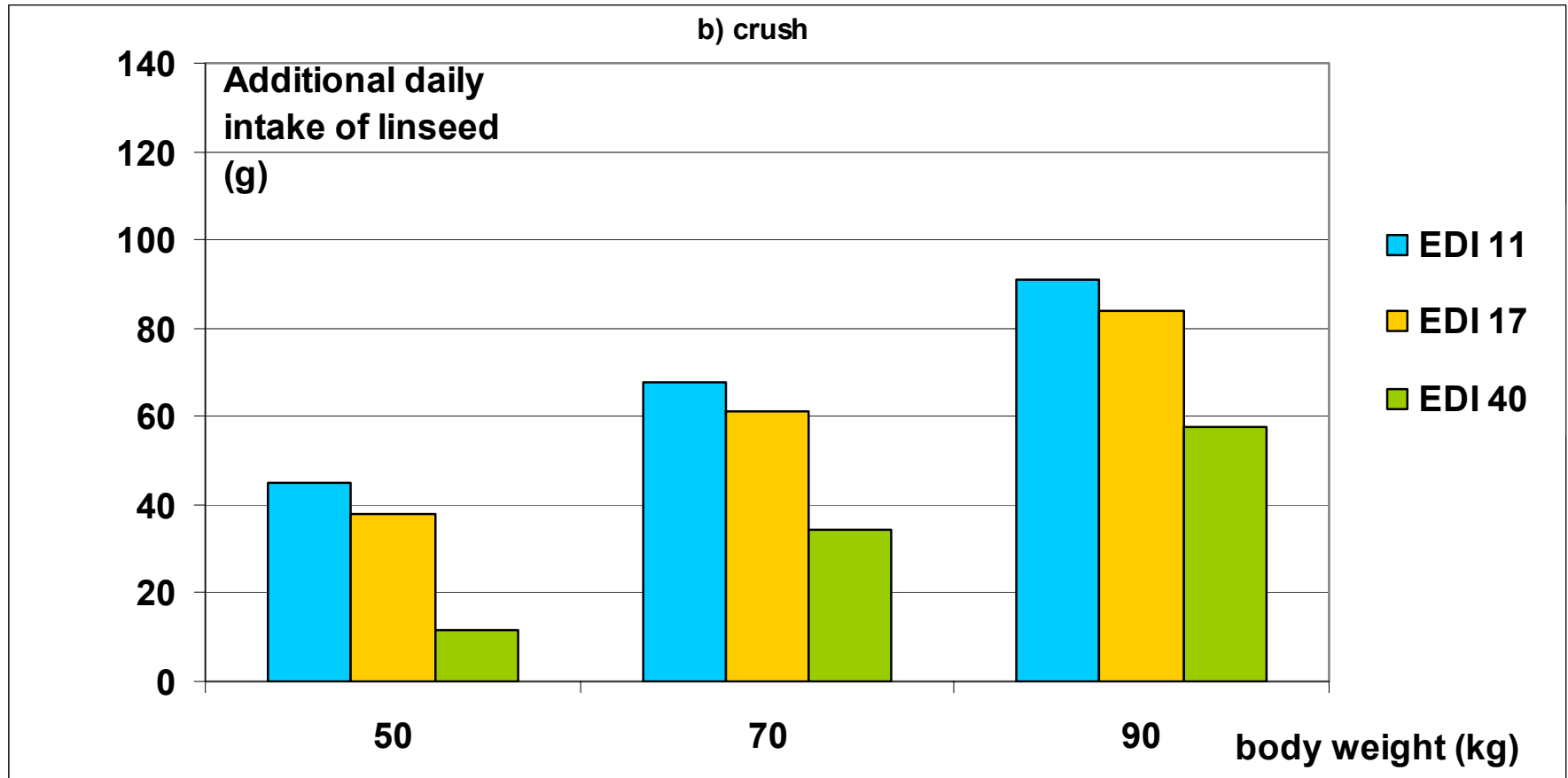
- According to this study, in most cases the dietary recommendation can safely be followed from the point of view of cadmium intake





- **Estimated average intake of linseed crush for persons with different body masses, when linseed is considered as an additional source of cadmium**

- In the case of a relatively low body weight (50 kg) the limit is rather close if linseed with a high Cd content is used





FATTY ACID COMPOSITION

- The content of **α -linolenic acid** of the Finnish samples was among the highest compared with results from several international studies (reference value 57.0 %, Morris 2003)

Table 2. Main fatty acid composition of linseed collected in Finland, presented as means of 2 measurements

| Fatty acid (%) | Variety of linseed | | |
|-----------------------------------|--------------------|-------|----------|
| | Helmi | Laser | Bor line |
| C16:0 (palmitic acid) | 4.3 | 4.1 | 4.1 |
| C18:0 (stearic acid) | 2.7 | 3.1 | 3.0 |
| C18:1 (oleic acid) | 19.0 | 17.0 | 20.0 |
| C18:2 (linoleic acid) | 16.1 | 15.6 | 17.4 |
| C18:3 (α -linolenic acid) | 57.3 | 59.6 | 54.9 |
| Saturated fatty acids | 7.0 | 7.2 | 7.1 |
| Mono-unsaturated fatty acids | 19.5 | 17.4 | 20.5 |
| Poly-unsaturated fatty acids | 73.5 | 75.3 | 72.4 |



EVALUATION OF THE FATTY ACID COMPOSITION

- The composition of fatty acids, especially unsaturated fatty acids, reported in different studies varies considerably
- This variation depends mainly on differences in the examined varieties and in industrial processing treatments



ACKNOWLEDGEMENTS

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- **Agro Fibre Network project in the EMOTR/ALMA program**



ADDITIONAL INFORMATION OF THE STUDY

- For more detailed information
 - **Kymäläinen, H.-R & Sjöberg, A.-M. 2006. Cadmium content of linseed and estimated consumer intake. Agricultural and Food Science 15, 1: 3-11.**
 - **Nykter, M., Kymäläinen, H.-R., Gates, F. & Sjöberg, A.-M. 2006. Quality characteristics of edible linseed oil. Agricultural and Food Science 15, 4: 402-413.**

