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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**

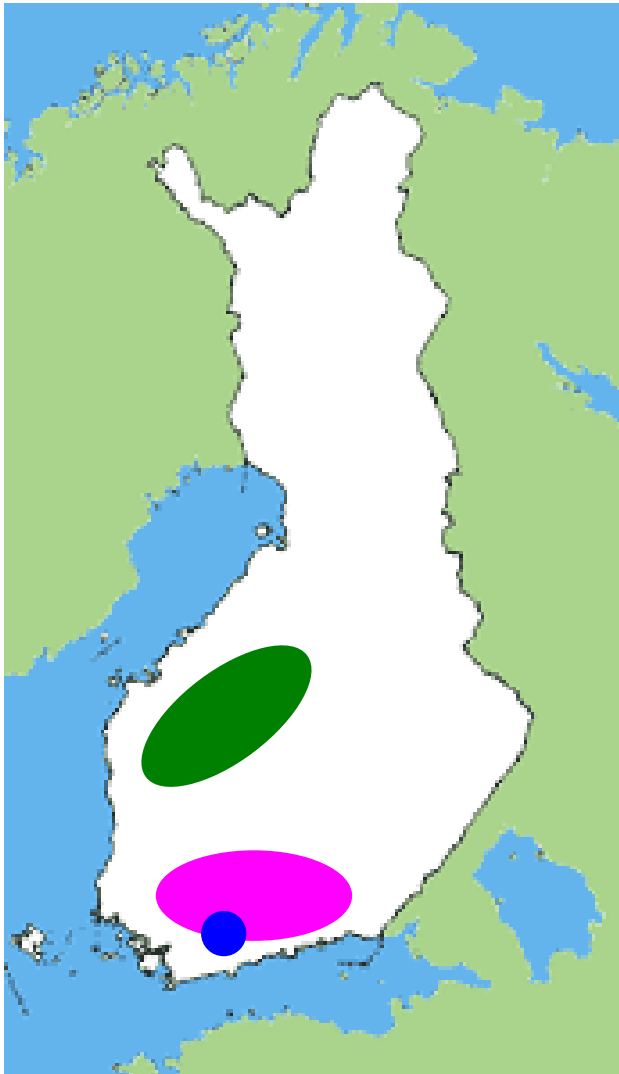


## **AIMS OF THE STUDY**

- 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

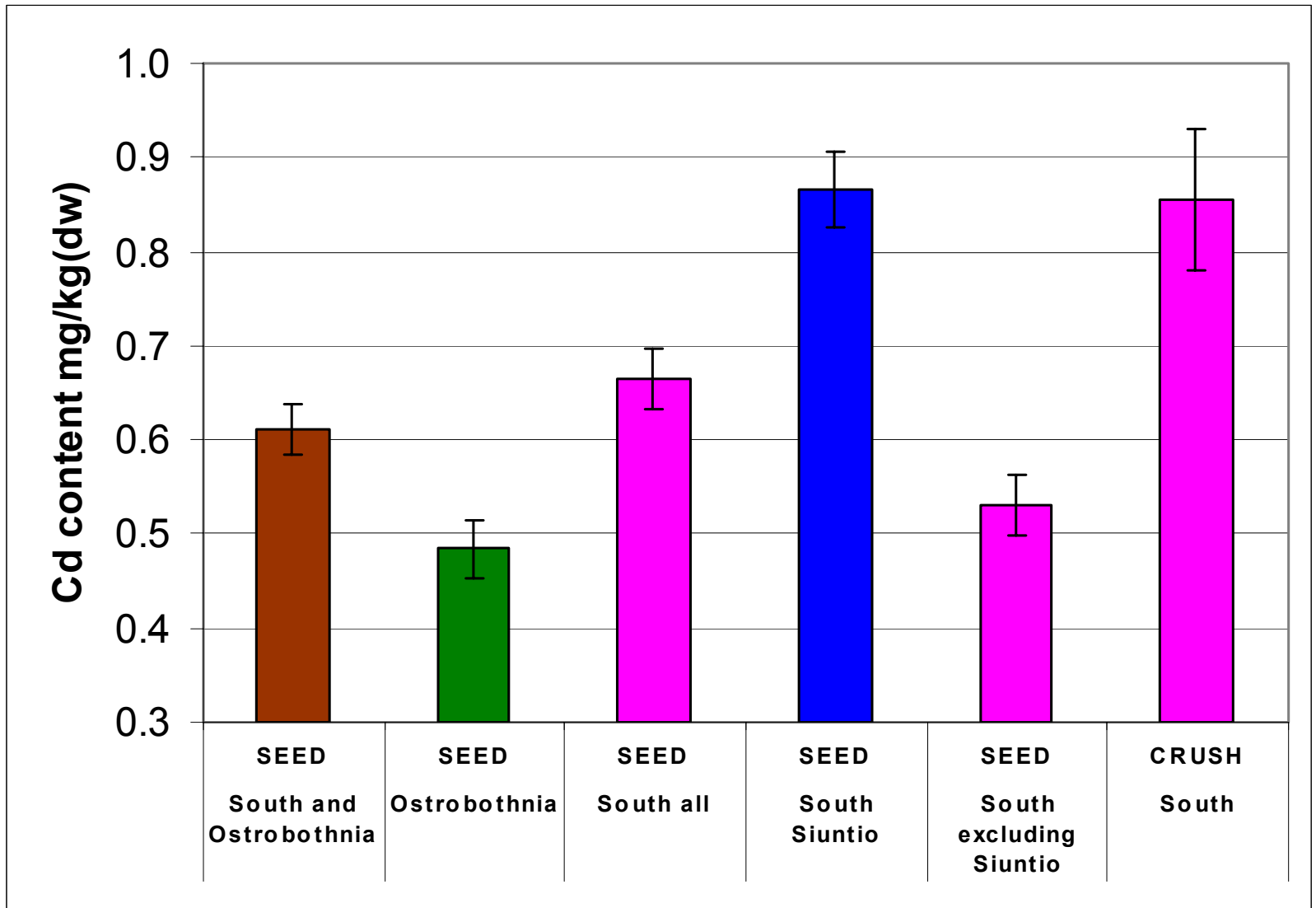
- The Cd content of the seed samples varied between 0.27 and 1.3 mg kg<sup>-1</sup> dry matter
- The Cd contents of the crush samples were 56% higher on average than those of the corresponding seeds

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

<b>Sample (N)</b>	<b>Mean (mg kg<sup>-1</sup> dry matter)</b>	<b>Variation range (mg kg<sup>-1</sup> dry matter)</b>
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

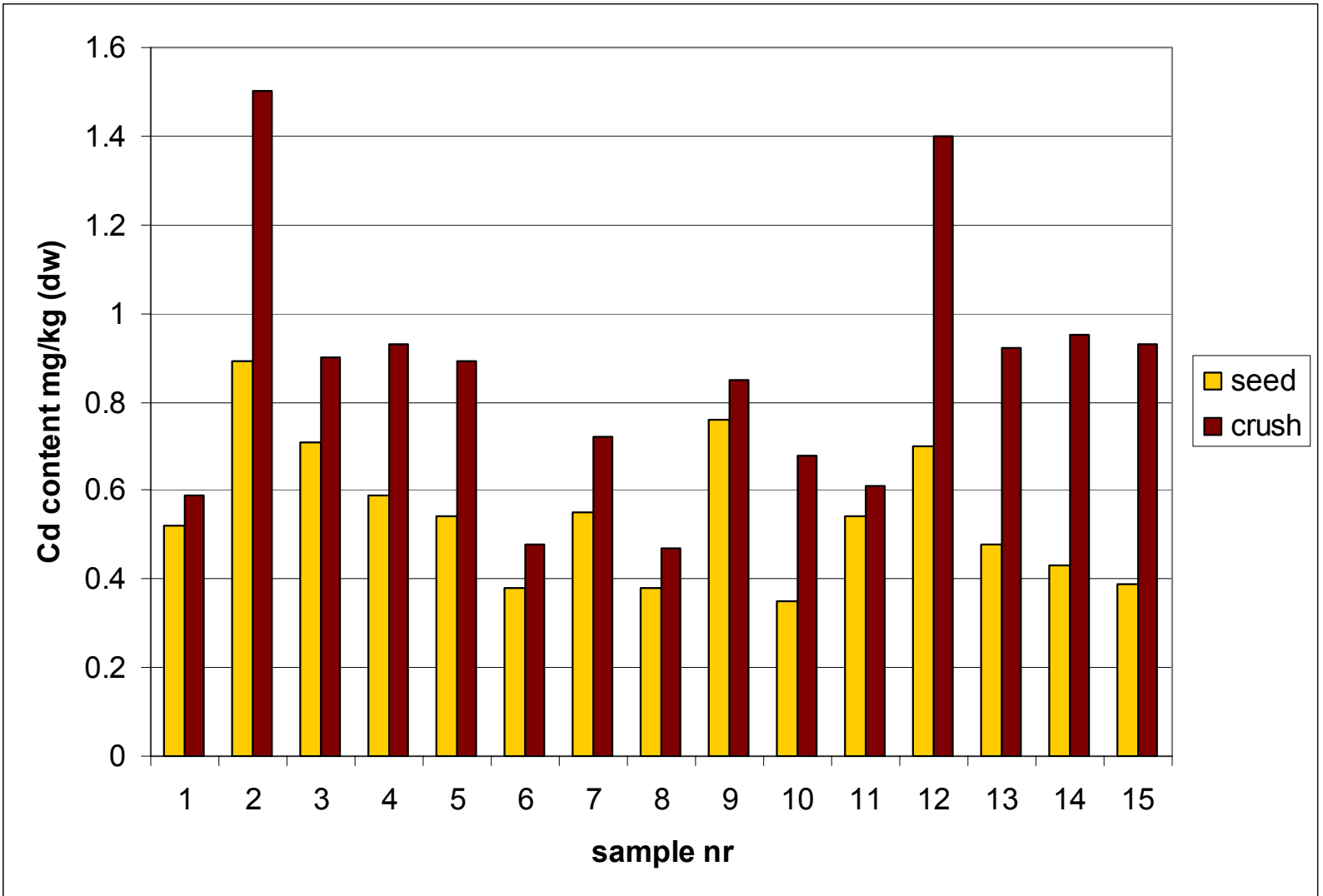


# AREAL VARIATION IN THE CADMIUM CONTENT OF LINSEED





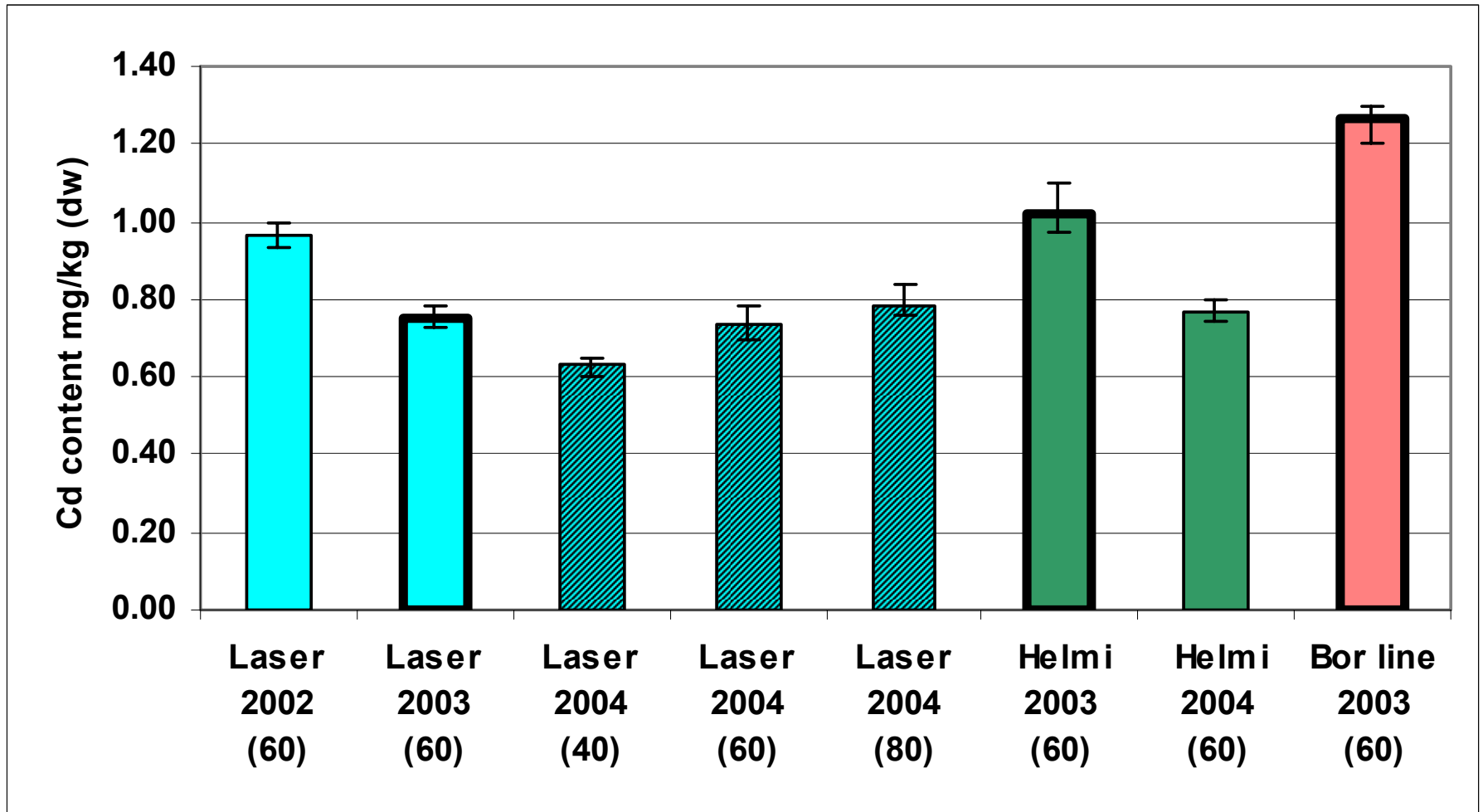
# COMPARISON OF SEED AND CRUSH







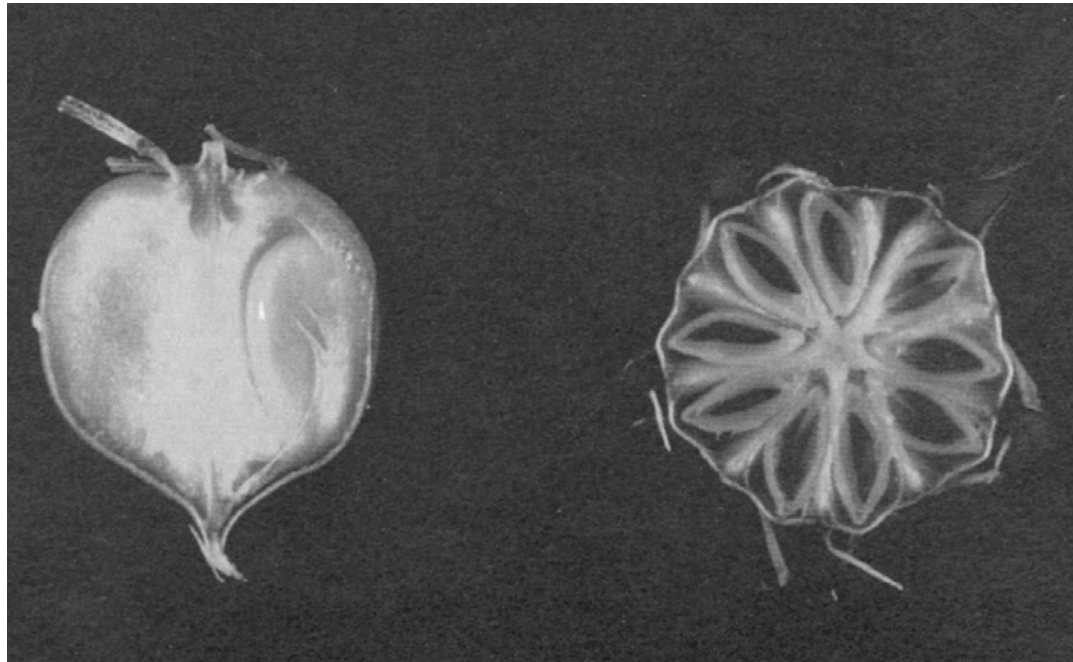
# VARIATION BETWEEN VARIETIES, YEARS AND LEVELS OF FERTILIZATION





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



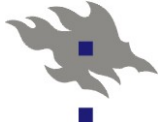
## ESTIMATED CADMIUM INTAKE

- 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  $\mu\text{g}$  Cd (seed)
    - 11–45  $\mu\text{g}$  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)



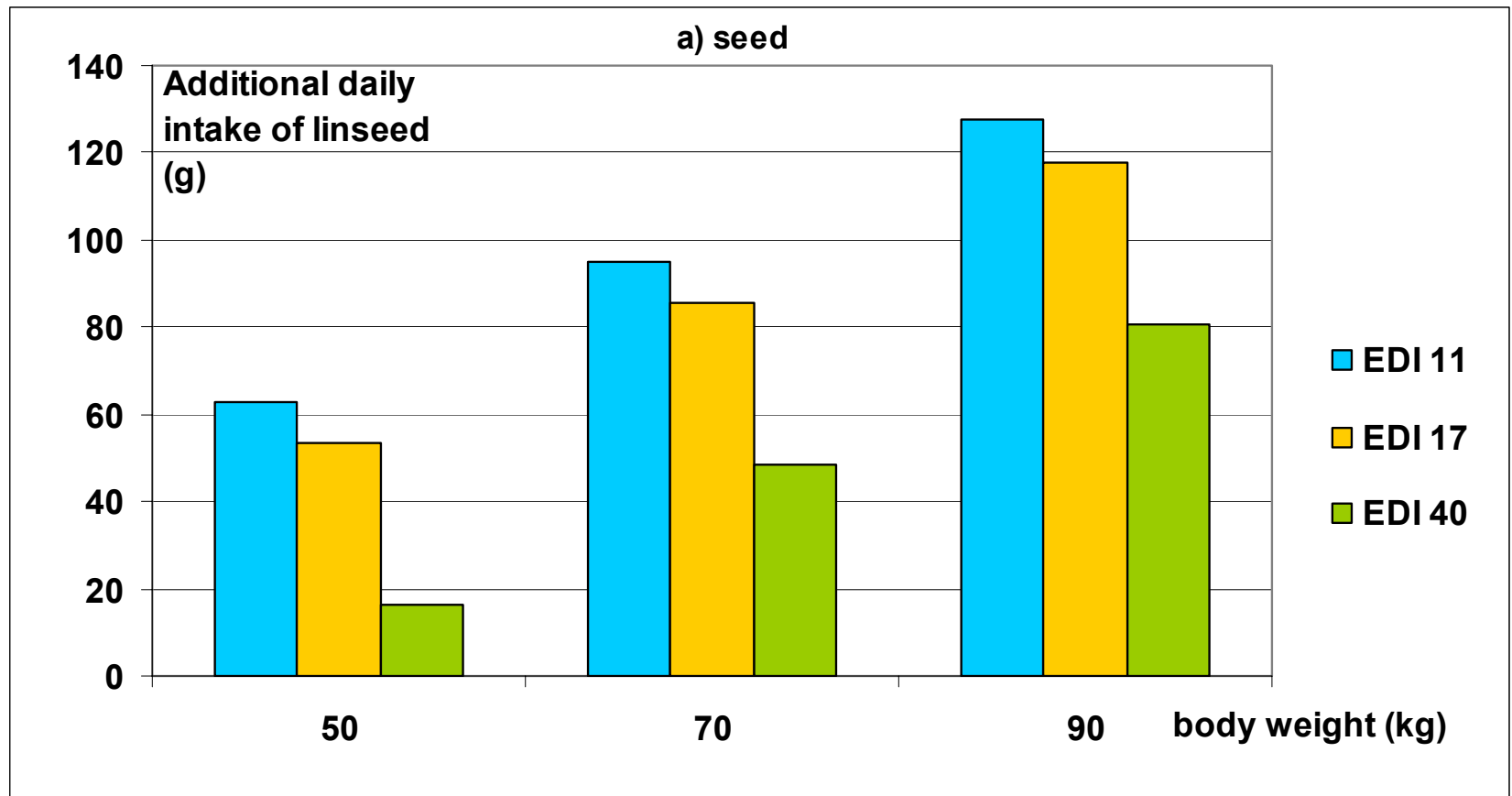
## PERMITTED CADMIUM INTAKE

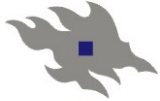
- Examples of estimated daily intakes (EDI) of Cd in food
  - **Finnish maximum: 11  $\mu\text{g}$  (Tahvonen 1995)**
  - **French: 17  $\mu\text{g}$  (Leblanc et al. 2000)**
  - **High (polluted area): 40  $\mu\text{g}$  (Skibniewska 2003)**
- Taking into account the provisional tolerable daily intake (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  $\mu\text{g}$ ), **the possible additional daily intake of Cd (from other sources than food) would be 30–60  $\mu\text{g}$**
- **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

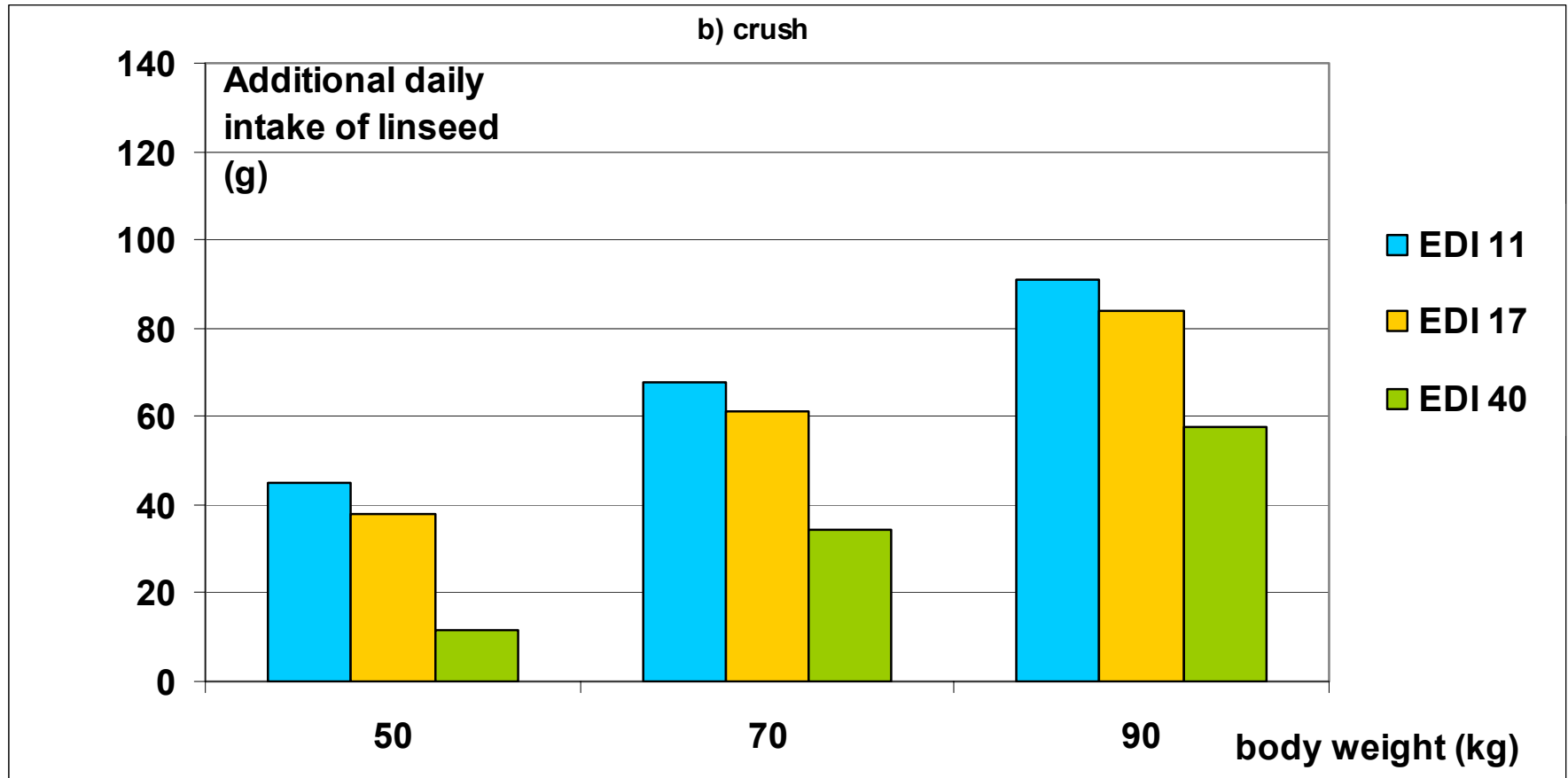
- According to this study, in most cases the dietary recommendation can safely be followed from the point of view of cadmium intake





- **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  **$\alpha$ -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 ( $\alpha$ -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.**

