59th Annual Meeting of the European Association for Animal Production

VILNIUS, LITHUANIA, August 24th - 27th, 2008

Influence of dietary linseed on fatty acid composition of pig muscle and adipose tissue

Danijel Karolyi, Ivan Jurić, Krešimir Salajpal
Faculty of Agriculture, Department of Animal Science
Zagreb, CROATIA

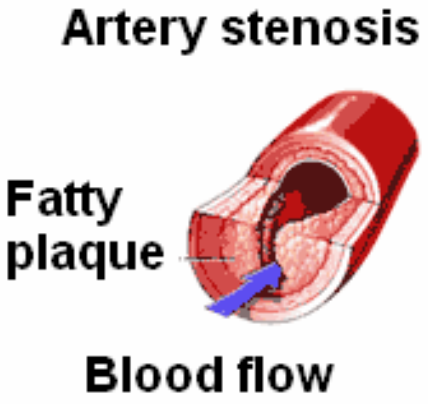
Matjaž Červek, Mihael Gajster
Emona RCP, Nutrition Reserch & Development Department
Ljubljana, SLOVENIA

Introduction

- **Meat consumption**
  - industrialised countries ~ 90 kg per capita annually
  - fast growth in developing countries
  - pork – most frequently consumed meat worldwide
- **Meat - significant source of fat in the diet**
  - > total fat intake
  - > intake of saturated fatty acids (SFA)
  - > cholesterol intake

Introduction

- **High fat, SFA and cholesterol intake**
  - aetiology of today's most frequent diseases, such as cardiovascular disease



- **PUFA and MUFA in diet**
  - Preventive role of polyunsaturated (**PUFA**) and monounsaturated (**MUFA**) fatty acids

Introduction

- **Nutritional recommendations** (*WHO/FAO 2003*)
  - fat intake: max 15 - 30% of total diet energy
  - max 10% of energy intake from SFA
  - 6 -10% from polyunsaturated (PUFA)
  - 10 - 15% of monounsaturated (MUFA)

  } Beneficial effects !

  - cholesterol < 300mg/day
- **Optimal P/S ratio ≥ 0.4** (*Dept. of Health,1994*)

- **Opposing effects of n-6 and n-3 PUFA:**

  - **linoleic acid** (**LA**,18:2n-6; cereals, vegetable oils…):

  - **alpha-linolenic acid** (**ALA**,18:3n-3; green leaves, oils from linseed and rapeseed):

  - **essential for mammals**

Introduction

- **In organism longer PUFA are metabolized**:
  - from **LA:** arachidonic (**AA**,20:4n-6; eggs, meat)
  - from **ALA:** eicosapentaenoic (**EPA**,20:5n-3; fish oil), docosahexaenoic (**DHA**,22:6n-3; fish oil)
  - in the membrane phospholipids
- **C20 PUFA - precursors for eicosanoides:**
  - mediators of physiological processes in tissues (blood clotting, inflammation…)

Introduction

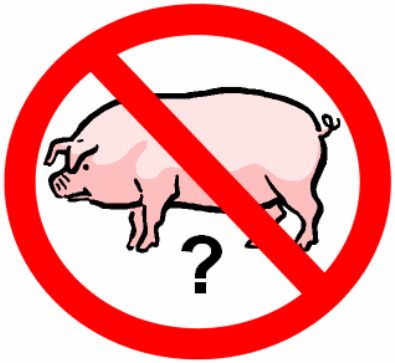
- **Different effects of n-6 and n-3 derived eicosanoids :**
  - **from n-3**: more anti-inflammatory and inhibitory
  - **from n-6**: more pro-inflammatory and more pro-active in other disease-promoting effects
- **Nutritional recommendations:**

> **optimal n-6/n-3 ratio in the diet 4 - 5 and less**

(*WHO/FAO 2003; Dept. of Health, 1994*)

Introduction

- **Composition of fats in pig meat**
  - SFA and MUFA - *de novo* synthesis in the body
  - PUFA primarily from diet, absorbed unchanged
  - industrial pork: low in n-3, high in n-6 due to high proportion of LA in cereal-based feeds
  - **P/S ratio ≥ 0.4** nutritionally positive
  - **n-6/n-3 ratio 7-10 and higher**! nutritionally unfavorable!



Introduction

- **Modification of pork fats by feeding**
  - primary goal - increase in n-3, reduction of n-6/n-3
  - long-chain n-3 rich feeds e.g. fish oil (EPA, DHA)
  - plant sources rich in ALA e.g. rapeseed, canola
  - **linseed** (ALA ~ 50%, n-6/n-3 = 0.2 -0.3)
  - > PUFA - possible negative side effects (reduced oxidative stability of fats and off-flavors)
  - increased dietary levels of antioxidants (vitamin E)

Aim of the work

- To investigate the influence of dietary linseed on fatty acid composition of pig muscle and adipose tissue
- To achieve better pork composition related to recommended n-6/n-3 PUFA ratio for human diet

Material and methods

- **Pigs and diet:**
  - commercial crossbreds (IHAN farm, Slovenia)
  - usual fattening from ~ 25 to 105 kg
  - 36 experimental pigs fed 3 % linseed diet + alpha-tocopherol 97.5 mg/kg
  - 6 conventionally fed farm pigs as a control
  - linseed diet: ALA = 19%, n-6/n-3 = 2.4
  - control diet: ALA = 3.7%, n-6/n-3 = 15.4

Material and methods

- **Sampling and analyses:**
  - meat quality (*m.longissimus dorsi* pH, colour *L*)*
  - longissimus muscle and back fat samples (last rib)
  - chemical analyses (EMONA RCP, Slovenia)
  - fatty acid composition (GLC method)

    (*in situ* trans-esterification, *Park and Goins, 1994*)
  - Rancimat test for back fat oxidative stability

    (*Läubli et al.,1998*)
  - Student t - test and correlations (*SAS, 1999*)

Results

Meat quality of longissimus muscle of pigs fed linseed or control diet

	Linseed	Control	Sign.
pH_1	6.26 ± 0.28	6.58 ± 0.18	*
pH_2	5.66 ± 0.14	5.56 ± 0.26	ns
Lightness (*L**)	55.13 ± 3.84	55.82 ± 4.95	ns

mean ± standard deviation

*P≤0.05; **P≤0.01; ns–not significant (P>0.05)

Results

Fatty acid composition (g/100g of total FA) of longissimus muscle of pigs fed linseed or control diet

Fatty acid	Linseed	Control	Sign.
14:0 myristic	1.30 ± 0.19	1.38 ± 0.71	ns
16:0 palmitic	22.65 ± 0.10	24.57 ± 0.82	***
16:1 palmitoleic	3.15 ± 0.61	4.43 ± 0.63	***
18:0 stearic	12.01 ± 0.54	9.45 ± 1.46	**
18:1 oleic	36.95 ± 3.72	38.84 ± 2.54	ns
18:2 n-6 LA	12.47 ± 2.64	13.03 ± 2.83	ns
18:3 n-3 **ALA**	2.48 ± 0.34	0.56 ± 0.14	***
20:4 n-6 **AA**	2.79 ± 0.88	3.90 ± 1.21	**
20:5 n-3 **EPA**	0.94 ± 0.29	0.28 ± 0.10	***
22:6 n-3 DHA	0.25 ± 0.15	0.33 ± 0.16	ns

↑ **>4 x**

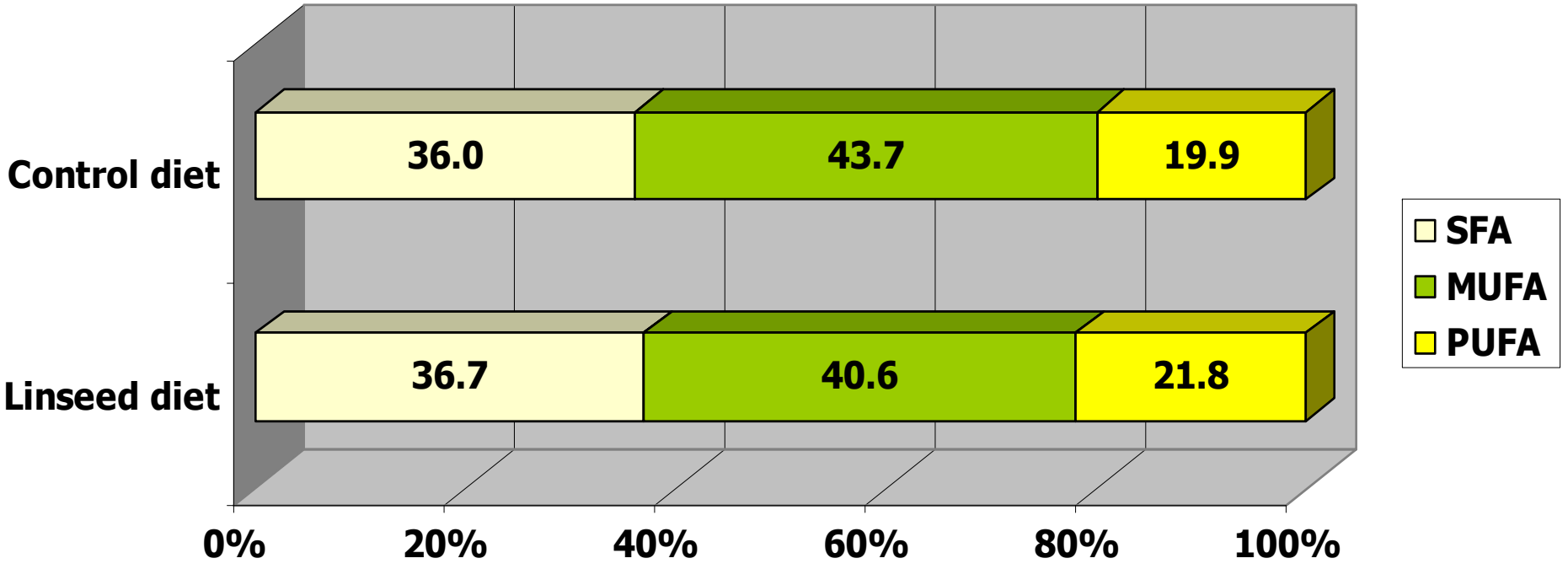
↑ **>3 x**

mean ± standard deviation

*P≤0.05; **P≤0.01; ***P≤0.001; ns–not significant (P>0.05)

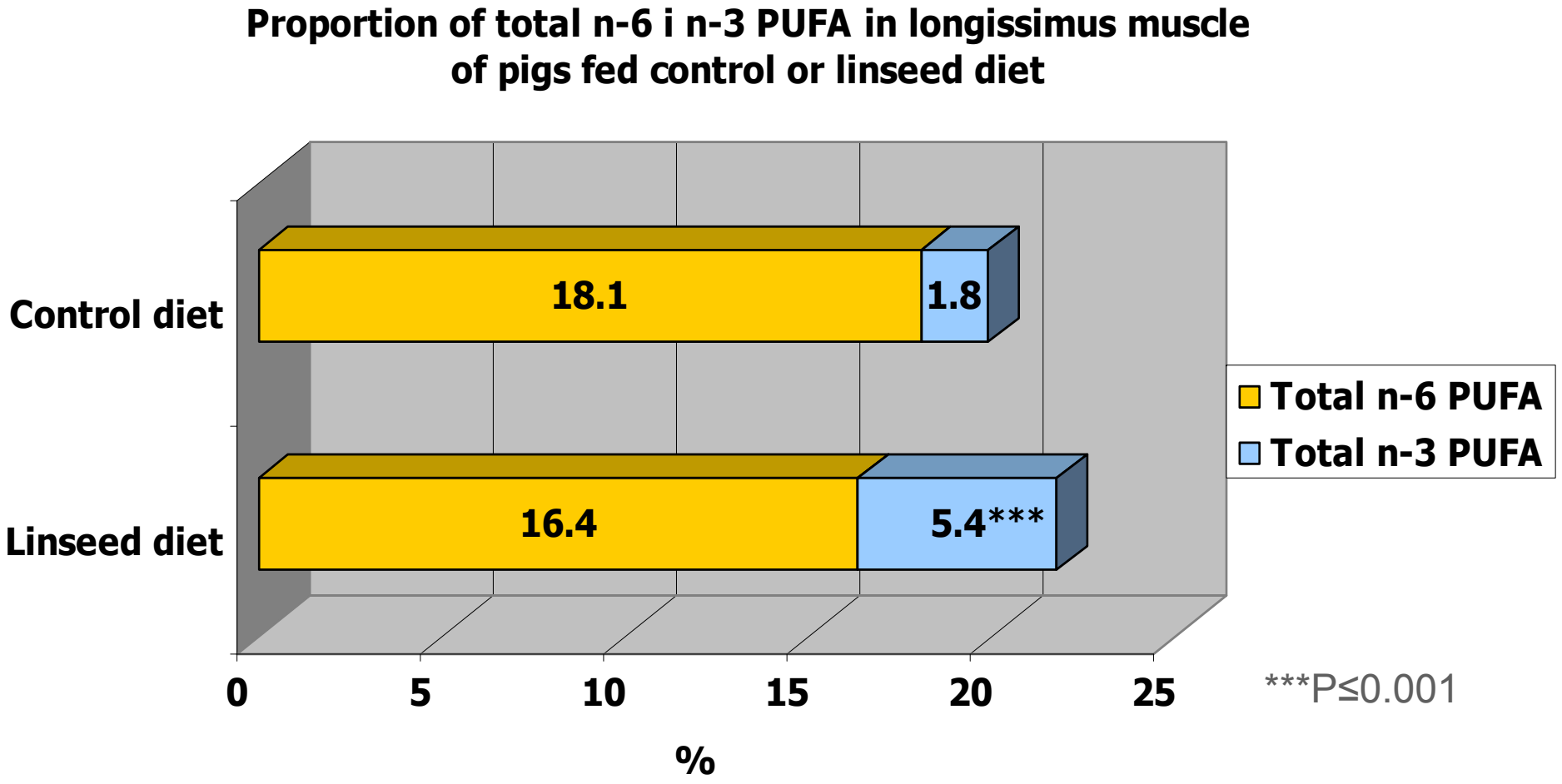
Results – muscle tissue

Proportions of total saturated, monounsaturated and poly-unsaturated fatty acids in logissimus muscle of pigs fed control or linseed diet



P/S ~ 0.6

Results – muscle tissue



total n-3 increased 3 x

n-6/n-3 reduced from ~10 on 3

Results – adipose tissue

Fatty acid composition (g/100g of total FA) of back fat of pigs fed linseed or control diet

Fatty acid	Linseed	Control	Sign.
14:0 myristic	1.35 ± 0.16	1.42 ± 0.12	ns
16:0 palmitic	21.61 ± 2.10	22.58 ± 0.86	***
16:1 palmitoleic	2.30 ± 0.36	2.26 ± 0.43	ns
18:0 stearic	10.87 ± 2.13	14.15 ± 1.00	***
18:1 oleic	39.17 ± 2.97	38.78 ± 1.09	ns
18:2 n-6 LA	14.35 ± 2.42	13.56 ± 1.64	ns
18:3 n-3 **ALA**	6.61 ± 0.97	1.01 ± 0.15	***
20:4 n-6 **AA**	0.18 ± 0.04	0.25 ± 0.04	***
20:5 n-3 **EPA**	0.10 ± 0.02	0.03 ± 0.01	***
22:6 n-3 **DHA**	0.05 ± 0.03	0.09 ± 0.01	**

↑ **>6.5 x**

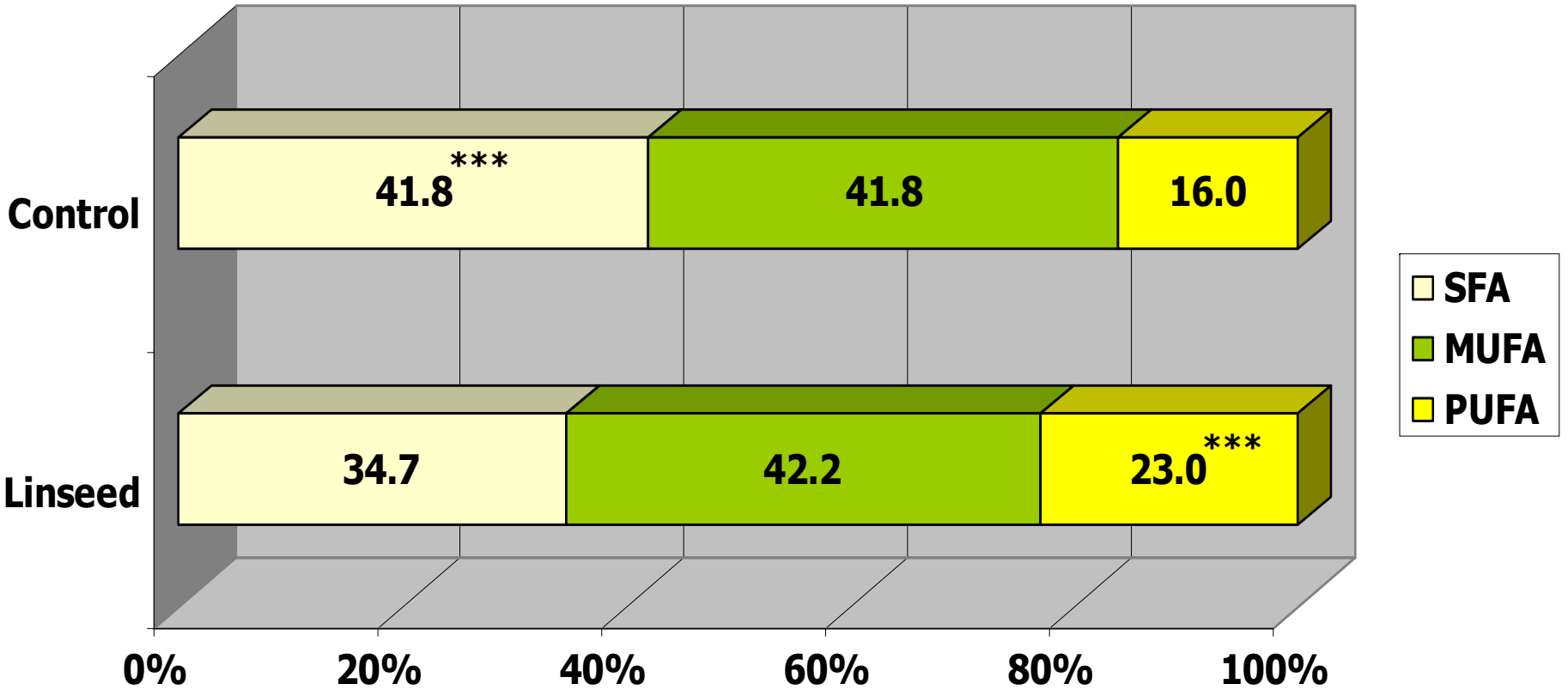
↑ **>3 x**

mean ± standard deviation

*P≤0.05; **P≤0.01; ***P≤0.001; ns–not significant (P>0.05)

Results – adipose tissue

Proportions of total saturated, monounsaturated and poly-unsaturated fatty acids in back fat of pigs fed control or linseed diet

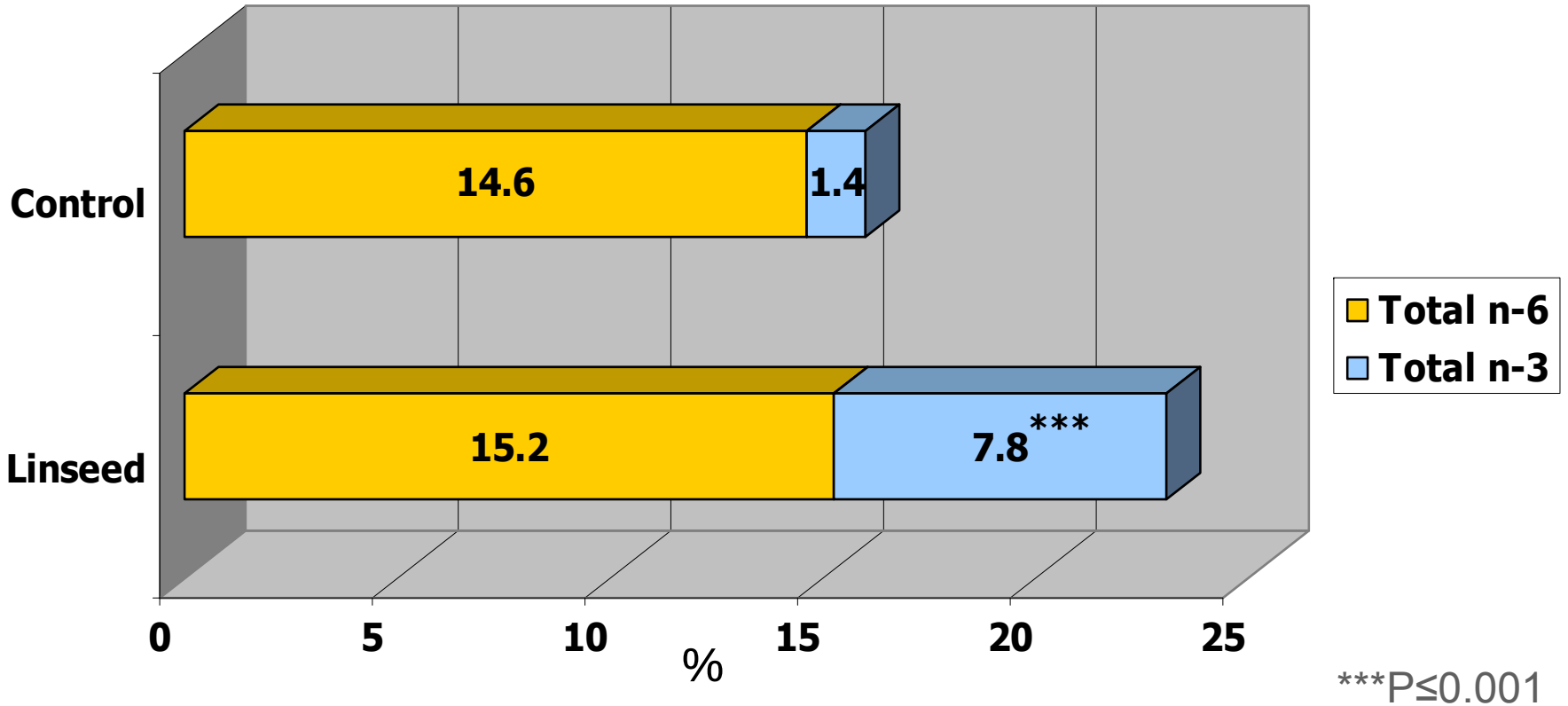


***P≤0.001

P/S raised from ~ 0.4 to 0.7 ✓

Results – adipose tissue

Proportion of total n-6 and n-3 PUFA in back fat of pigs fed control or linseed diet



***P≤0.001

total n-3 increased ~ 5.5 x

n-6/n-3 reduced from ~ 10.3 to 1.9 ✓

Results – back fat oxidative stability

Oxidative stability of fats in back fat of pigs fed control or experimental diet

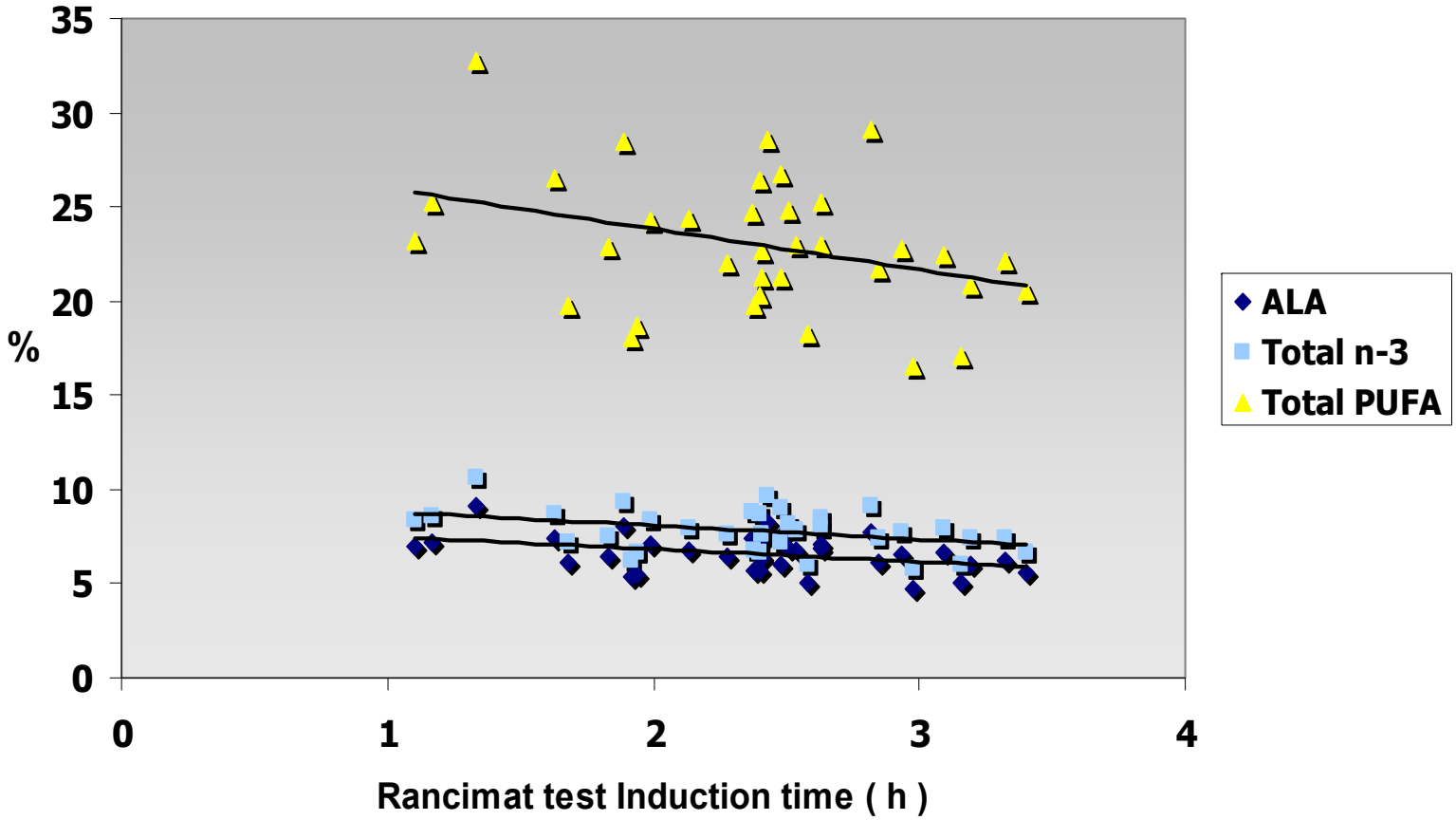
Rancimat test	Control	Linseed	Sign.
Induction time (h)	4.38 ± 0.51	2.38 ± 0.58	***

mean ± standard deviation; *** P≤0.001

Reduced ~ 46 % !

Results – back fat oxidative stability

Relation between oxidative stability of backfat and proportion of total PUFA, ALA and total n-3 PUFA in pigs fed linseed diet



ALA (r = -0.40), Total **n-3** (r = -0.39), Total **PUFA** (r = -0.35)

P≤0.05

Conclusions

- Linseed - effective feed for the increase of n-3 PUFA content of pork
- Feeding 3 % linseed diet to fatlings lowered n-6/n-3 ratio in muscle and adipose tissue and improved nutritional quality of pork fats
- To improve oxidative stability of fats higher dietary levels of vitamin E are needed
- Including linseed in commercial pig feeds - a practical way for the rising population intake of n-3 PUFA through consumption of nutritionally improved pork

Acknowledgement

This research was carried out as a part of

EUREKA Project E! 3114-AFA,

THANK YOU FOR THE ATTENTION !

dkarolyi@agr.hr