Lipids in Seeds of Oat (*Avena s*pp.), a Potential Oil Crop

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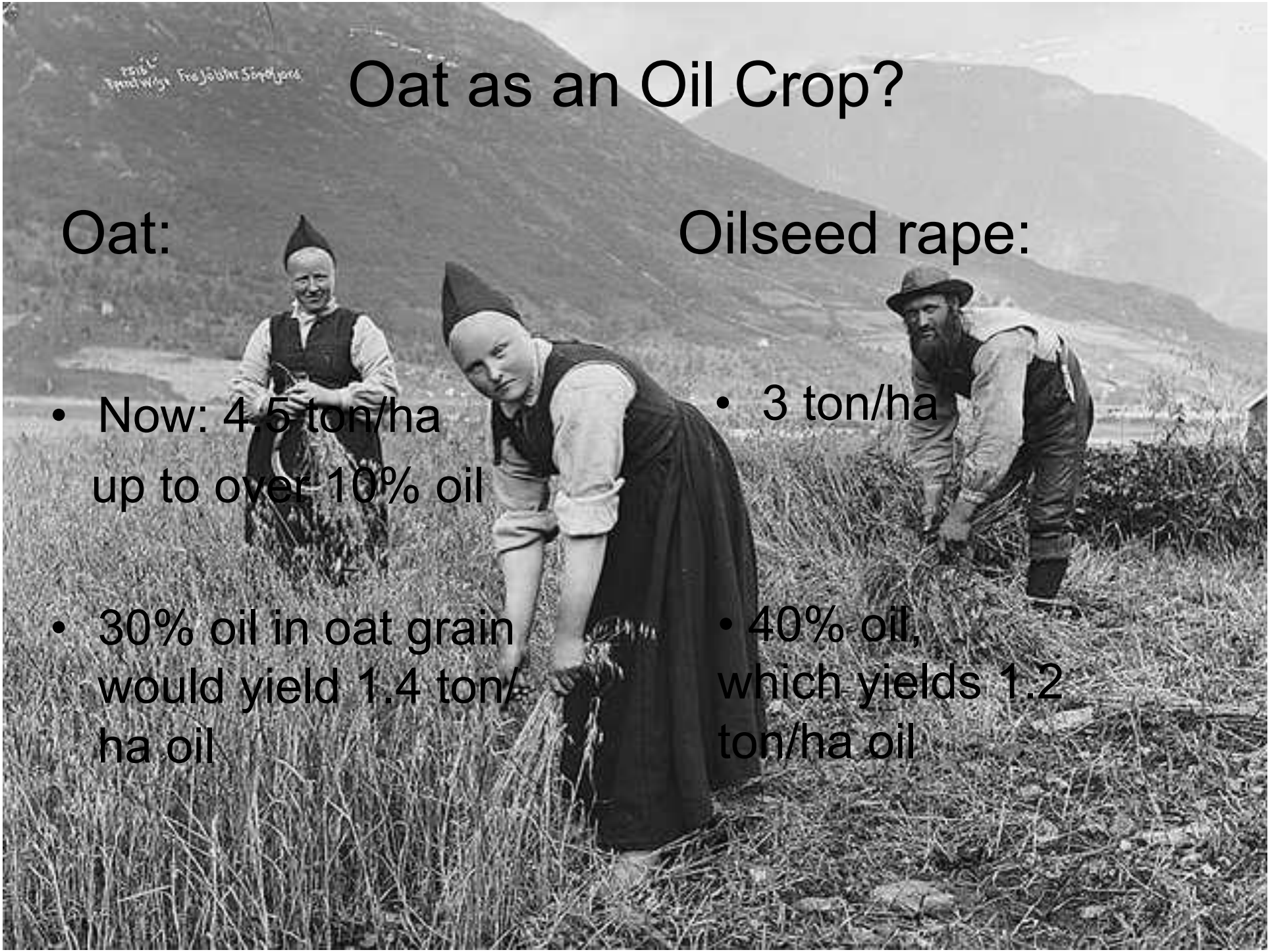
Content

- Background
- Lipids in different wild and cultivated oat species
- Lipids distribution in oat seed
- Mobilization of lipids during germination
- Conclusions

Oat as an Oil Crop?



Oat:

- Now: 4.5 ton/ha
  up to over 10% oil
- 30% oil in oat grain would yield 1.4 ton/ ha oil

Oilseed rape:

- 3 ton/ha
- 40% oil, which yields 1.2 ton/ha oil

Nikolai Vavilov

- Founder of VIR collection
- 1911: first oat accessions
- 2013: 12000 acc. of cultivated oat and 2000 acc. of wild oat

10 cultivars and 33 wild oat species of different ploidy level (di-, tetra-, hexaploid)

A. hirtula *A. canariensis* *A. barbata* *A.murphyi* *A.fatua* *A. sterilis* *A.sativa*

Oil content, lipid classes and fatty acid composition were the subjects of the study

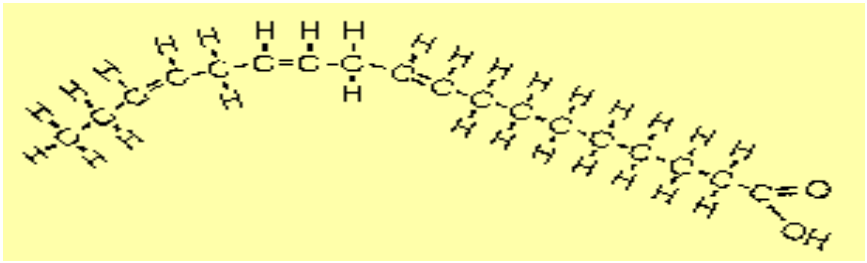
Gas chromatography (GC), thin layer chromatography (TLC) and GC-MS

Lipids

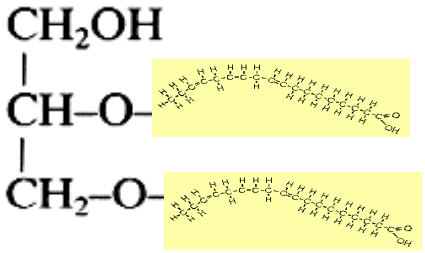
contain fatty acids (FA)

FA can be free (FFA)

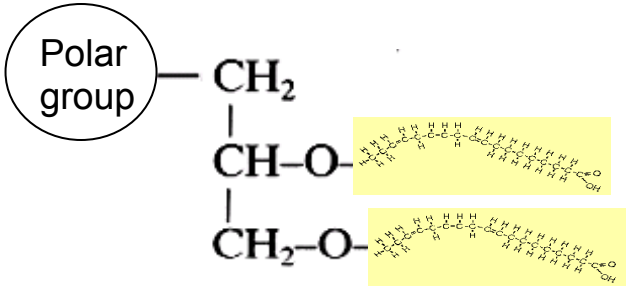
or esterified to glycerol



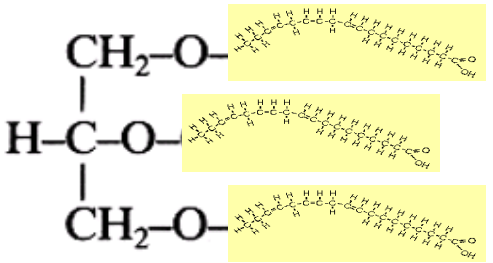
18:3 Linolenic acid



Diacylglycerol



Polar lipids

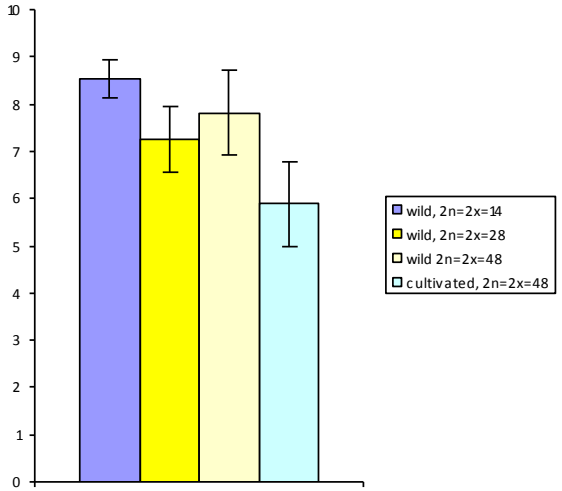


Triacylglycerol

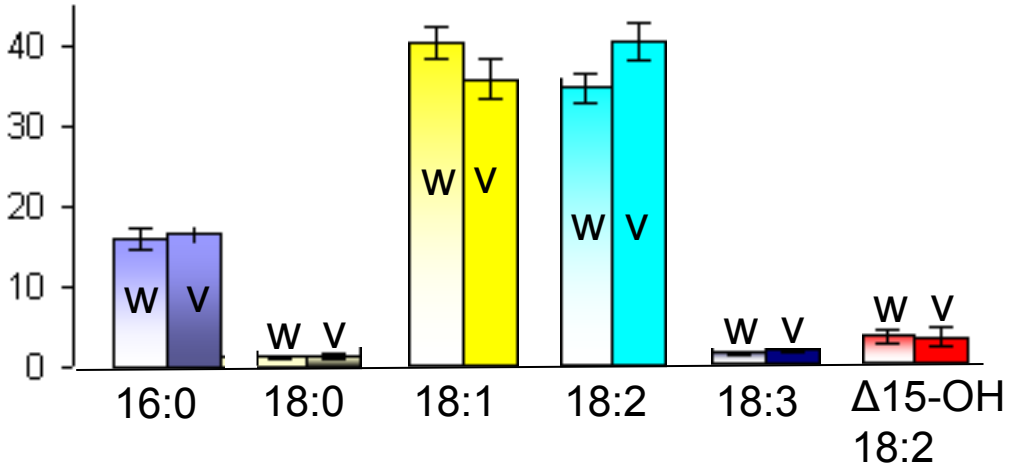
(TAG) = oil

Results I: Total grain oil

Gas chromatograph



w – wild oat species; v – oat varieties

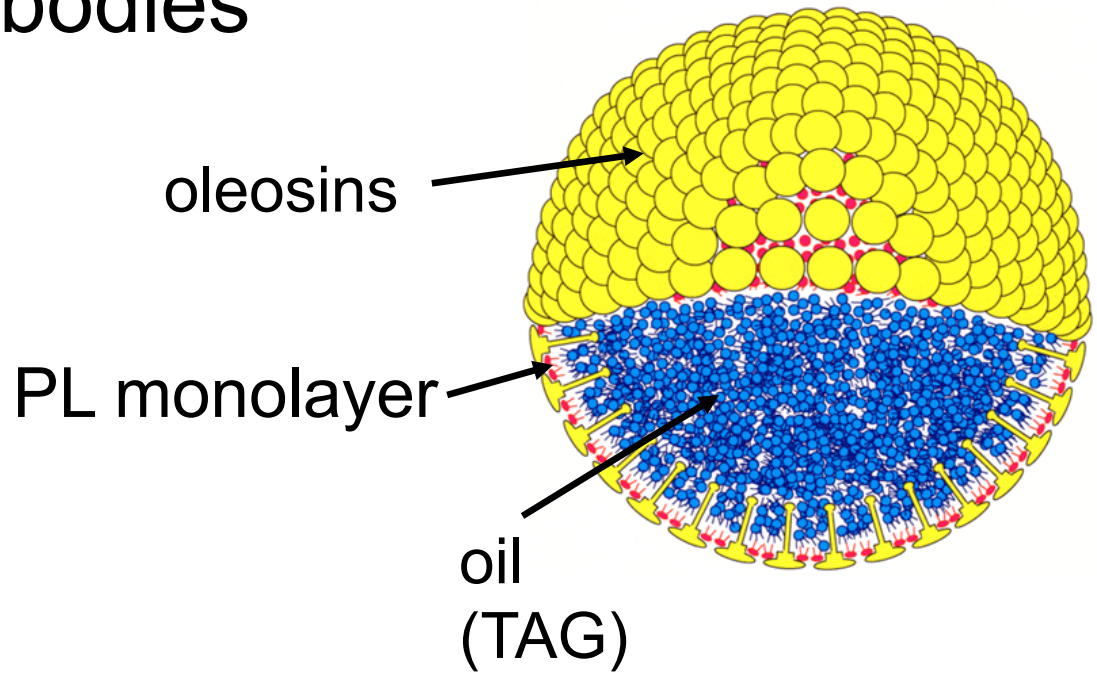


Wild diploid oat has the highest oil content, cultivated – the lowest

no significant differences in FA composition between wild and cultivated oat

Leonova *et al.*, 2008

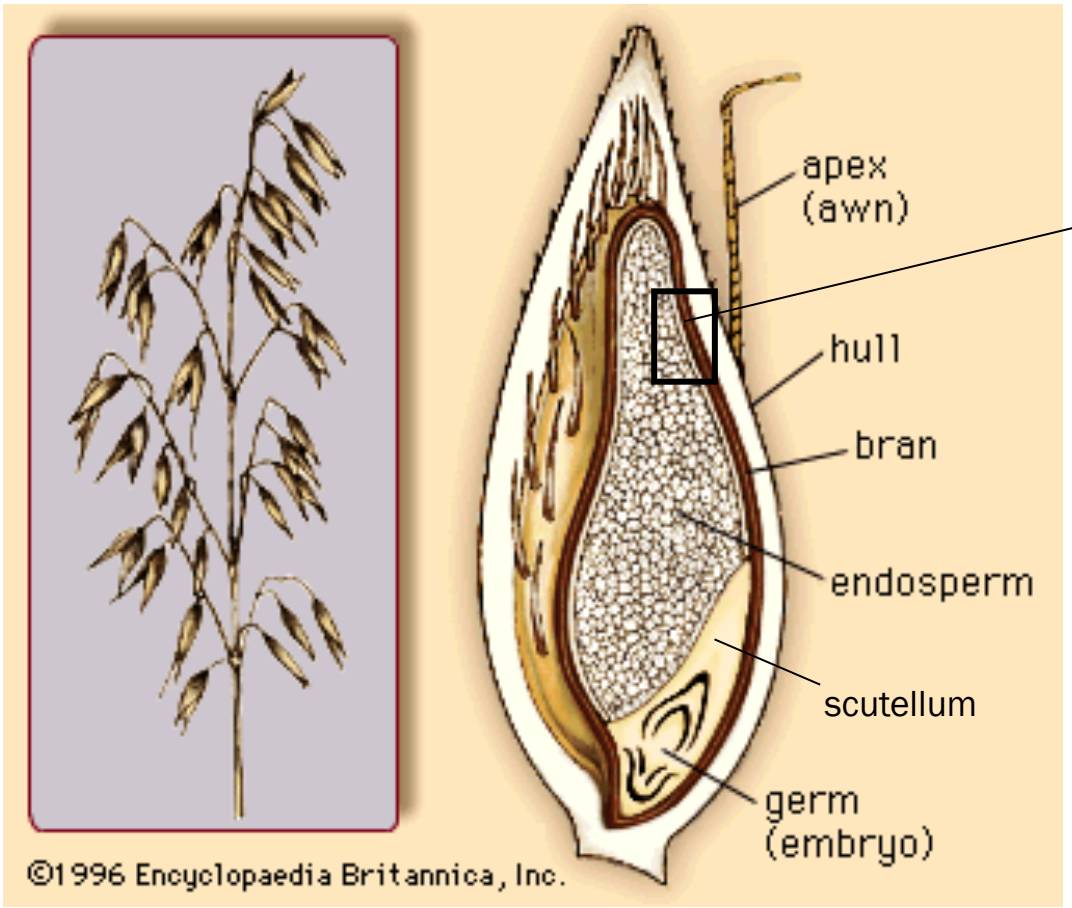
In oilseed cells, oil exists in form of oil bodies

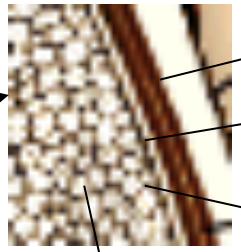


http://plantbiology.ucr.edu/faculty/huang.html

In the endosperm of mature oat seed oil bodies fuse upon maturation (Banas et al. 2007)

Structure of oat seed





pericarp

aleurone

subaleurone

bran

endosperm

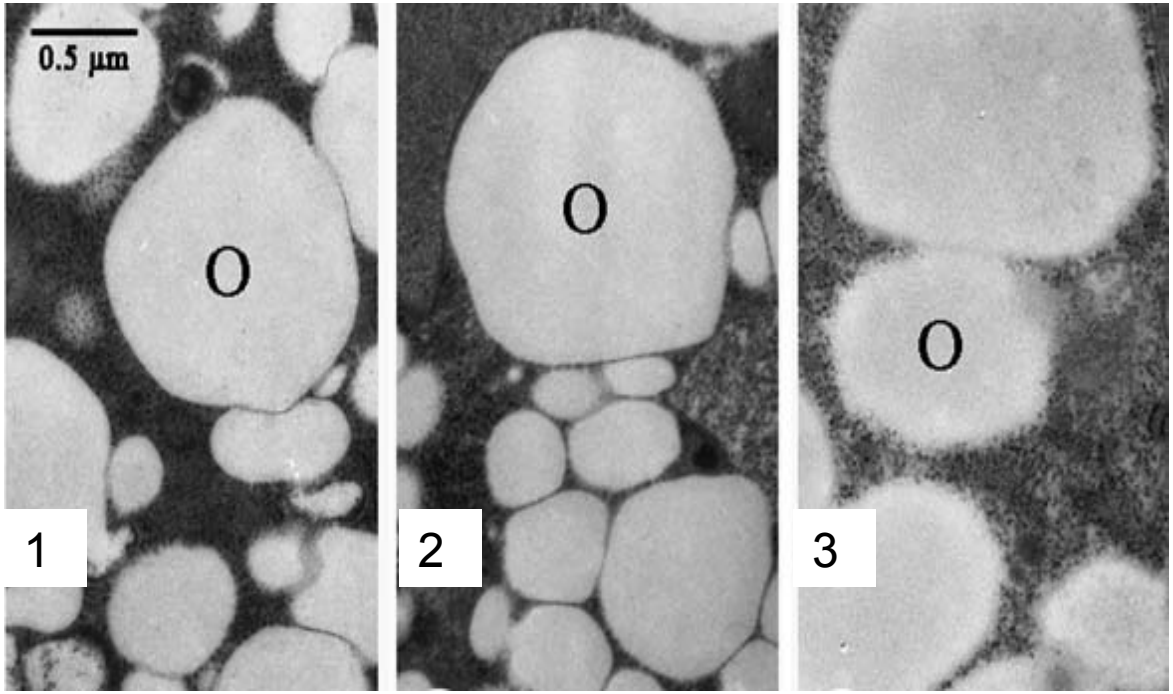
Results II: TEM

early stage of seed development

embryo

aleurone layer

endosperm

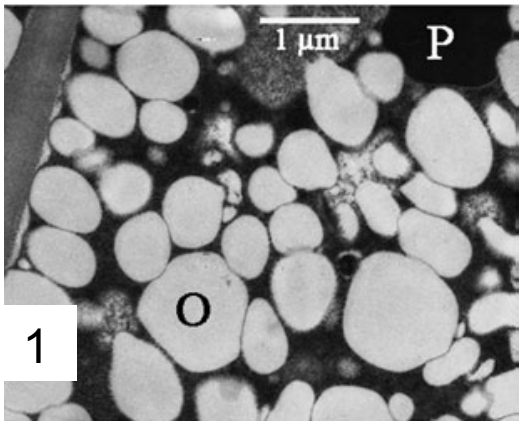


O – oil

Heneen *et al*., 2008

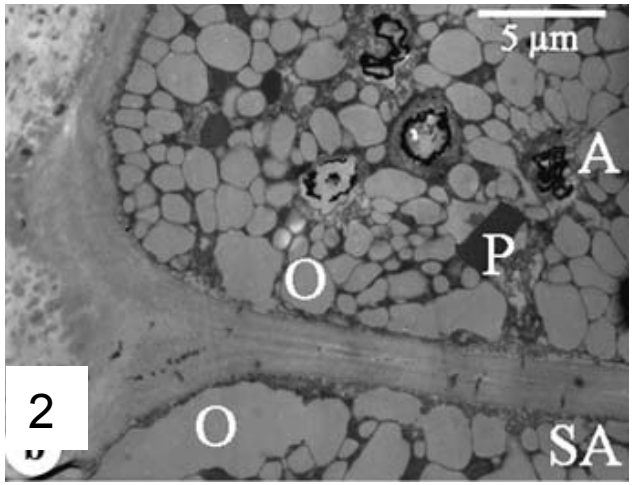
Results II: TEM
late stage of development

embryo



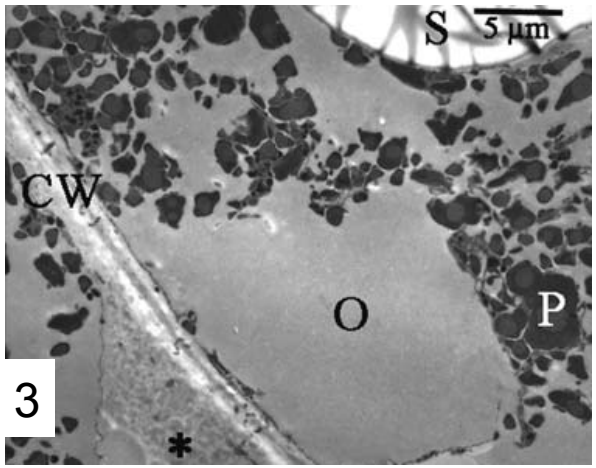
Banas et al., 2007

aleurone layer



O – oil; P – protein;
A – aleurone layer;
SA – subaleurone layer

endosperm



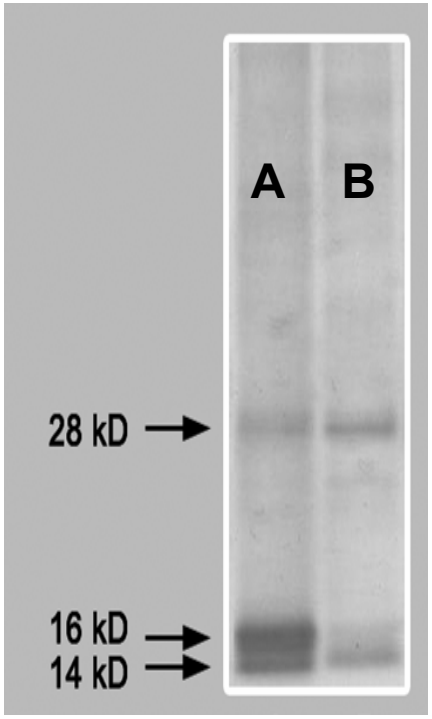
Heneen *et al*.,
2008

Results II: Oleosin

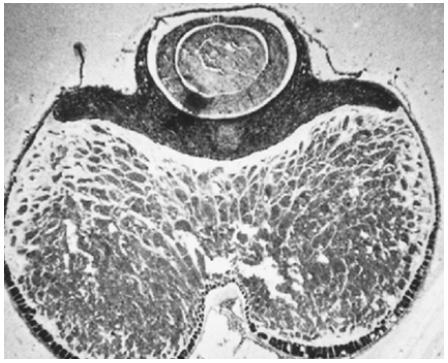
A –

embryo;

B -
endosperm



SDS-PAGE protein separation



Immunolocalization with antibodies against oleosins

Heneen *et al*., 2008

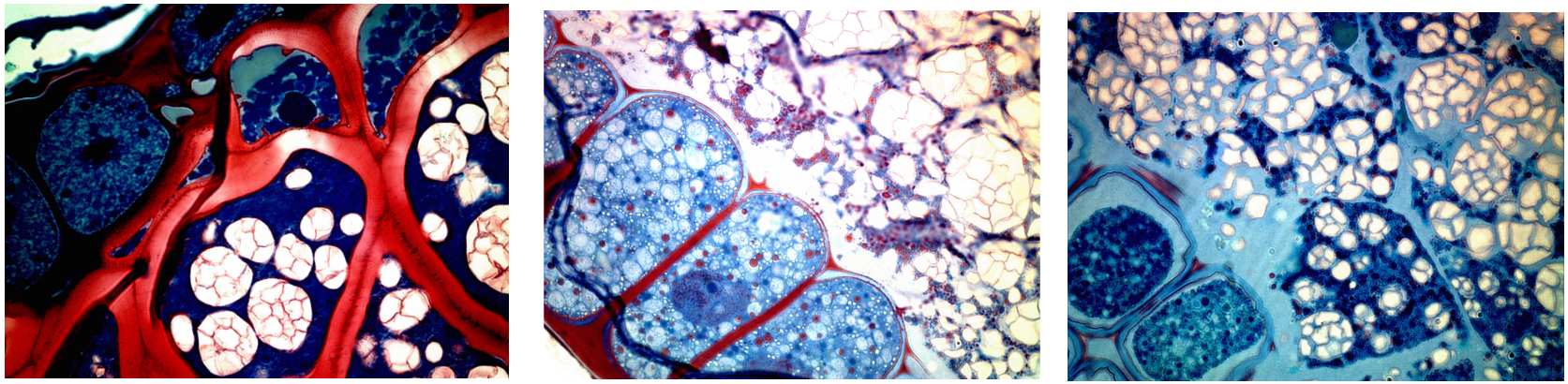
- No enzymes for fatty acids degradation in endosperm

- Oil smears instead of structured oil bodies impair accessibility of this oil for hydrolyzing enzymes

Is oil in oat endosperm a dead-end product?

Results III: Light microscopy

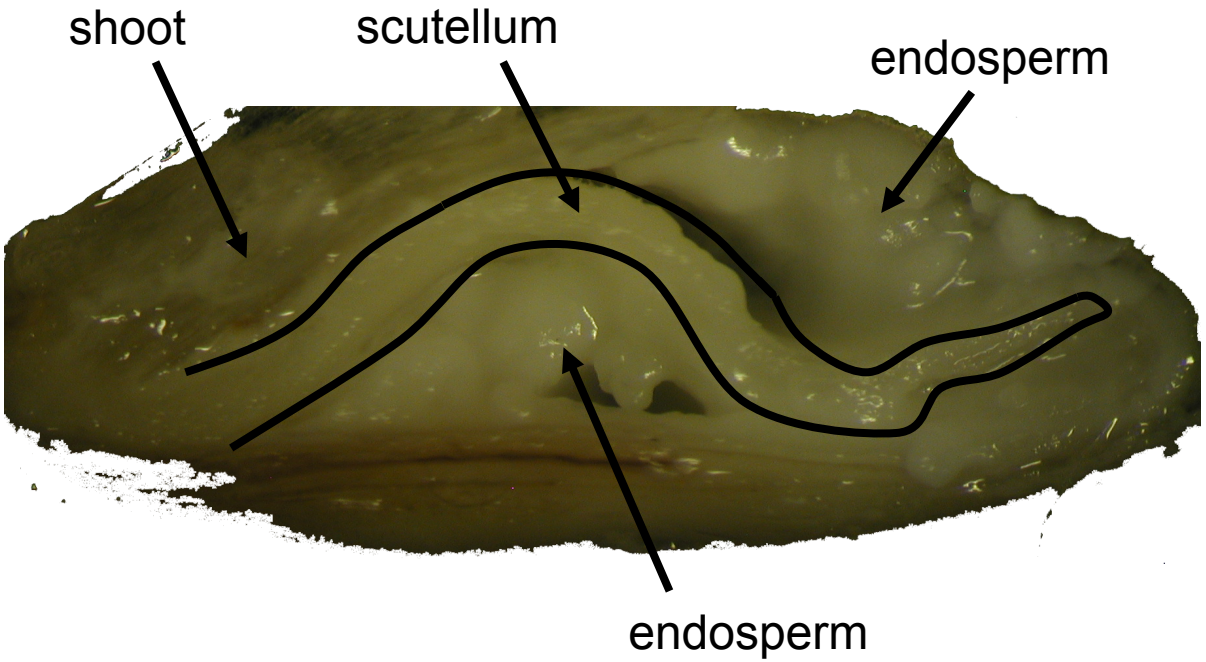
1d **4d** **7d**

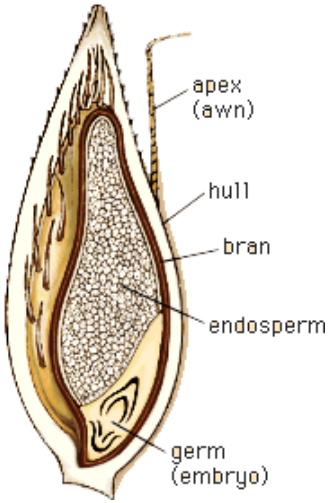


Leonova *et al*, 2010

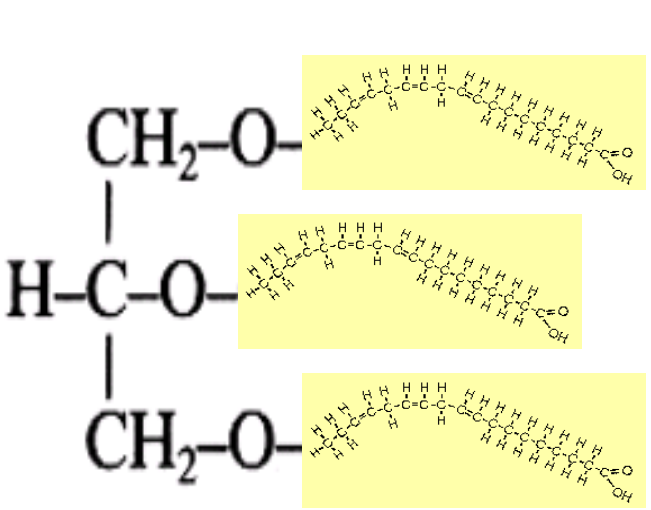
Scutellum – an absorptive organ

Oat seed, 7 days of germination



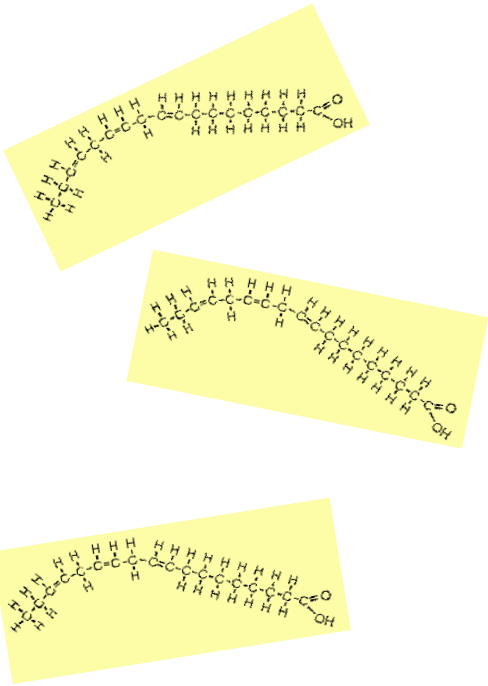


scutellum functions as an
absorptive organ, which transports the nutrients from the endosperm to the growing embryo.



Oil

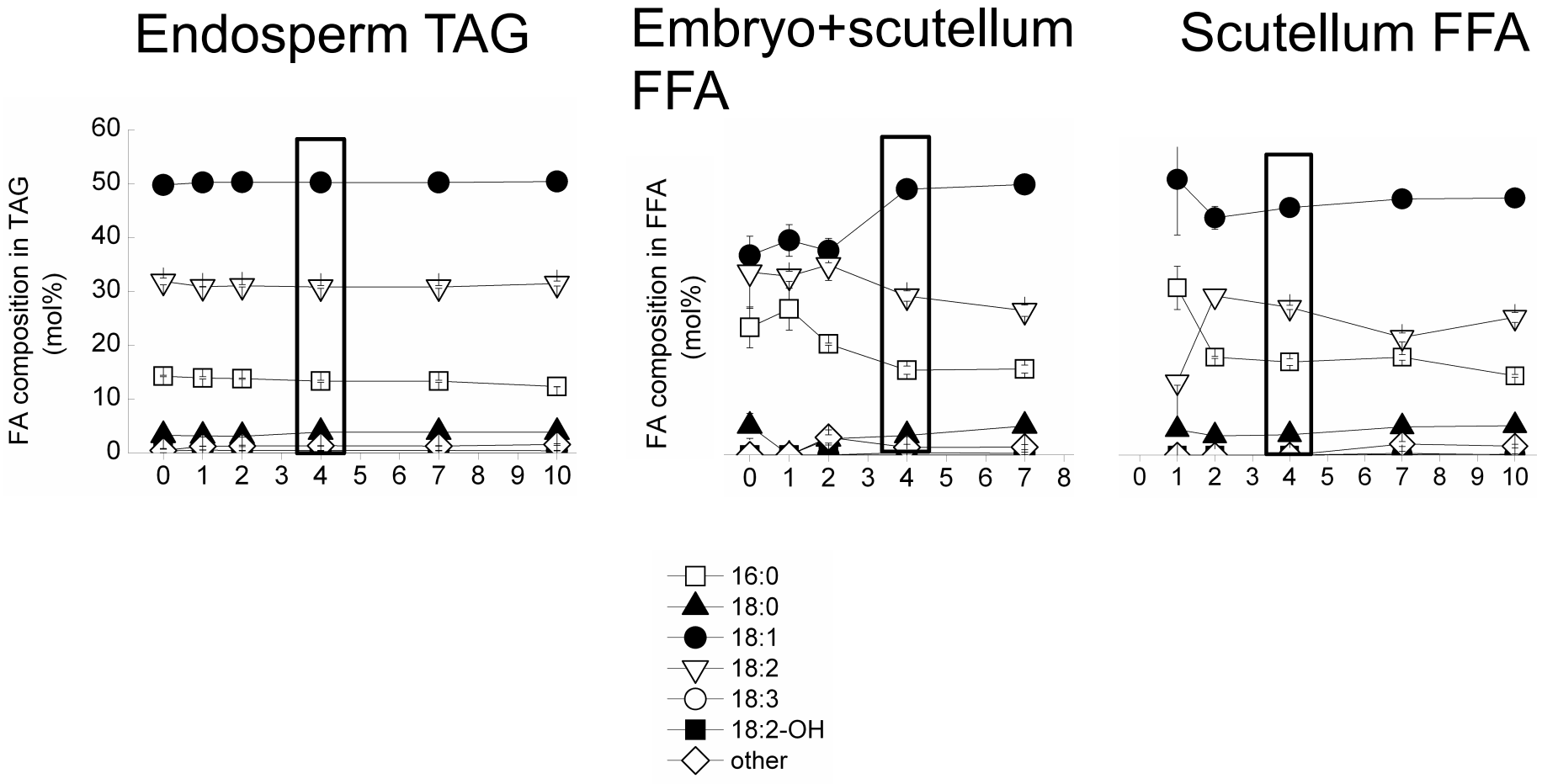
lipase



Free fatty acids

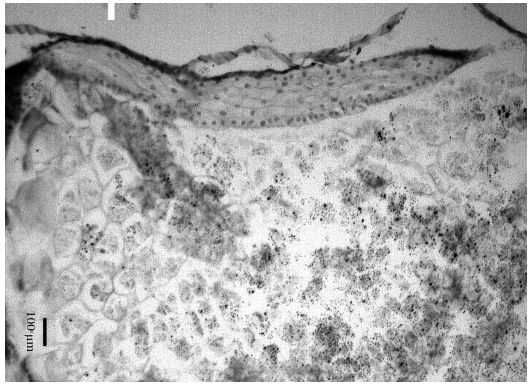
Beta-oxidation

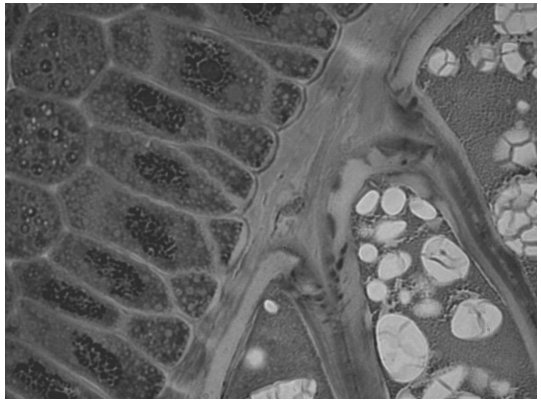
Results III: FA profile



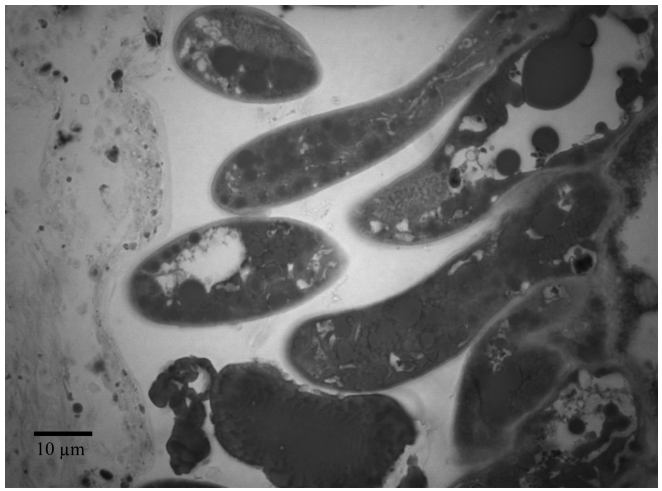
Scutellum and oil transport

1d





7d



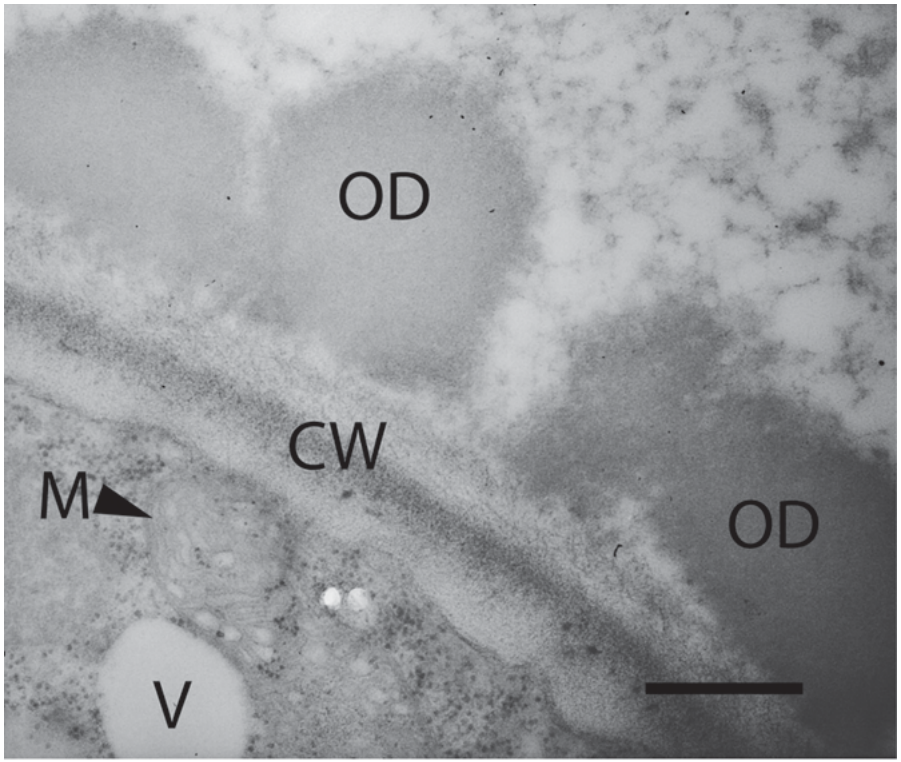
Scutellum: parenchyma and epithelium

Epithelium absorbs nutrients from endosperm

Parenchyma metabolises these nutrients

Results III: TEM confirms the LM and chemical results

Close contact between oil droplets (OD) and cell wall (CW) of scutellum epithelium cells



Bar = 0,5 µm

M - mitochondria

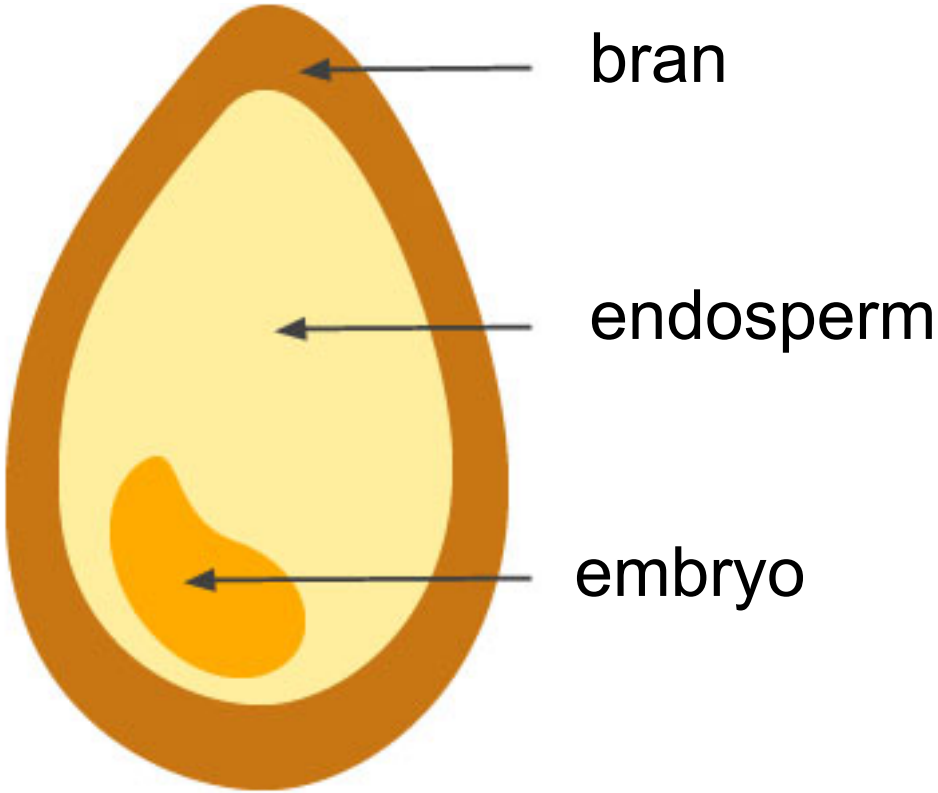
V - vacuole

These we want to change for converting oat into oil crop:

- Oil content: 20-30% with preserved yield
- FA composition: raised level of ω-3 FA

Oat is unique among cereals by having oil in the endosperm

Cereal seed:

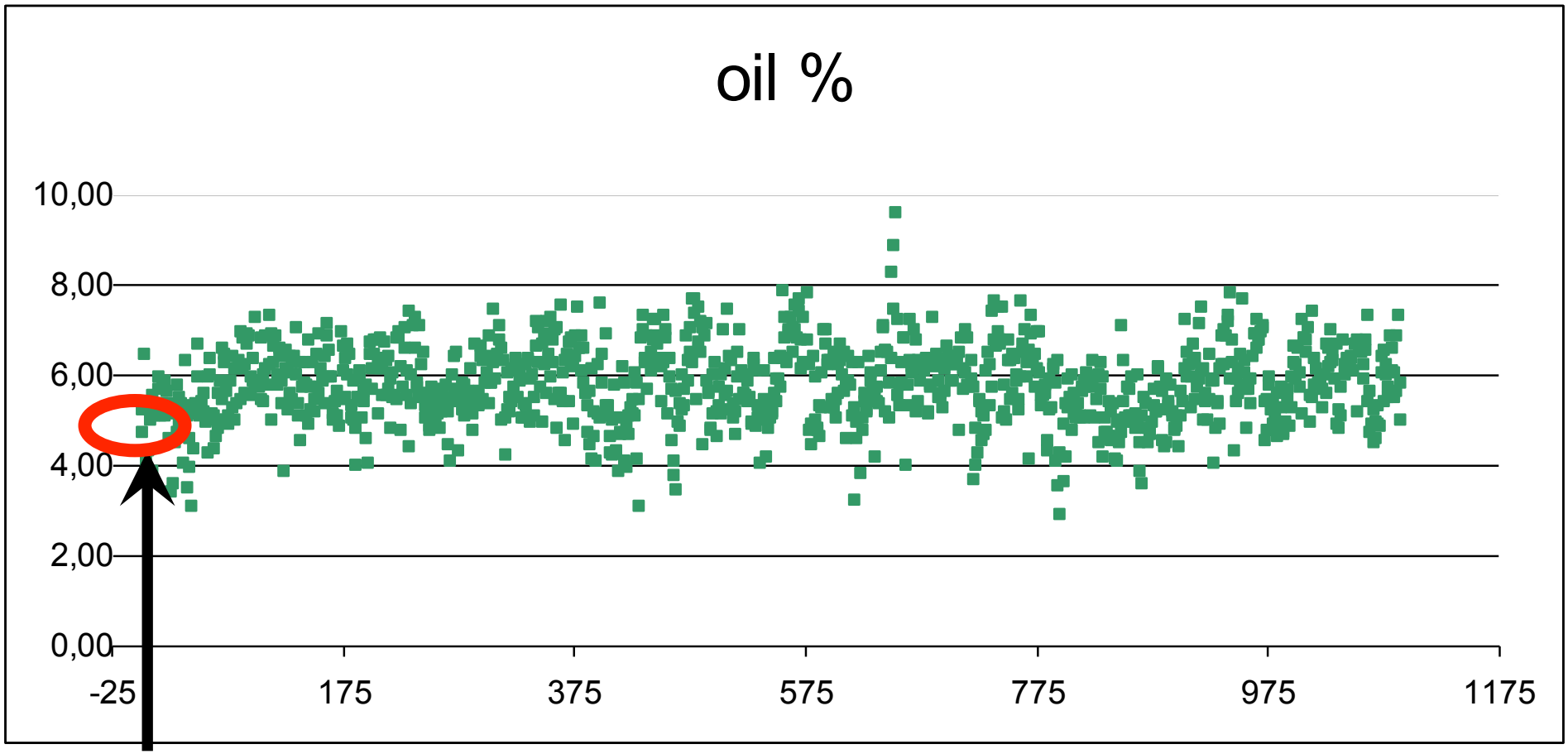


http://safefrommsg.blogspot.se/2010/05/whole-grains.html

Approaches

- Transformation

- Mutagenesis: screening for high oil and omega-3 lines in mutagenized population



cv. Belinda

Conclusions

- not enough diversity on oil content and FA composition;
- oil in endosperm changes appearance from oil bodies to smears upon maturation. Lower amount of oleosin in endosperm of mature seeds compared to embryo;
- both medium- and high-oil oat cultivars utilize free fatty acids from the endosperm to nourish the growing embryo;
- scutellum of the germinating oat seeds is involved in the transport of the products of starch, protein, and oil reserves breakdown from the endosperm to the growing embryo

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Thank you