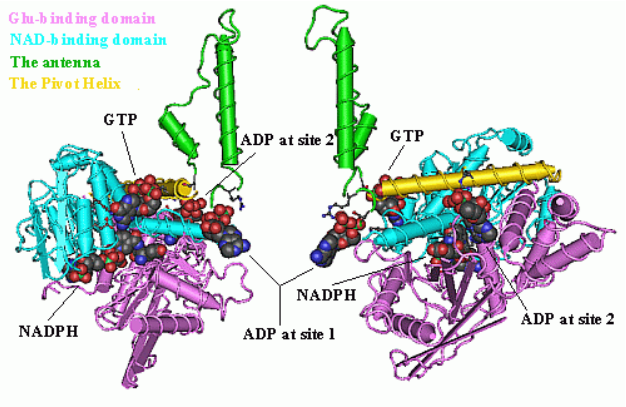
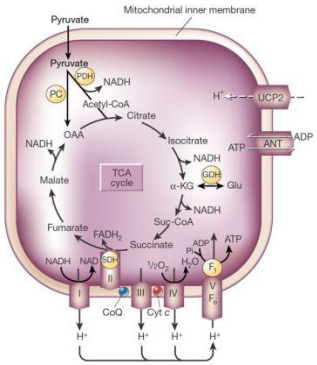
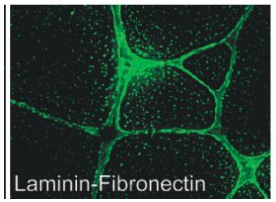
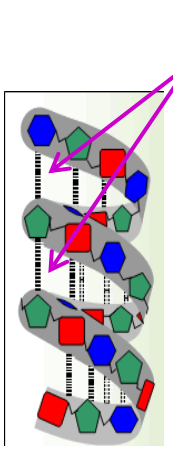
Tekstur i laks

Turid Mørkøre



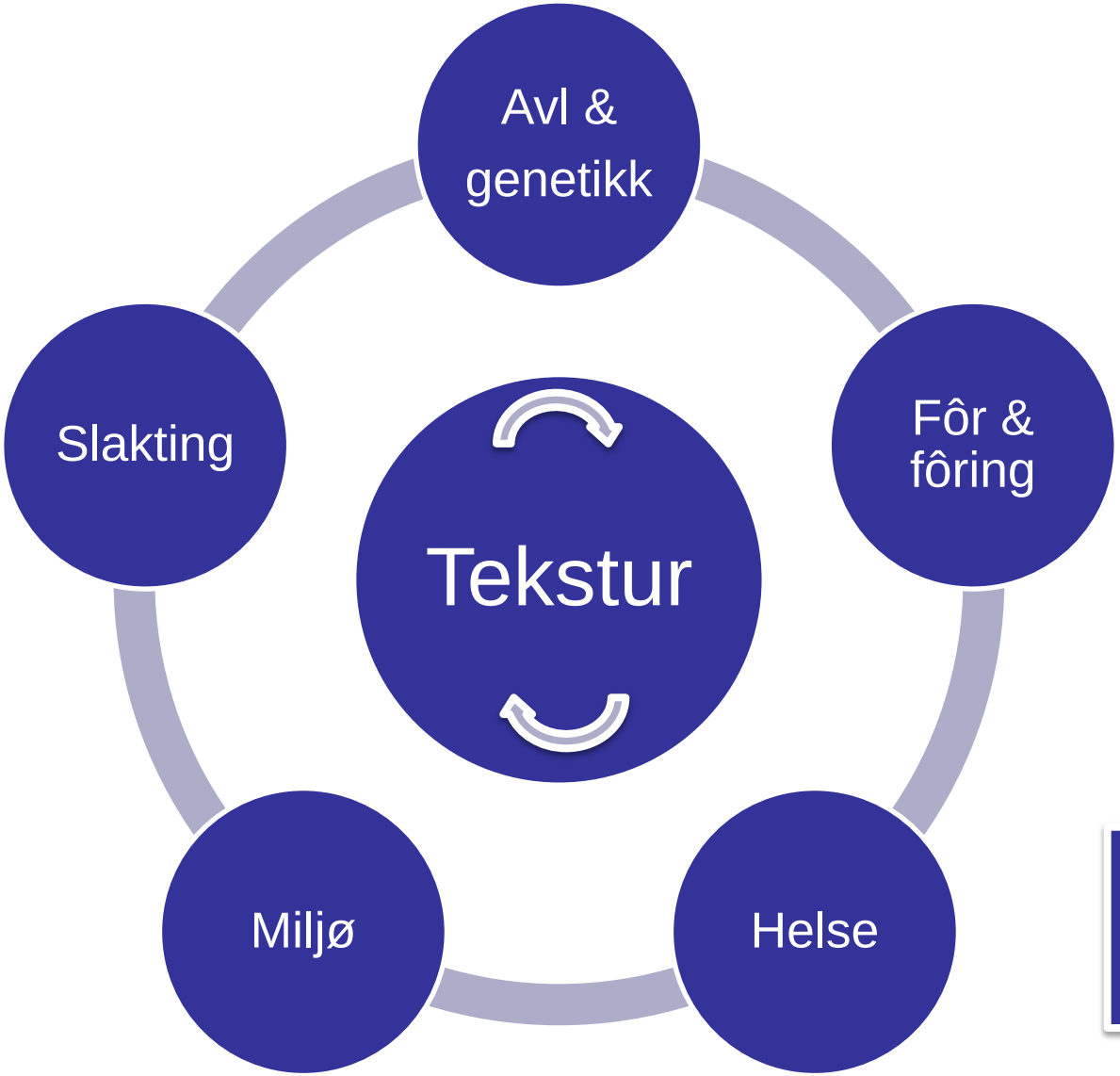






Nofima

Participants, contributors



Lagring
Prosessering
Tilberedning

Nofima

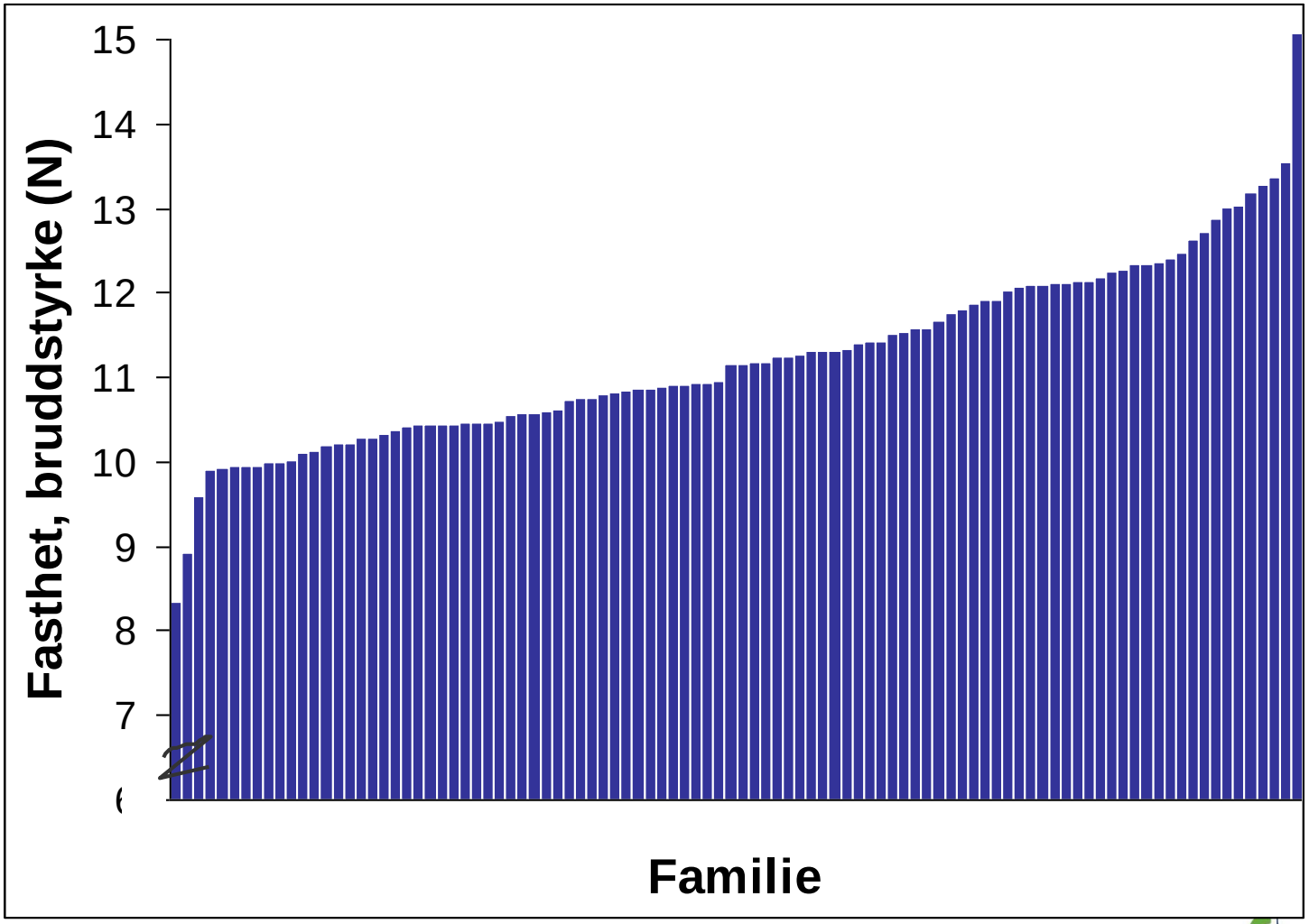
Gode foreldre

$h^2 = 0.16 – 0.31$

Nofima

Betydelig variasjon i tekstur mellom familier

⇩ Fastheten kan forbedres gjennom avlsarbeid

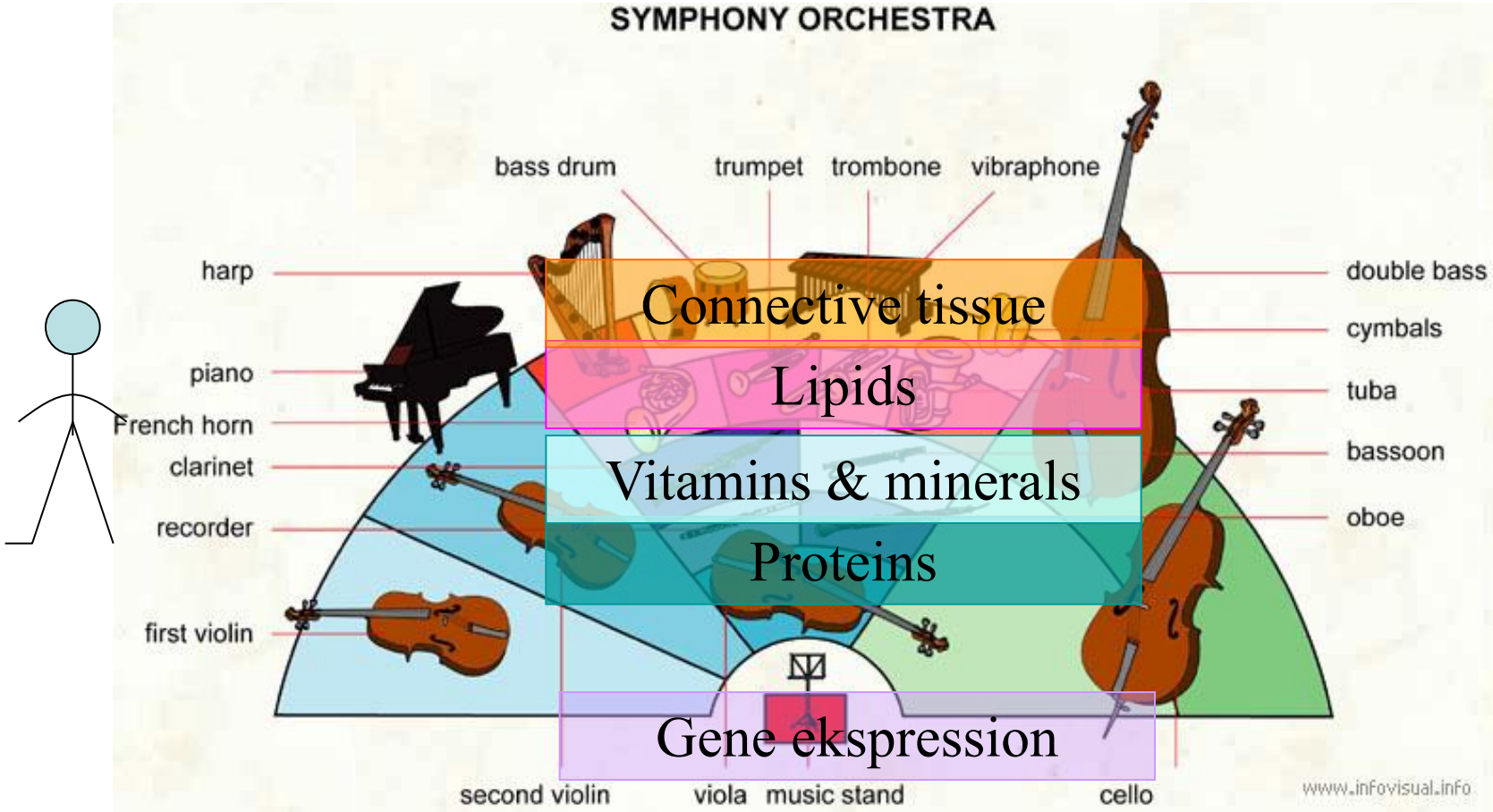


Nofima

Hvilke gener er aktive i hhv bløt og fast laks

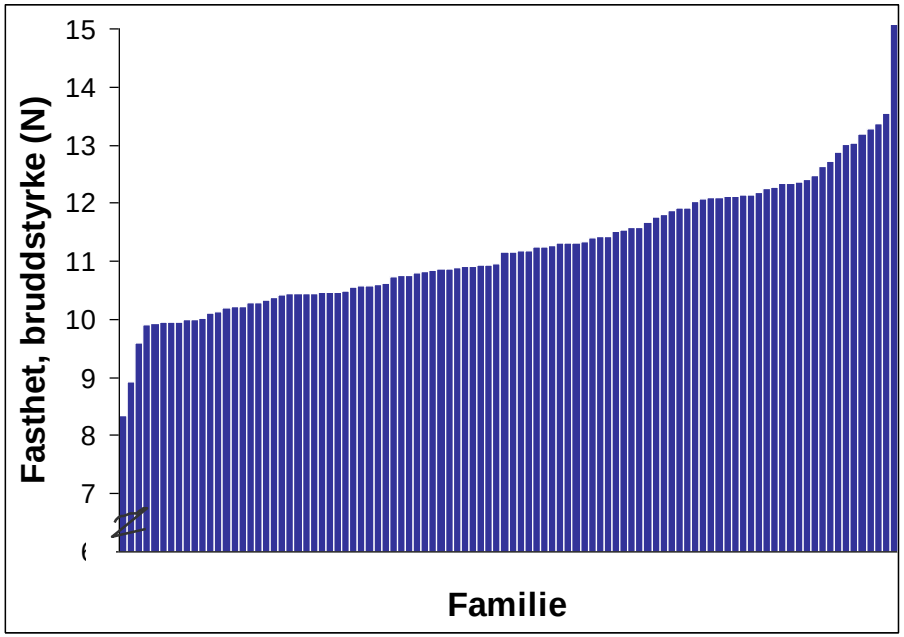
Nofima

Physical components



Avlspopulasjon på 1000 laks

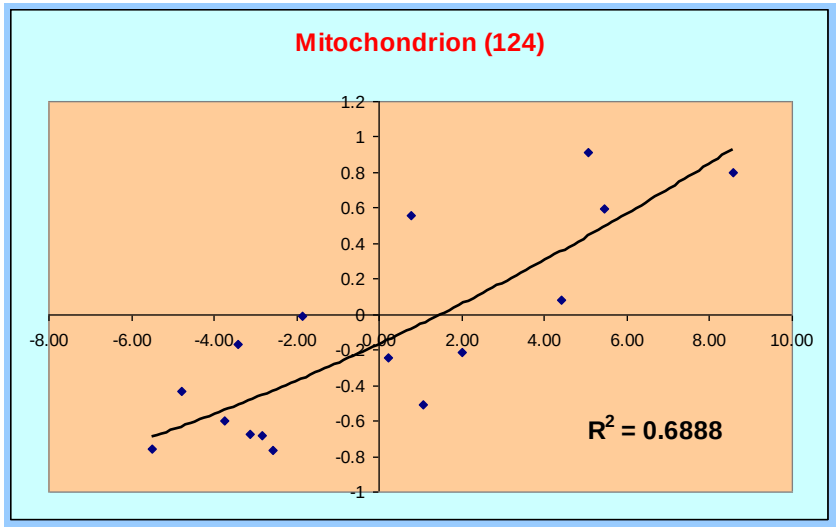
- Valgt ut 16 individer
  - Bløt ⇒ fast
- Analysert ved Microarray
- 21 K oligonucleotide microarray
- Veldig bra sorteringsverktøy
- Undersøkt ca 2000 gener

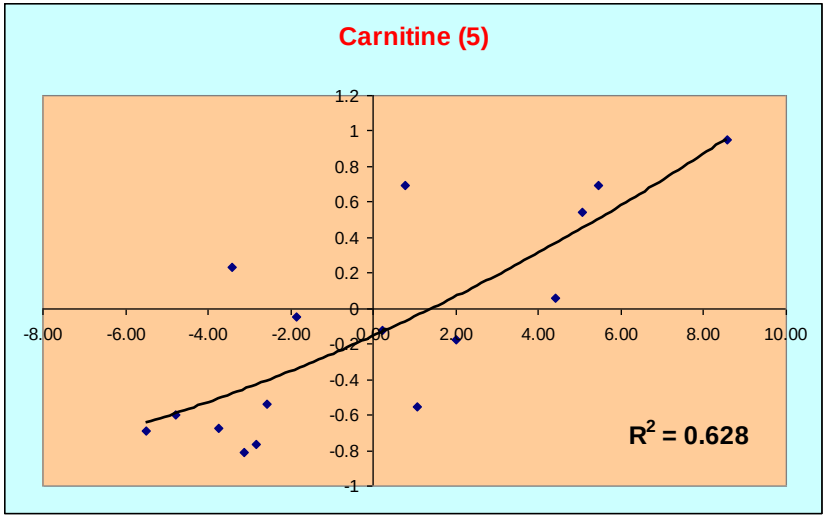


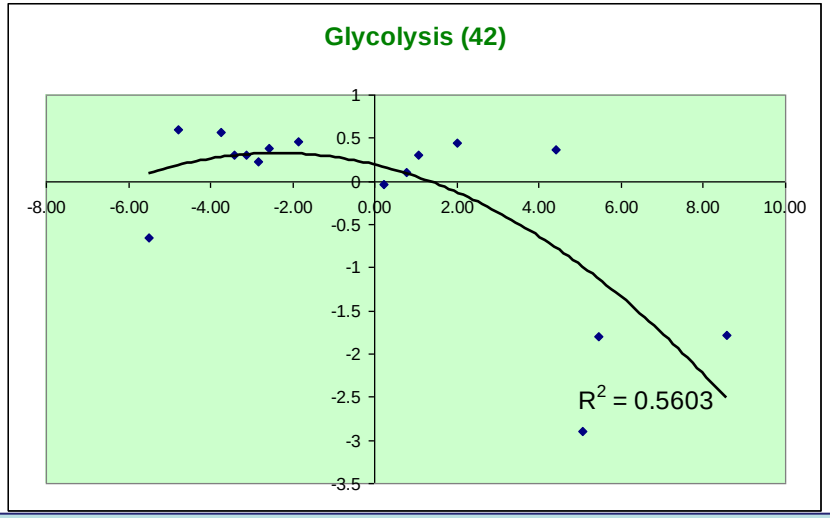
- Utviklet i prosjektet

Larsson, T., Mørkøre, T., Kolstad, K., Østbye, T-K., Krasnov, K.
Gene expression profiling of soft and firm Atlantic salmon fillet.
Accepted for publication in PLoS ONE

Correlations with firmness – Microarray







- Salmon with soft muscle suffered from hypoxia
- Low expression of carnitine
- Low expression of mitocondria proteins
- High expression of immune genes
- Texture problems appear to originate from problems inside the muscle cells

Larsson, T., Mørkøre, T., Kolstad, K., Østbye, T-K., Krasnov, K.
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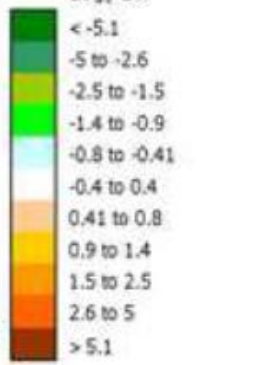
Aminosyre metabolisme

Genes	Firmness (N) -5.5	-3.7	-4.8	-3.4	-3.1	-2.8	-2.6	-1.9	0.2	1.1	2.0	4.4	0.8	5.0	5.5	8.6	r	S
Amino acids metabolism																		
Aspartate aminotransferase, cytoplasmic	-0.9	-0.5	-0.7	0.0	-0.5	-0.4	-0.7	-0.1	0.0	-0.3	-0.2	-0.1	1.2	0.9	1.3	1.0	0.80	0.13
Aspartate aminotransferase, mitochondrial	-1.2	-0.6	-0.3	0.5	-0.7	-0.8	-1.0	0.7	0.0	-0.4	0.2	0.6	0.1	1.0	0.8	1.1	0.77	0.14
Pyrroline-5-carboxylate reductase 2	-0.4	-0.8	0.0	0.4	-0.5	-0.5	-0.8	-0.1	0.4	-0.5	0.1	0.5	-0.2	0.4	0.8	1.1	0.77	0.10
Cystathionine gamma-lyase	-0.8	-0.8	-0.1	0.4	-0.2	-0.9	-0.9	0.1	0.0	-0.4	0.2	0.3	0.7	0.5	0.9	1.0	0.75	0.11
Glutamate decarboxylase-like	1.1	1.9	0.5	-0.8	2.2	2.7	1.6	0.8	-0.7	0.9	-0.5	0.7	-3.2	-1.5	-3.3	-2.0	-0.65	-0.29
S-adenosylmethionine synthetase isoform	2.1	1.9	0.4	-0.2	1.7	1.5	0.5	0.0	-1.0	0.9	-0.8	1.3	-2.3	-1.9	-1.8	-2.2	-0.69	-0.25
Branched-chain-amino-acid aminotransferase	0.6	0.8	0.7	0.7	1.4	1.1	0.8	0.7	0.1	0.5	0.0	-0.1	-2.3	-1.2	-1.6	-2.0	-0.79	-0.22
Cysteine dioxygenase type 1	0.9	1.1	1.0	0.1	0.9	0.5	0.3	0.9	0.3	1.1	0.5	-0.6	-1.8	-2.4	-1.3	-1.8	-0.78	-0.22
L-arginine:glycine amidinotransferase	1.5	1.0	1.4	-0.3	0.8	1.3	1.3	-0.4	-0.3	0.3	-0.4	-0.6	-1.5	-1.6	-1.4	-1.2	-0.82	-0.22
L-pipecolic acid oxidase	1.0	0.8	0.2	0.1	0.9	0.7	1.0	-0.1	0.2	0.3	-0.3	0.3	-1.5	-1.4	-1.1	-1.1	-0.74	-0.16
Sodium-coupled neutral amino acid transporter 3	0.7	0.5	0.5	0.4	0.7	-0.1	1.0	-0.1	0.4	-0.2	0.0	-0.4	-1.1	-1.0	-0.5	-0.8	-0.78	-0.12
Argininosuccinate synthase	0.7	0.7	0.5	0.3	0.6	0.0	0.3	0.3	-0.2	0.3	-0.2	-0.1	-1.0	-0.3	-0.9	-0.9	-0.81	-0.11
Intracellular proteases																		
Cathepsin H	-1.0	-0.3	-0.7	0.1	-0.3	-0.4	-0.6	0.6	-0.4	-0.6	-0.7	-0.1	1.2	0.7	1.4	1.2	0.66	0.12
Cathepsin L1	-0.8	-0.5	-0.4	-0.2	-0.6	-0.4	-0.5	-0.3	0.0	-0.3	-0.2	0.0	1.7	1.0	0.8	0.9	0.72	0.12
Dipeptidyl-peptidase 1	-0.5	-0.8	-0.3	-0.1	-0.7	-0.5	-0.7	-0.3	0.0	-0.3	0.1	-0.1	1.5	1.5	0.9	0.5	0.67	0.12
Dipeptidyl-peptidase 3	-1.2	-0.6	-0.6	0.1	-0.6	-0.8	-0.7	0.2	-0.1	-0.3	0.4	-0.2	1.1	1.1	1.2	1.0	0.80	0.15
Cysteine protease ATG4B	-1.7	-0.6	-0.6	0.3	-0.9	-0.8	-1.0	0.3	0.3	-1.2	0.8	0.1	0.8	0.9	2.0	1.7	0.78	0.20



Larsson, T., Mørkøre, T., Kolstad, K., Østbye, T-K., Krasnov, K.
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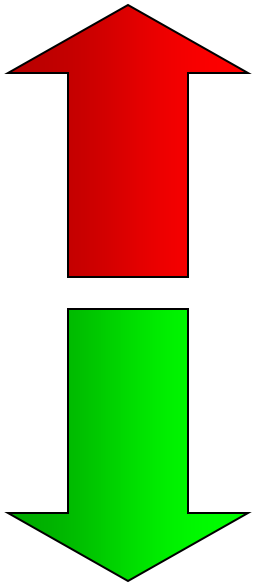
Firm meat



Aerobic metabolism
Fatty acids as main fuel
Rapid degradation of damaged protein via proteasomes

Anaerobic metabolism
Amino acids as main fuel

Soft meat

What is inherited: structure of muscle?
Interactions with environment?
Resistance to hypoxia?

Larsson, T., Mørkøre, T., Kolstad, K., Østbye, T-K., Krasnov, K.
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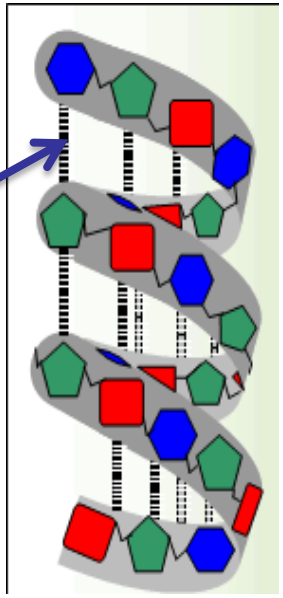
Bindevevet, hvilken betydning har det ?

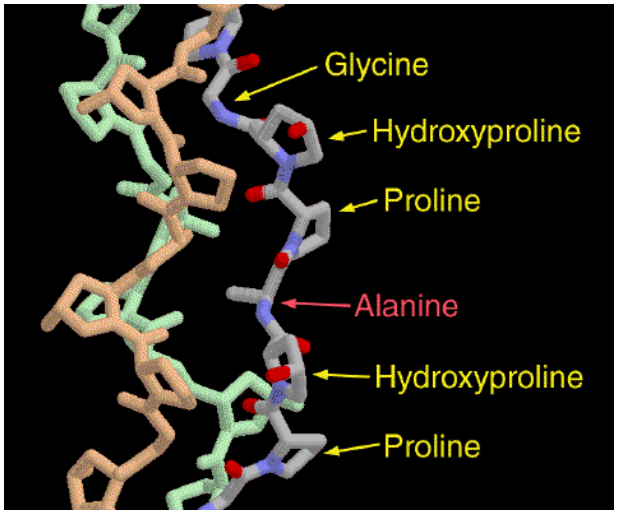


Fast vs. bløt laks

Samme mengde bindevev

Høyere nivå av aminosyrene alanin og glycin (r = 0.7 – 0.9)

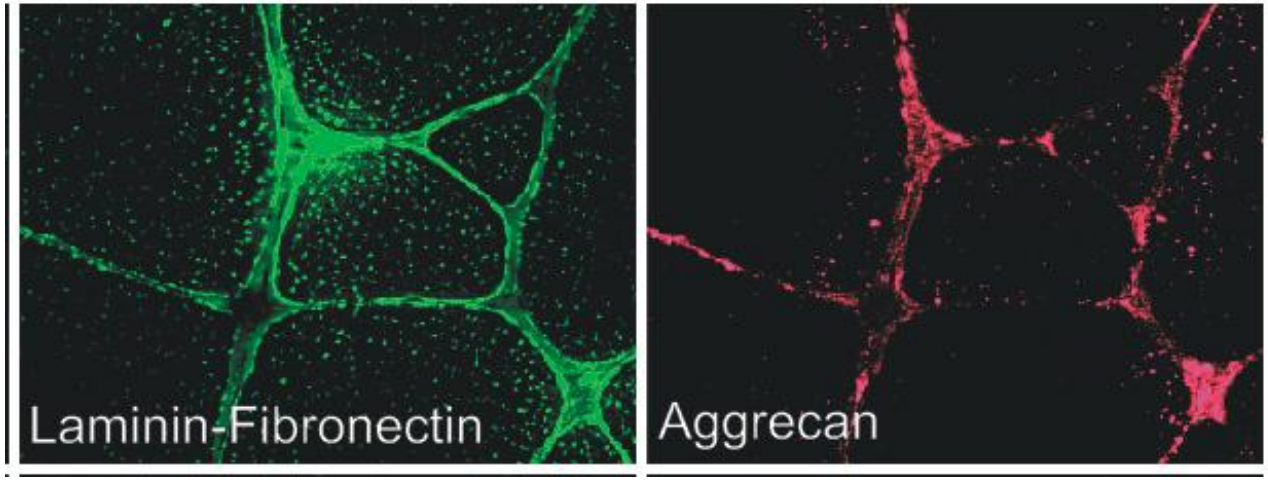
Mer stabilt bindevev



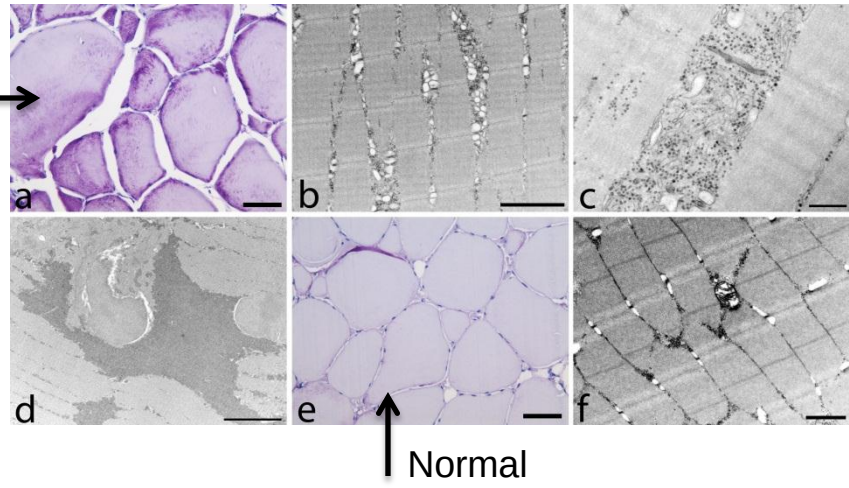
H.M. Moreno, M.P. Montero, M.C. Gómez-Guillén, F. Fernández-Martín, T. Mørkøre, J. Borderías
Collagen characteristics of farmed Atlantic salmon with firm and soft fillet texture
Food Chemistry, In press

Mikroskopi-bilder av laksemuskel

Fast



Torgersen, J. S., Koppang, E.O., Pedersen, M. E., Stien, L.H. and Mørkøre, T
Morphological characterisitation revealed abnormal glycogen deposition in soft muscle of Atlantic salmon (*Salmo salar* L).
Manuscript



Sukkerlaks/ bløt laks

Viktig årsak hos andre dyr:

- Udekket ernæringsmessig behov i spesifikke perioder?

- Genetikk ?

Opphopning av glykogen medfører

- Nedbrytning av muskelprotein
- Bløt (bleik?) muskel
- Takler ikke stress
- Hjerteproblemer (kan gi plutselig død hos voksne dyr)
- Diagnostiseres ved blodanalyser og histologi

Bløt laks hadde også forstørra mitokondrier

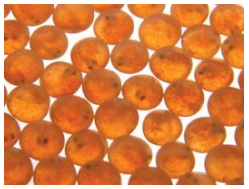
Vi vet ikke når problemet oppstår

Mulige årsaker

- Lavt nivå vitamin E i fôret (evt tidlig i livet)
- Proteinfattig fôr/ lite karnitin & taurin
- Metabolsk syndrom (problemer med omsetning av næringsstoffer)

Torgersen, J. S., Koppang, E.O., Pedersen, M. E., Stien, L.H. and Mørkøre, T
Morphological characterisitation revealed abnormal glycogen deposition in soft muscle of Atlantic salmon (*Salmo salar* L). *Manuscript*

Quality downgrading due to cartilage
– associated with production conditions and nutrition during eraly life stages

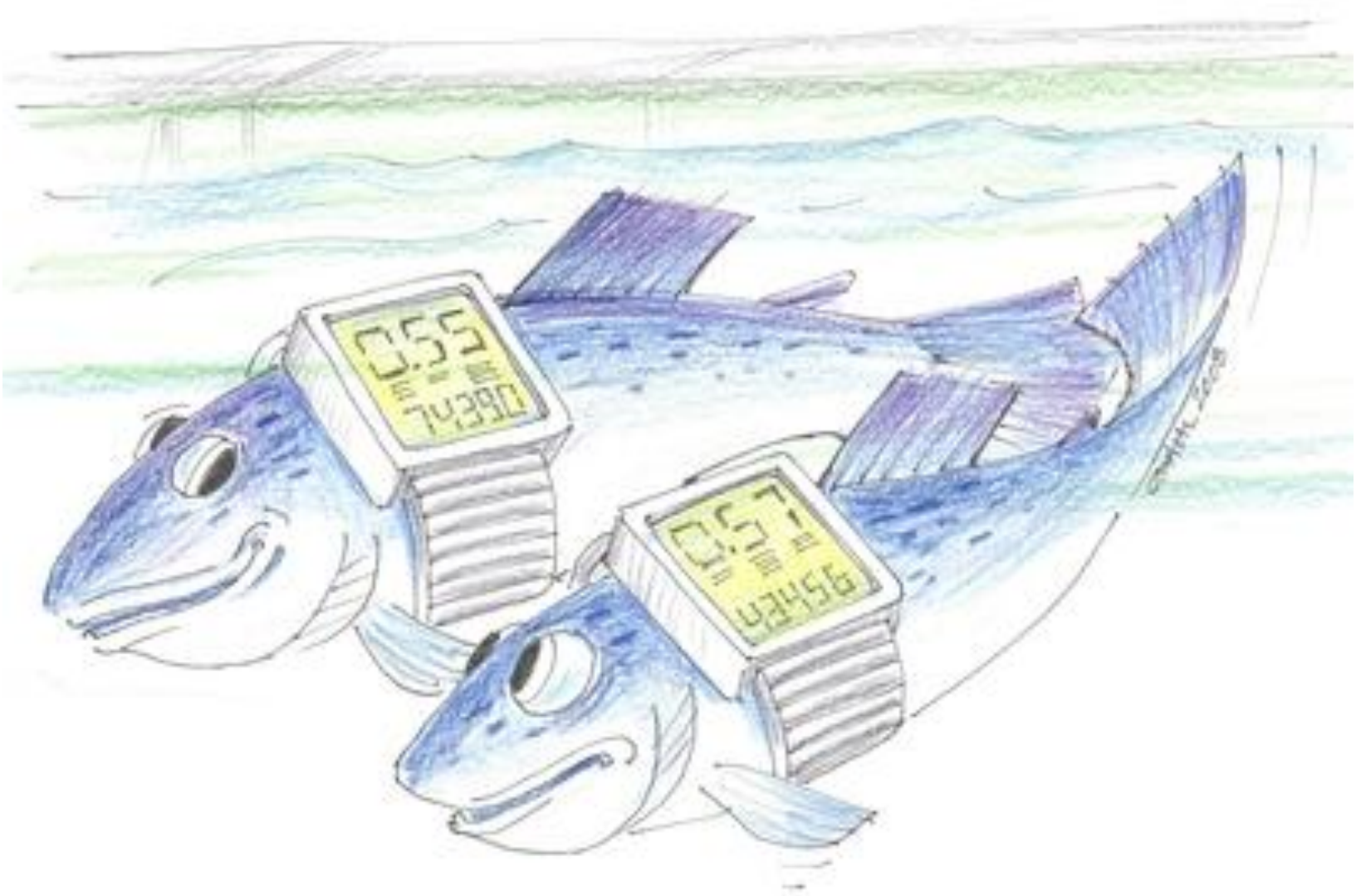


Vertebrae damages develop over time

Source: Bæverfjord, Lein & Helland

Nofima

Trening er sunt – også for laks



Nofima

”The pure and simple truth is rarely pure and never simple”

Oscar Fingal O'Flahertie Wills Wilde

men :

- Det ser ut til av vi har funnet en viktig årsak til bløt tekstur
- Er årsak(er) til bløt/bleik filet og hjerteproblemer i «familie» ?

Åsted identifisert, ikke underliggende årsak

- Hva er frekvensen av fenomenet ?

Hovedmistenkte

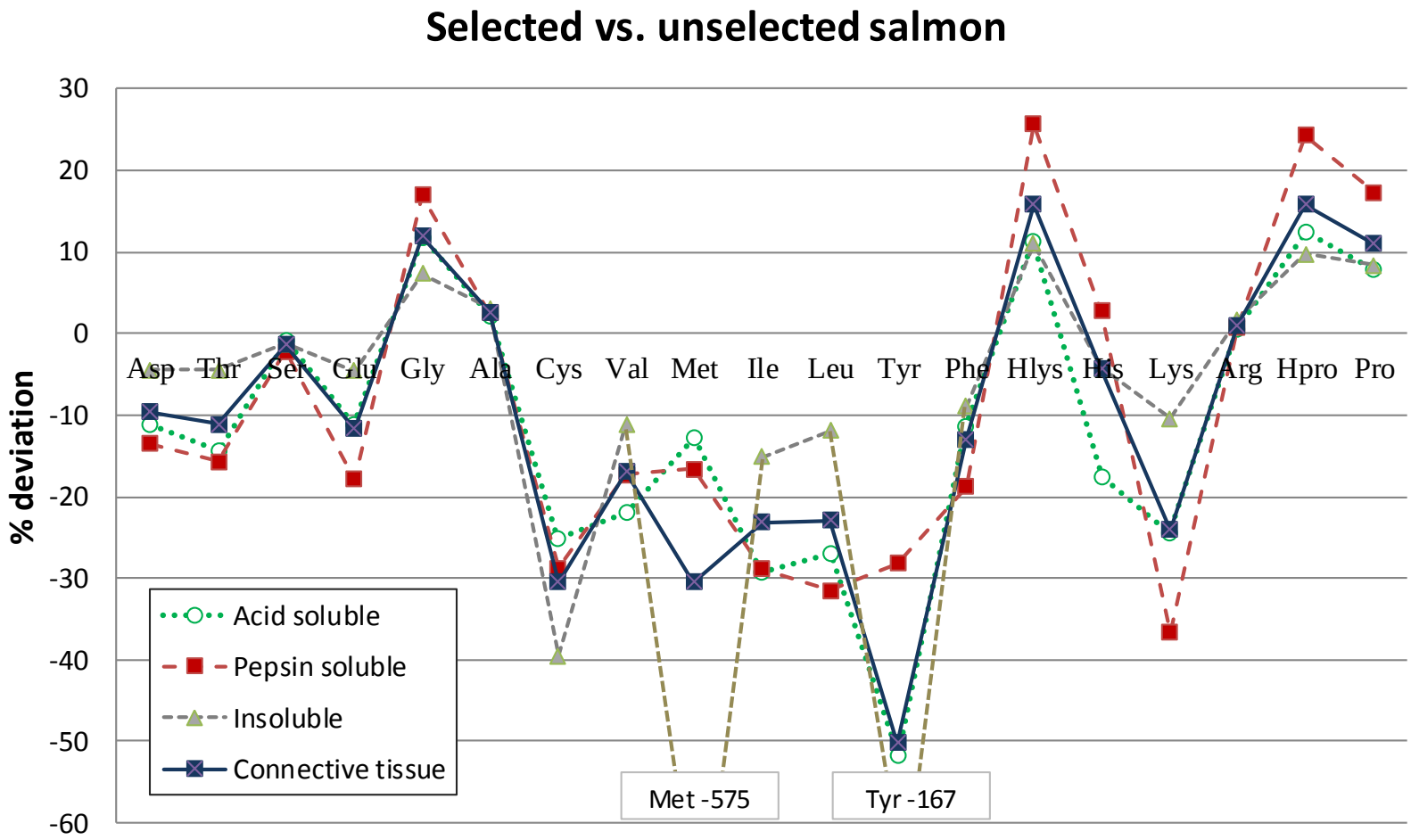
- Underdekning av visse fôringredienser / når i livet, tidlig ?
- Mulig å reparere med fôr evt. slaktefôr?
- «Genfeil»?

Store forskjeller i bindevevssammensetningen mellom vill og oppdrettslaks

	Acid soluble		*Pepsin soluble*		*Insoluble*		*Connective tissue*	
	Unselected	Selected	Unselected	Selected	Unselected	Selected	Unselected	Selected
Aspartic acid	65.5	58.8***	76.2	67.1***	70.3	67.3***	70.6	64.4***
Threonine	31.7	27.7***	38.2	33.0***	38.3	36.7**	36.1	32.5***
Serine	49.6	49.2^{ns}	52.4	51.3**	60.5	59.8^{ns}	54.1	53.4^{ns}
Glutamic acid	94.0	84.5***	108.7	92.2***	92.5	88.4***	98.8	88.5***
Glycine	265.9	301.2***	209.3	252.2***	248.7	268.4***	241.3	273.9***
Alanine	110.0	112.5**	98.0	100.6***	99.8	103.0**	102.6	105.4***
Cysteine	1.8	1.4**	3.1	2.4***	1.8	1.3**	2.2	1.7***
Valine	26.3	21.6***	35.4	30.2***	38.0	34.2***	33.5	28.6***
Methionine	20.6	18.2***	20.8	17.8***	7.1	1.1***	16.2	12.4***
Isoleucine	18.8	14.5***	24.0	18.6***	28.0	24.3***	23.6	19.2***
Leucine	36.5	28.7***	49.7	37.8***	45.4	40.6***	43.9	35.7***
Tyrosine	9.6	6.3***	14.4	11.2**	5.5	2.0**	9.8	6.5***
Phenylalanine	20.0	18.0***	21.6	18.2^{ns}	21.2	19.5***	20.9	18.5*
Hydroxylysine	7.5	8.4**	6.7	9.0***	9.0	10.1**	7.7	9.2***
Histidine	10.7	9.1***	16.0	16.5^{ns}	13.9	13.3**	13.5	13.0^{ns}
Lysine	40.4	32.4***	52.4	38.3***	40.1	36.3***	44.3	35.7***
Arginine	48.1	48.3^{ns}	46.6	45.0^{ns}	48.5	49.3**	47.7	48.2^{ns}
Hydroxyproline	55.4	63.3***	50.3	66.4***	49.9	55.2**	51.9	61.6***
Proline	88.3	95.8***	75.0	90.7**	81.7	89.2***	81.5	91.6***
Hydrophobic AA	351.7	336.6	362.7	346.4**	359.5	348.5***	358.0	343.8**

Moreno, H.M, Montero, M.P., Gómez-Guillén, M.C, Turid Mørkøre, Celeste Jacq, Borderías, J.
EFFECT OF SELECTIVE BREEDING ON COLLAGEN PROPERTIES OF ATLANTIC SALMON AND THE IMPACT ON MUSCLE TEXTURE
Manuscript

Store forskjeller i bindevevssammensetningen mellom vill og oppdrettslaks



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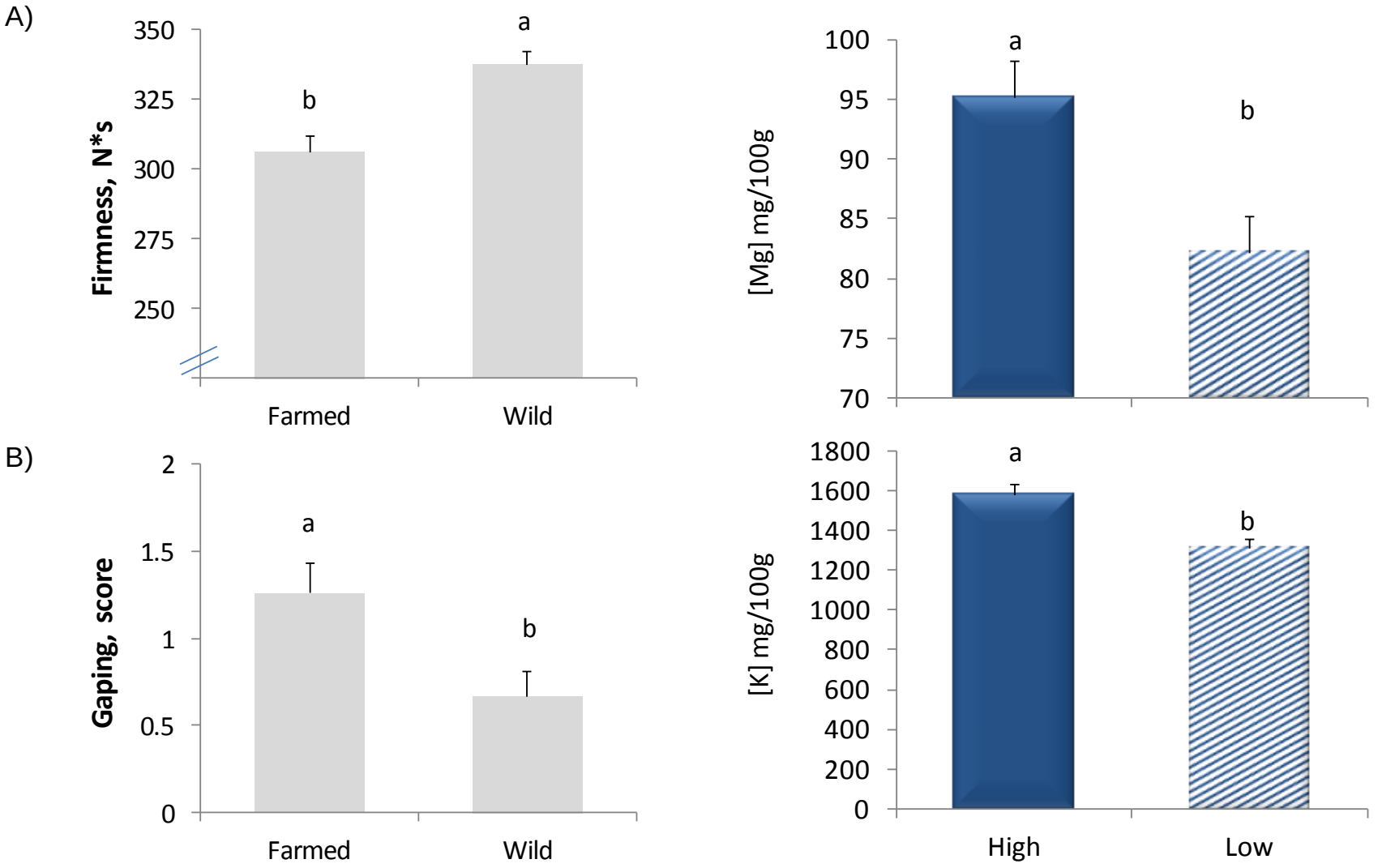
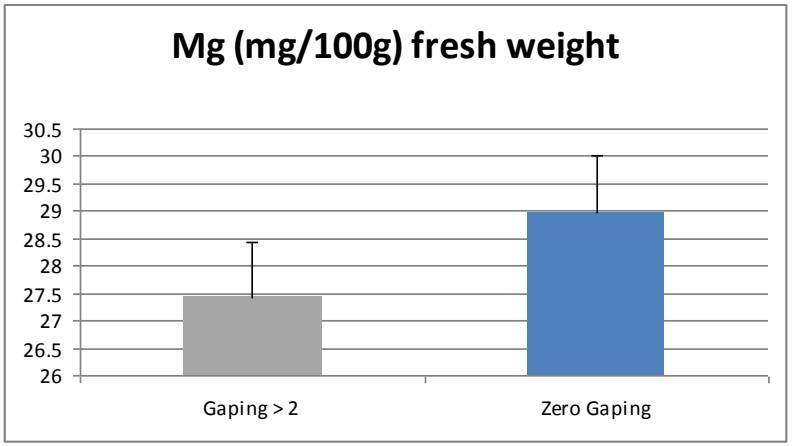
EFFECT OF SELECTIVE BREEDING ON COLLAGEN PROPERTIES OF ATLANTIC SALMON AND THE IMPACT ON MUSCLE TEXTURE
Manuscript

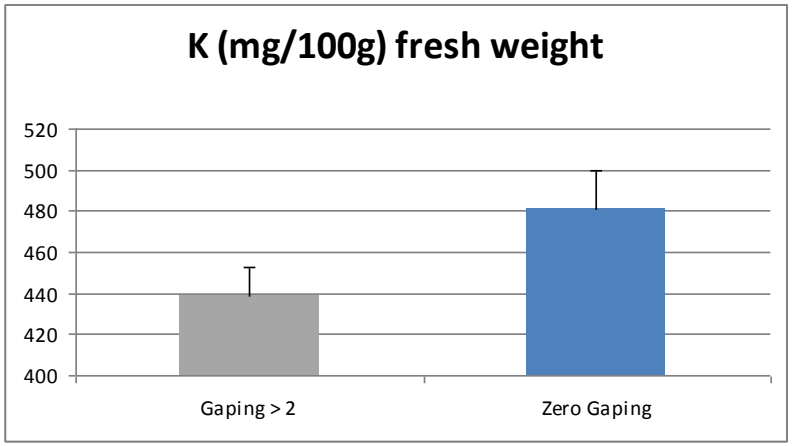
Villaks vs oppdrettslaks



Celeste Jacq, Bjarne Gjerde, Ingun Thorland, Håvard Bakke, Turid Mørkøre
The impact of selection on fillet quality traits and sexual maturation of Atlantic salmon (Salmo salar L.)
Manuscript

Lavere mineralstatus i laks med gaping
Lavt innhold av vitamin E





Celeste Jacq, Bjarne Gjerde, Ingun Thorland, Håvard Bakke, Turid Mørkøre
The impact of selection on fillet quality traits and sexual maturation of Atlantic salmon (Salmo salar L.)
Manuscript

1. Fliser. Fugemasse
2. Flislim.
3. Membran.
4. Påstøp. Støpemørtel
Varmekabler primer.
5. Betong, mur, puss, gips, våtromsplater
6. Ventilering

Nofima

Verktøy på boks

WD40 - For tusen formål på jobben og hjemme

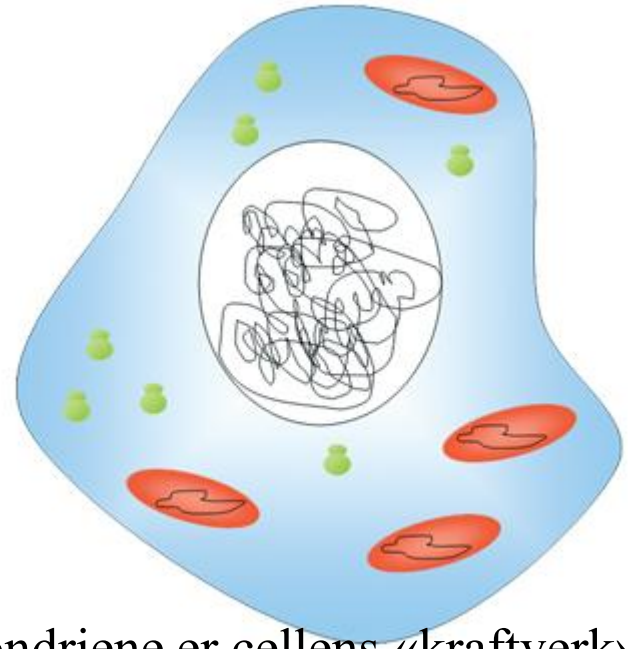
- smører
- driver ut fuktighet
- renser og beskytter
- løsner fastrustede deler
- løsner fastlåste mekanismer

Innehold 400ml

Nofima

Glutamate

Glutamate derived from hydrolyzation of glutamine is a very important aerobic substrate



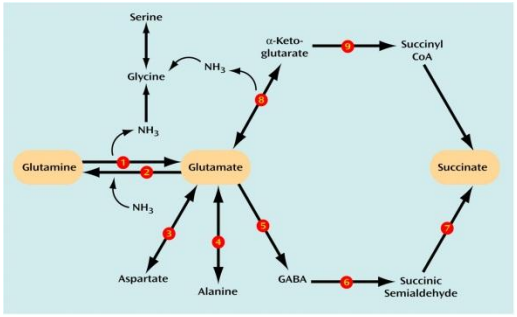
Mitokondriene er cellens «kraftverk» og produserer de energirike forbindelser som cellen trenger til sin virksomhet

http://www.oroboros.at/fileadmin/user_upload/Protocols/MiPNet11.04_MitoPathways-CI.pdf

Nofima

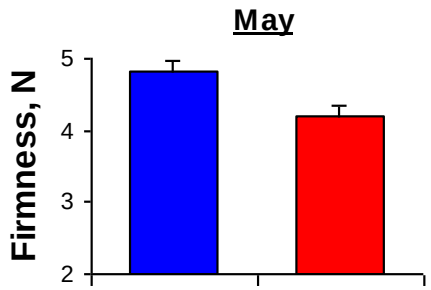
Glutamat

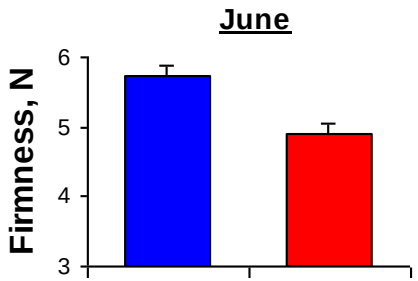
Alle proteiner består av aminosyrer
Aminosyrene glutamat, aspartat, alanin og glutamin finnes i høye konsentrasjoner. Disse er viktige for stoffskiftet –
Spesielt **glutamat**

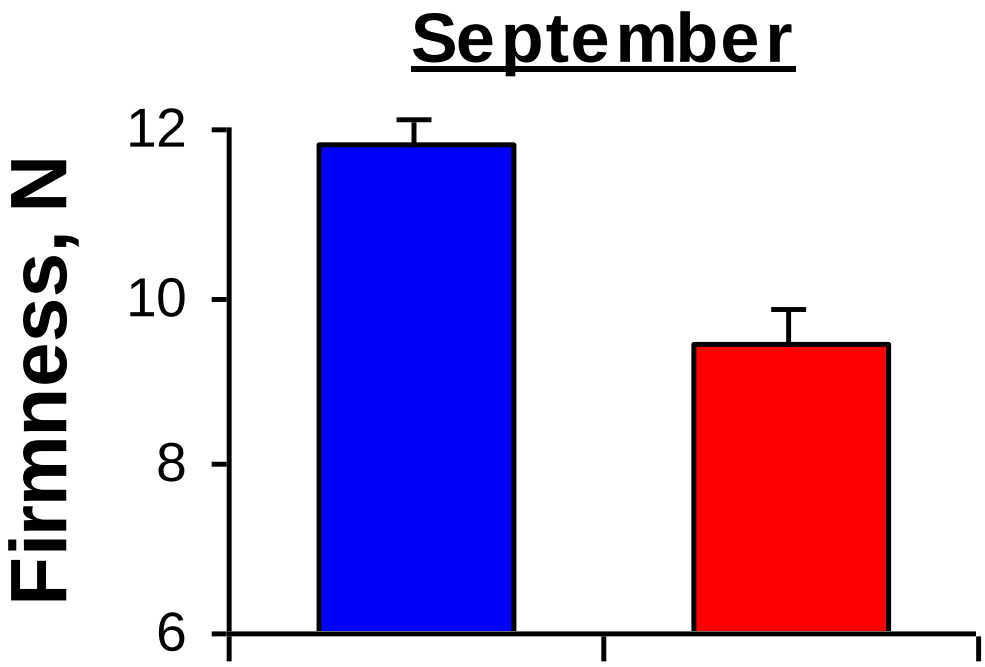


Energiomsetning
Dannelse av bindevev
Nerveoverføring
Antioksidant
Tarmhelse
Syre-base balansen
Kan omdannes til andre viktige aminosyrer
Hjelper ved stress +++++++

Fôr tilsatt glutamat+arginin ⇒ fastere filet enn standardfôr







Mulig å oppnå fastere filet via fôret

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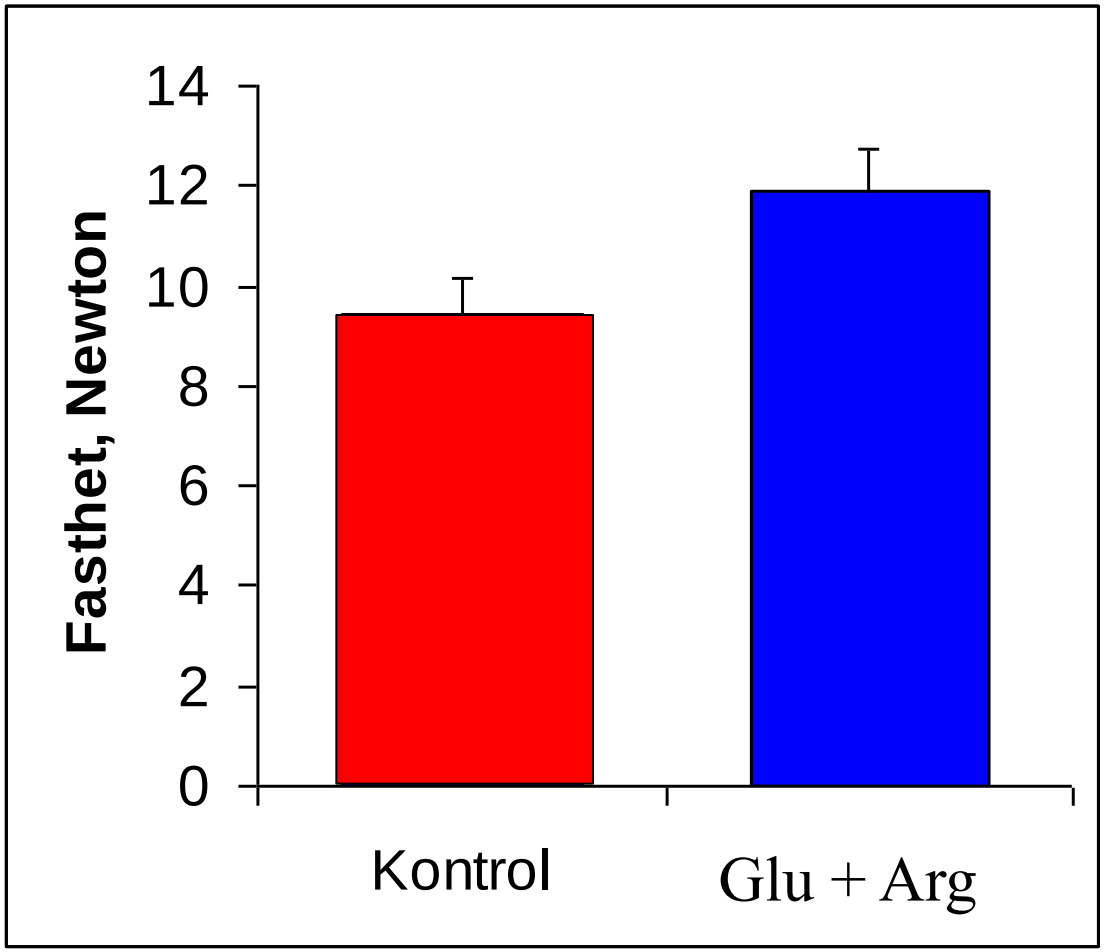
Etter 20 timers stress

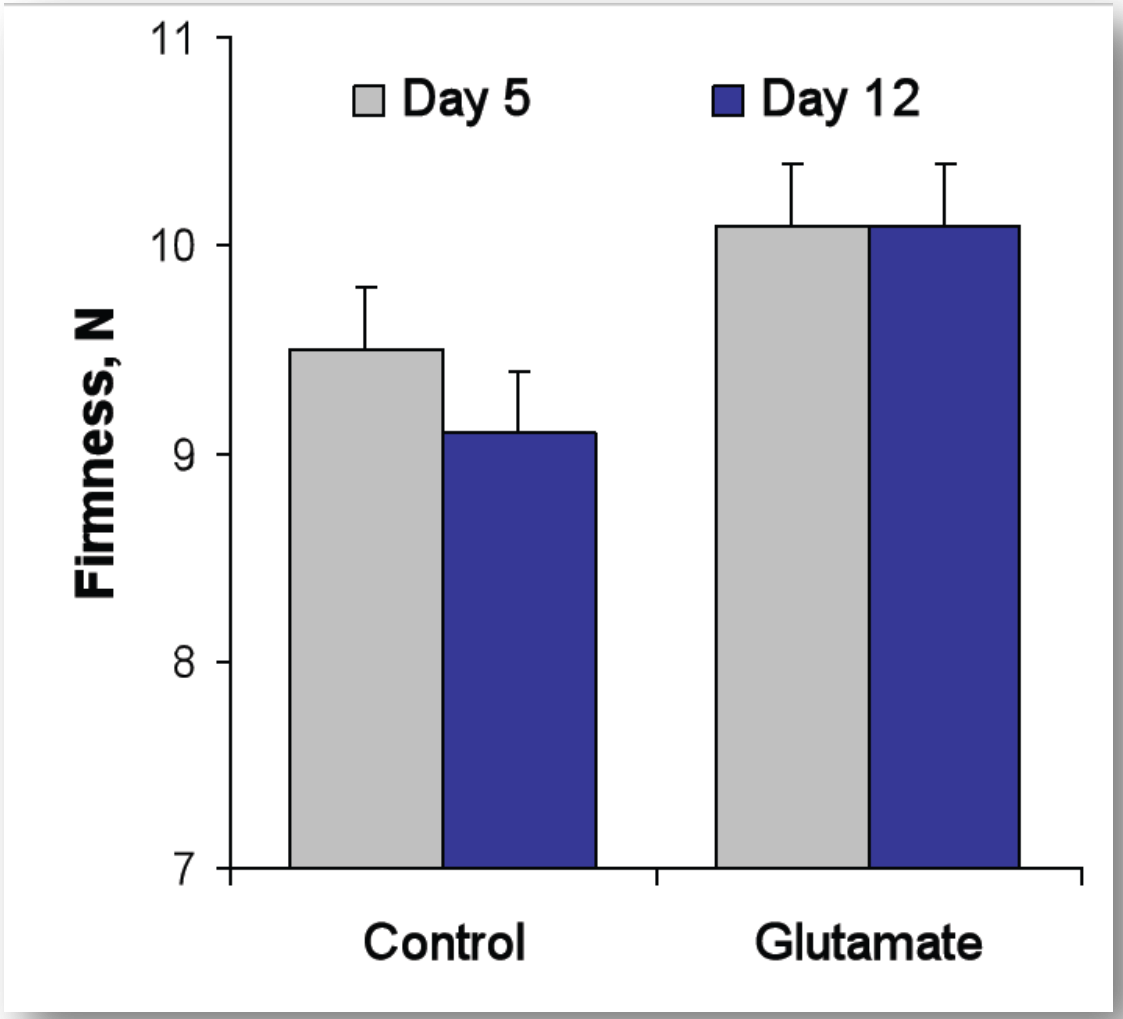


Konklusjon

- Teksturen i laksefilet påvirkes av mange faktorer der fôret synes å spille en viktigere rolle enn tidligere antatt
- Det er mulig å forbedre teksturen ved å justere aminosyreprofilen i fôret
- Aminosyrene glutamat og arginin ga helsemessige gevinster, og disse var sammenfallende med fastere tekstur
- Gevinst ved tilskudd av aminosyrer kan variere gjennom året
- Optimalt nivå, varighet og alternative fôrkilder bør vurderes

Nofima

Firmer salmon fillets



Addition of glutamate and arginine separately improved the

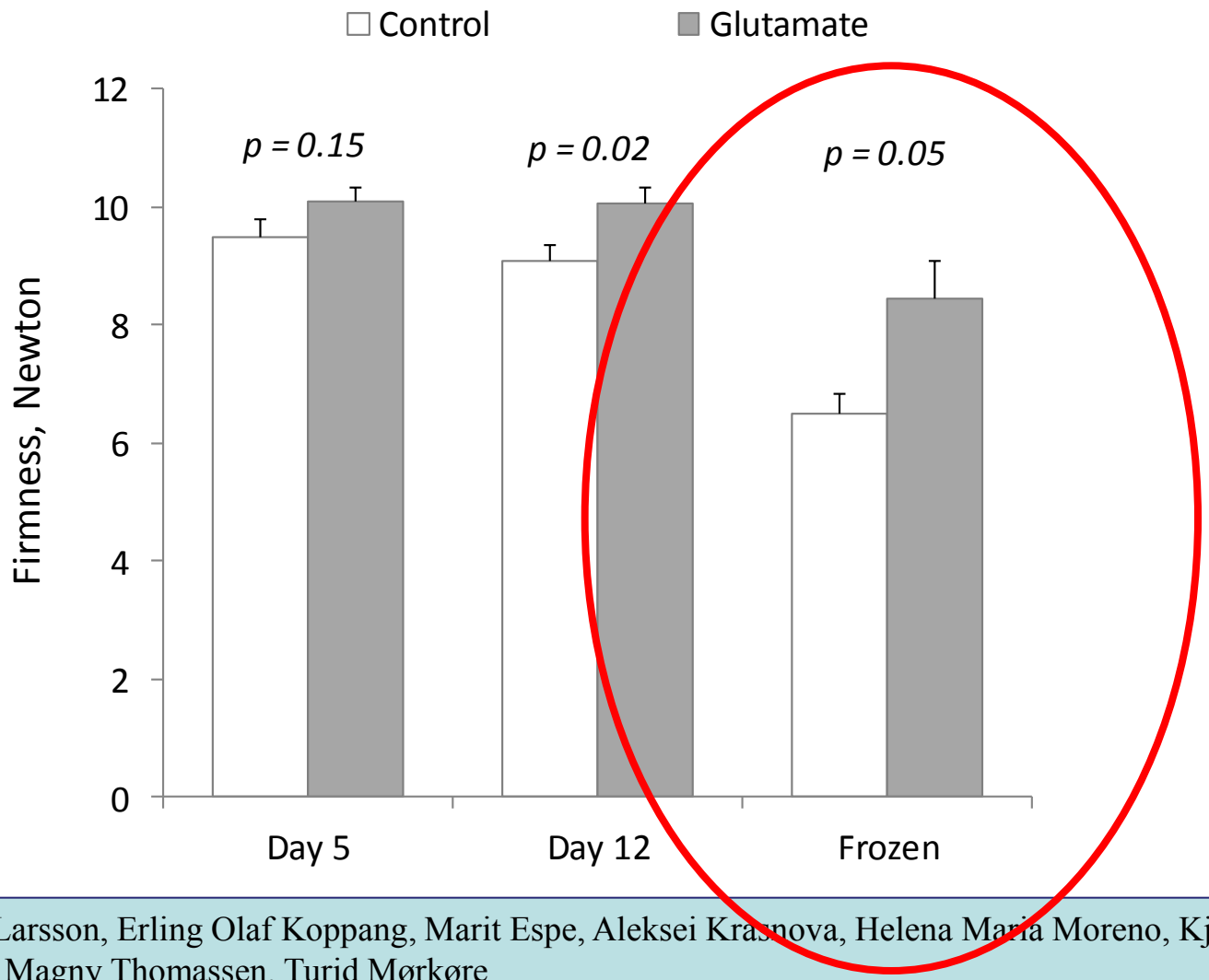
- Fillet firmness
- Health of the fish
- Robustness to stress

In particular

glutamate

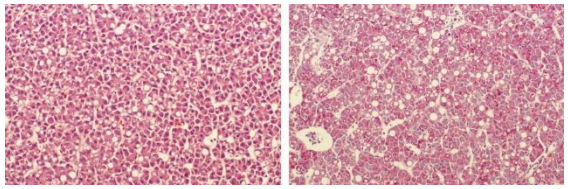
Fruitful interdisciplinary research

FHF · The Research Council of Norway · Norges veterinærhøgskole · CSIC · Havforskningsinstituttet Institute of Marine Research · SINTEF · SLU · Nofima

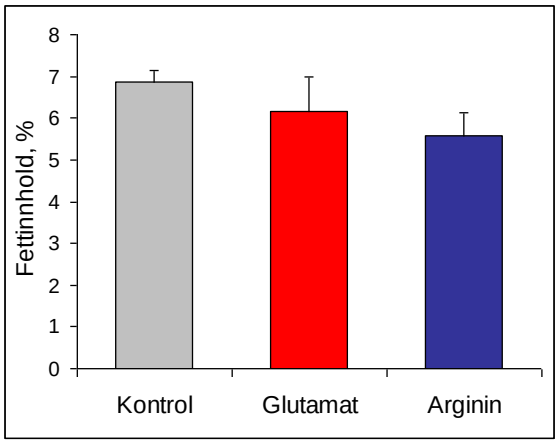


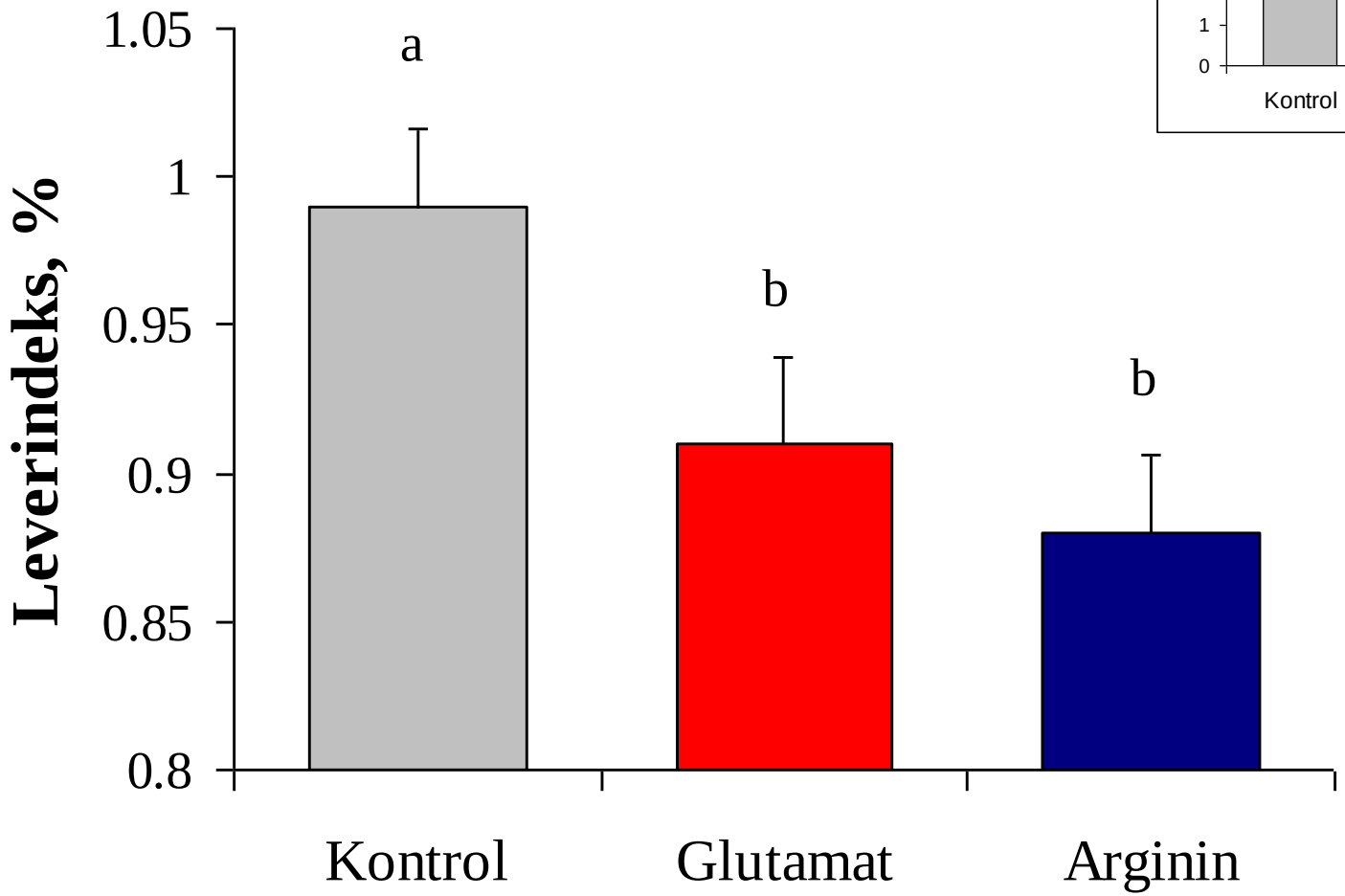
Thomas Larsson, Erling Olaf Koppang, Marit Espe, Aleksei Krasnova, Helena Maria Moreno, Kjell-Arne Rørvika, Bendik F. Terjesen, Magny Thomassen, Turid Mørkøre
Dietary glutamate level affects fillet texture and health parameters of Atlantic salmon (Salmo salar L). *Manuscript*

Lever



Avvik fra normalstruktur: Vakuolisering i lever





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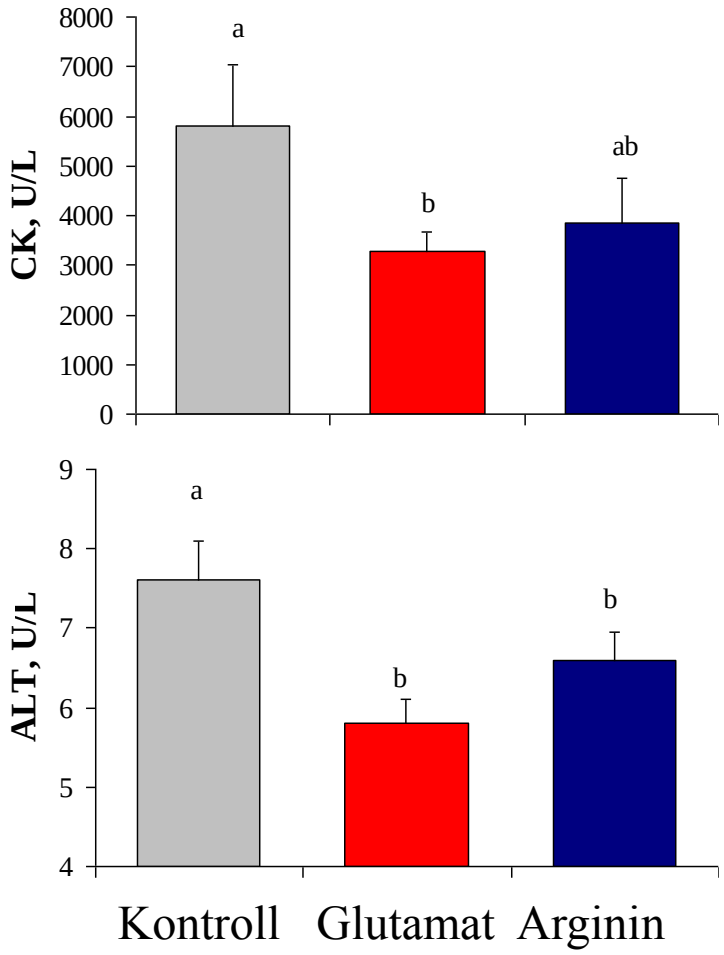
Dietary glutamate level affects fillet texture and health parameters of Atlantic salmon (Salmo salar L). *Manuscript*

Plasmaanalyser



CK, *kreatinkinase*

- enzym som finnes i muskelvev og som spalter kreatinfosfat
- **stiger ved muskelskade**

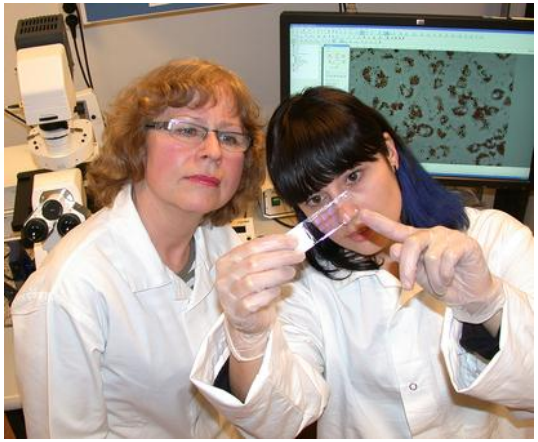
ALAT, *alaninaminotransferase*

- enzym som er virksomt i aminosyrestoffskiftet
- **stiger ved skade av levervev**

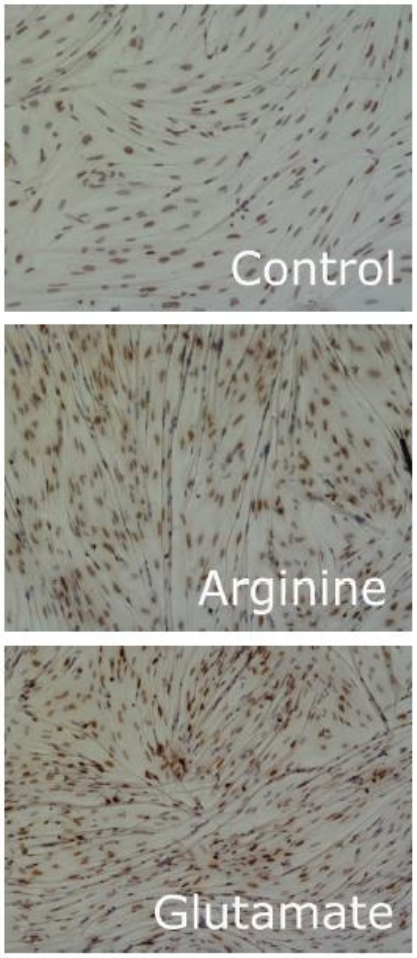
Thomas Larsson, Erling Olaf Koppang, Marit Espe, Aleksei Krasnova, Helena Maria Moreno, Kjell-Arne Rørvika, Bendik F. Terjesen, Magny Thomassen, Turid Mørkøre
Dietary glutamate level affects fillet texture and health parameters of Atlantic salmon (Salmo salar L). *Manuscript*

«Hva»

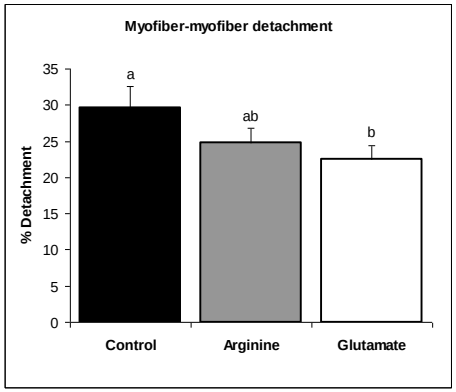
«Hvorfor»

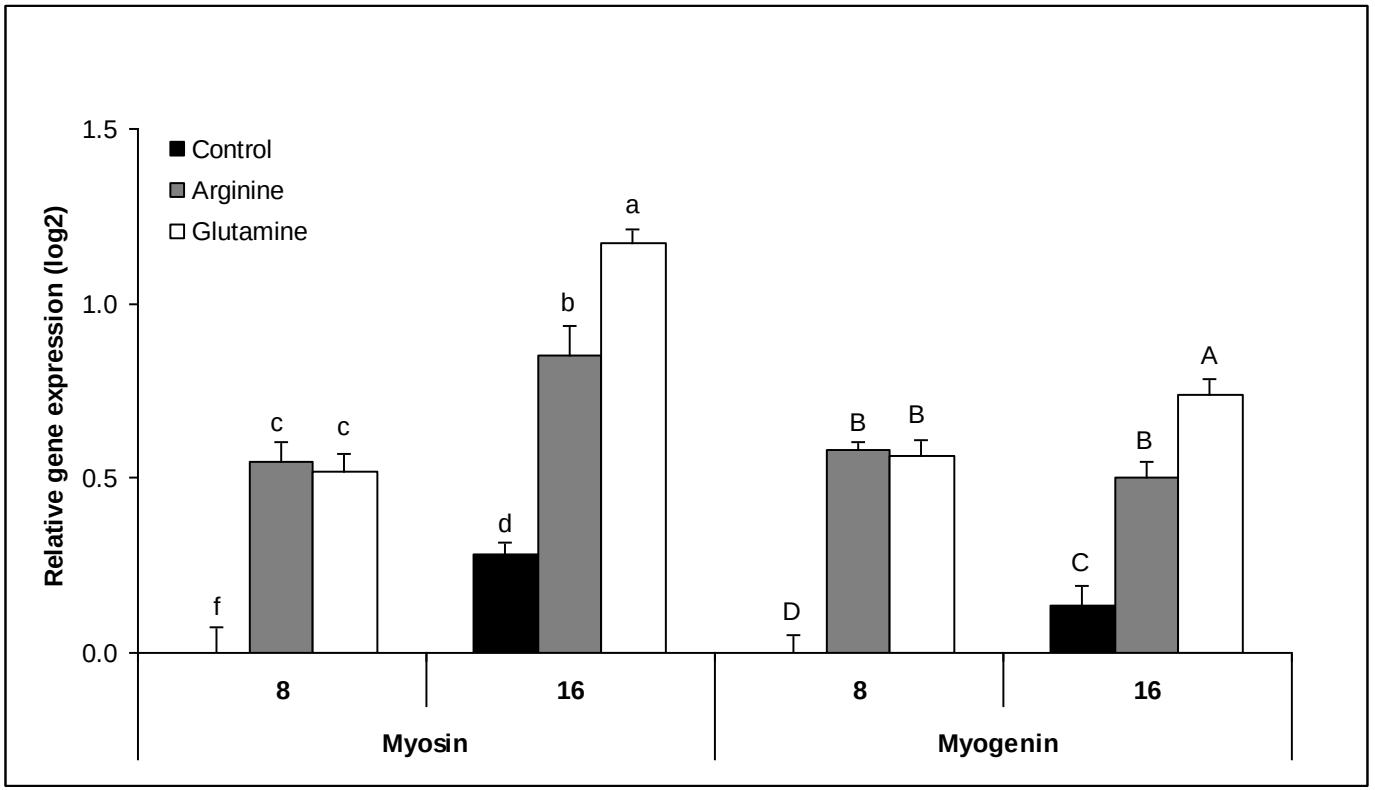


Underlying causes



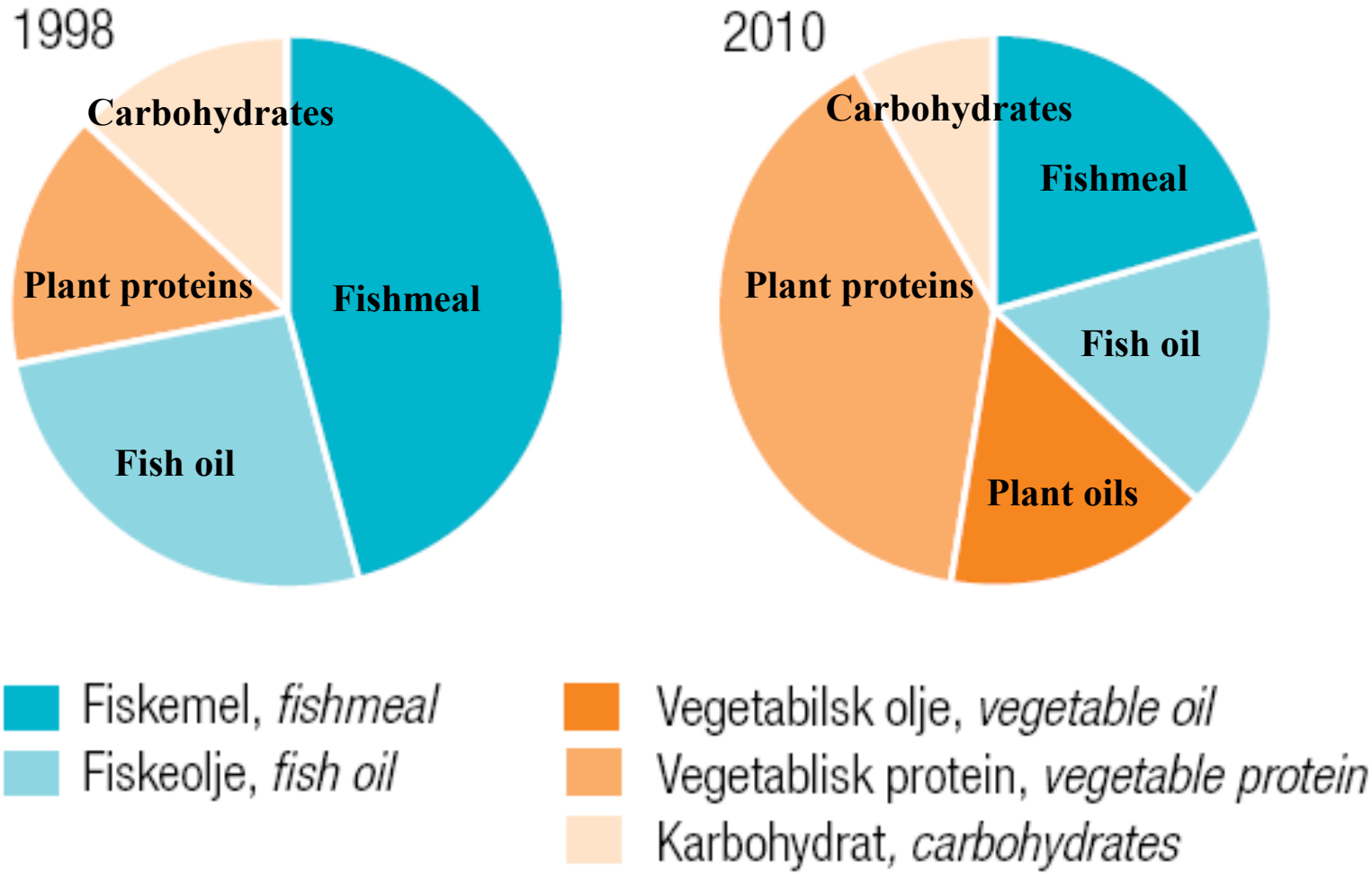
Muscle precursor cell morphology and proliferating versus non-proliferating cells nuclei





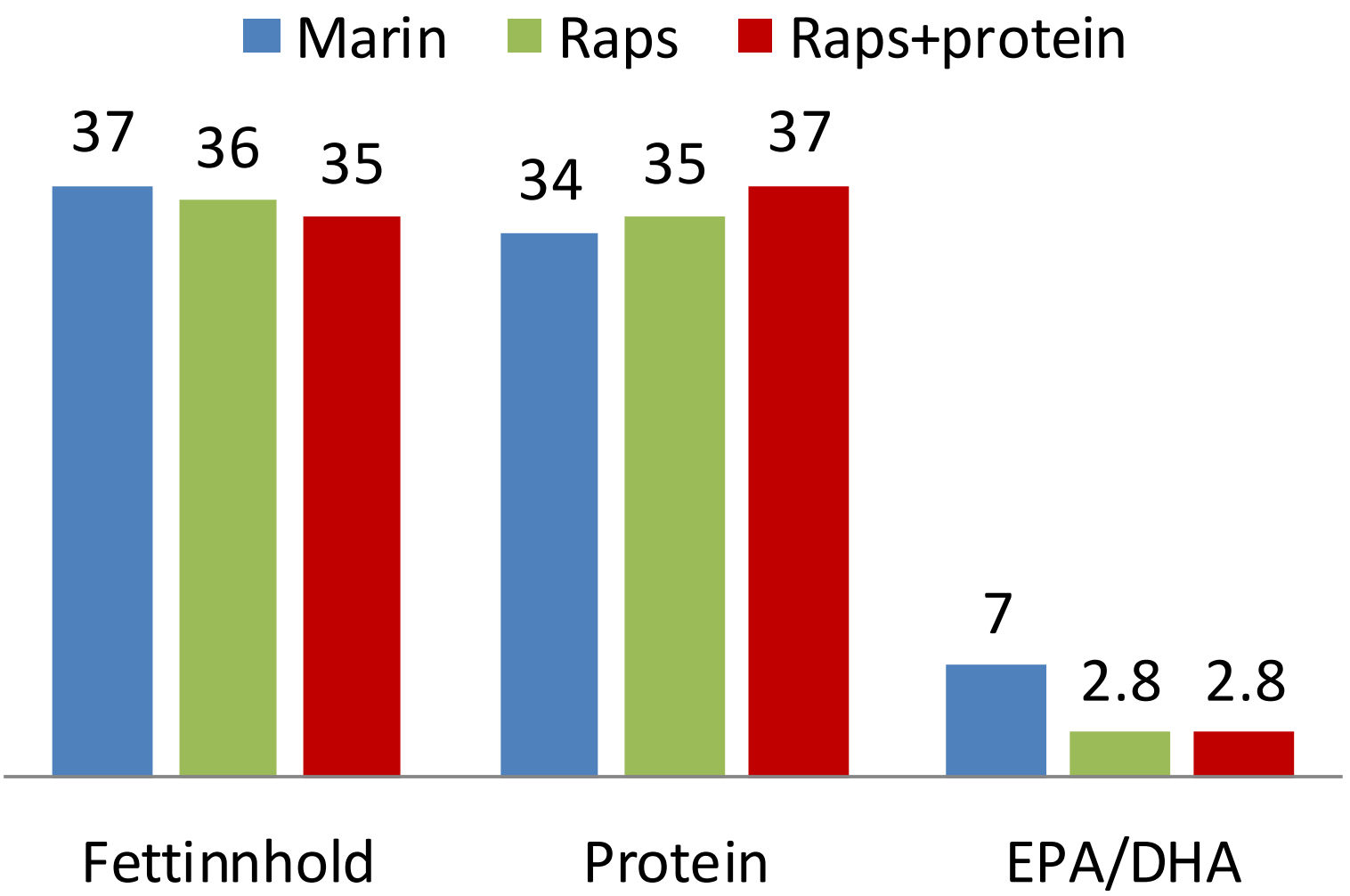
Tone-Kari Østbye, Bente Ruyter, Muhammad Saqib Latif, Bendik Fyhn Terjesen, Kjell-Arne Rørvik, Diane Bahuaud, Lars Helge Stien, Turid Mørkøre. Terjesen, Magny Thomassen, Turid Mørkøre
Influence of supplemented amino acids on muscle development and texture of farmed Atlantic salmon (Salmo salar L.); in

Raw material use

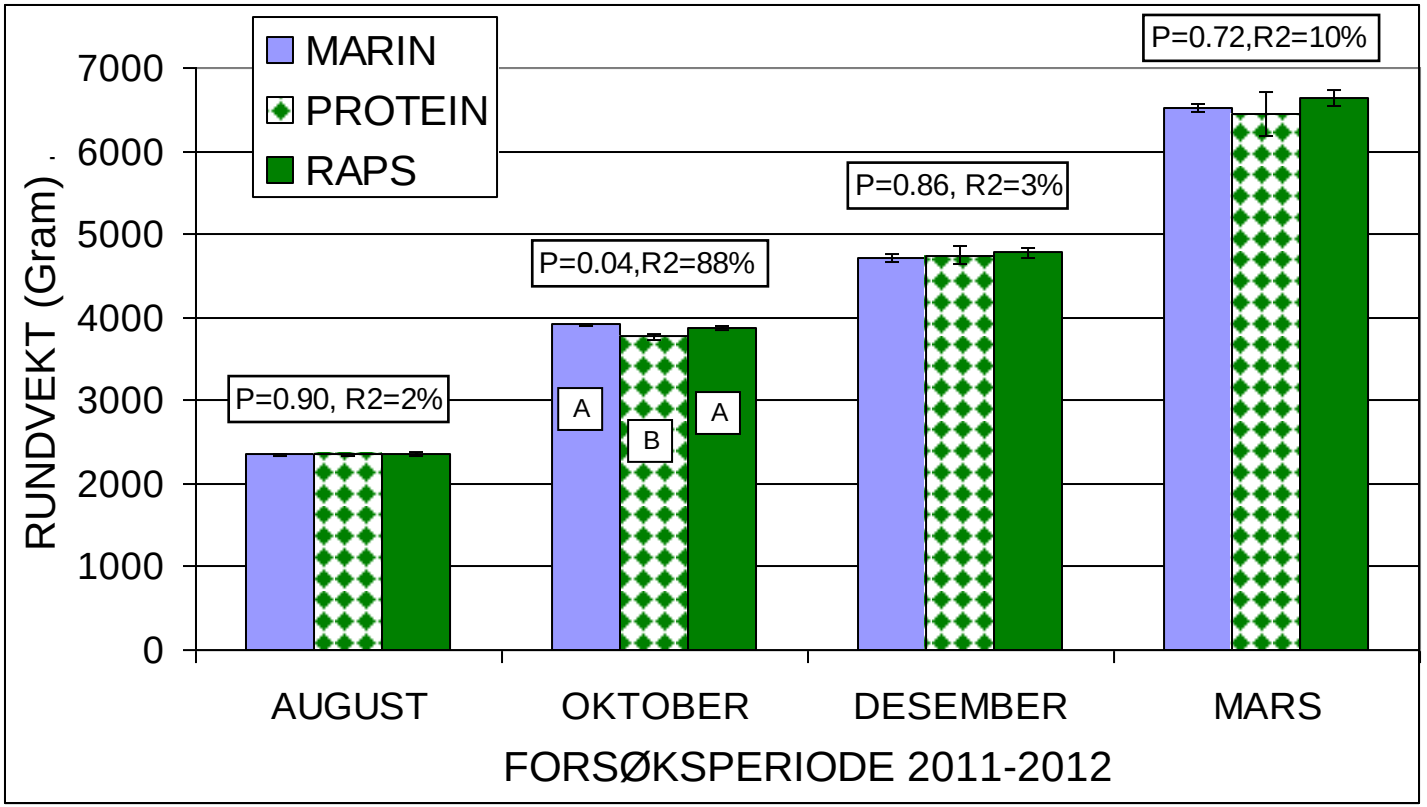


Fôrsammensetning (9mm)

«Rousselot® FG is an edible fish gelatin made of all essential amino-acids except tryptophan. It is particularly rich in glycine, glutamic acid, proline, alanine and arginine. Rousselot® FG»

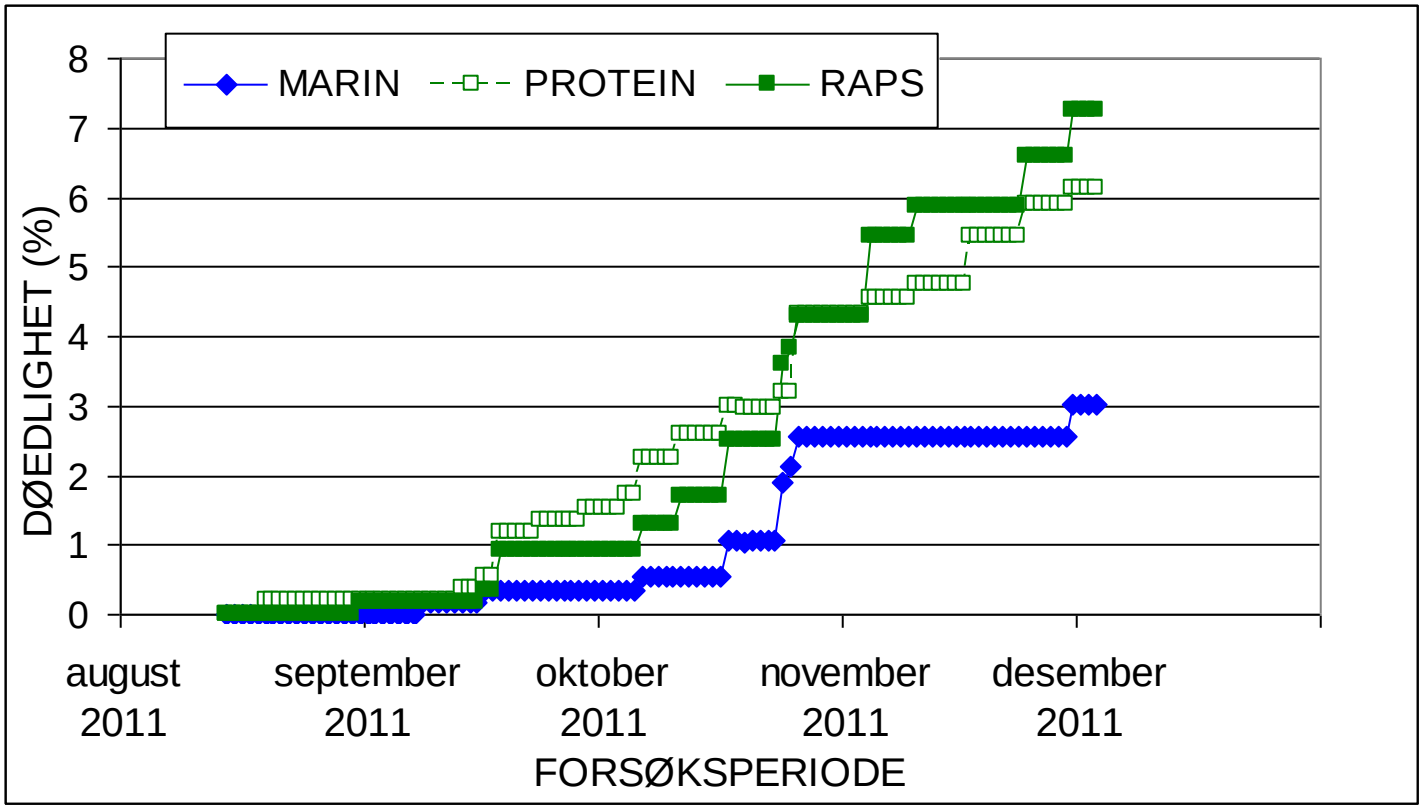


LITEN EFFEKT AV FORSØKSFÔRENE PÅ KROPPSVEKT GJENNOM FORSØKSPERIODEN



UTVIKLING I USPESIFIKK DØDELIGHET HØSTEN 2011

Test for uavhengig dødelighet mellom fôrgrupper gir P=0.005



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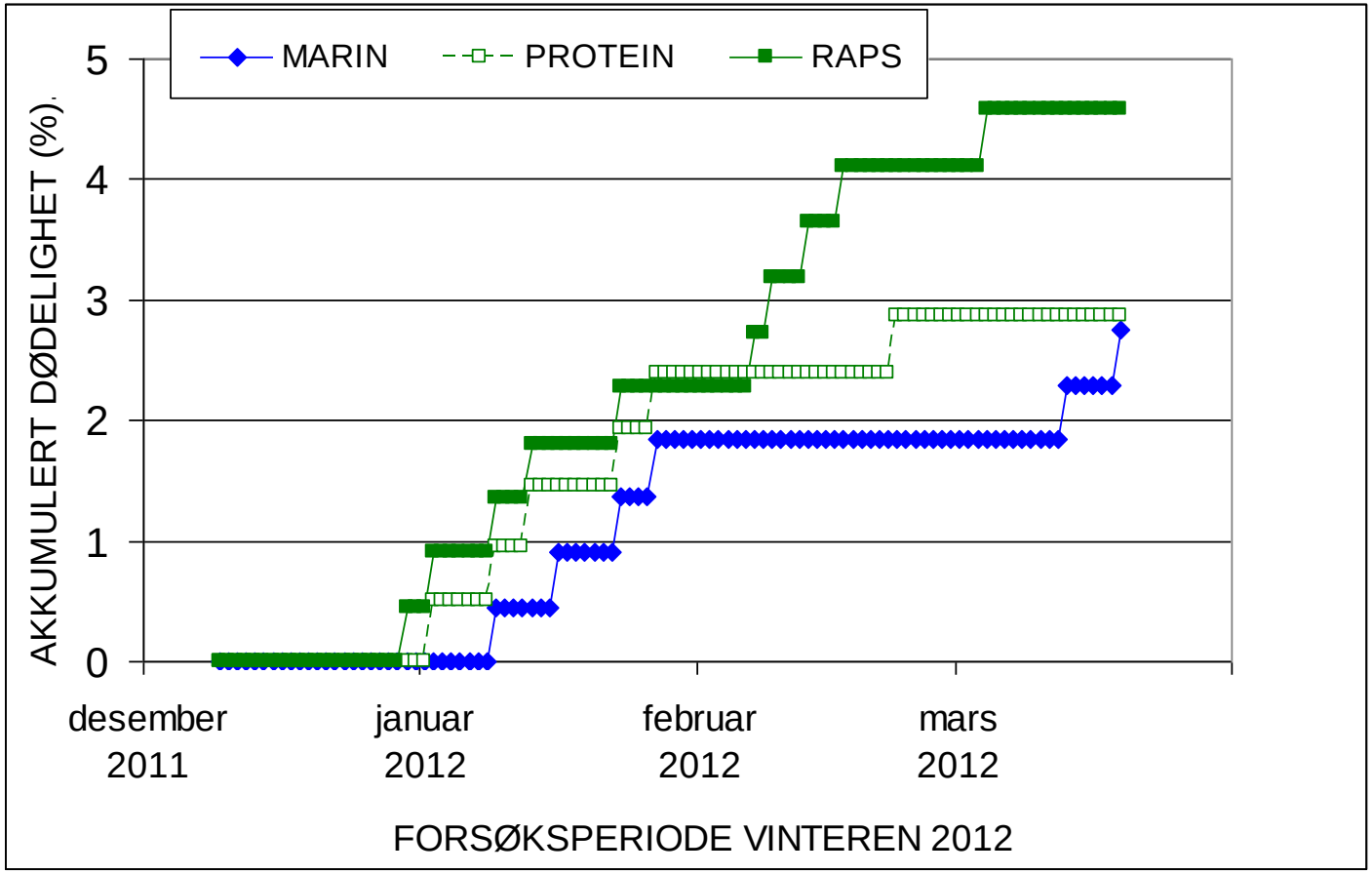
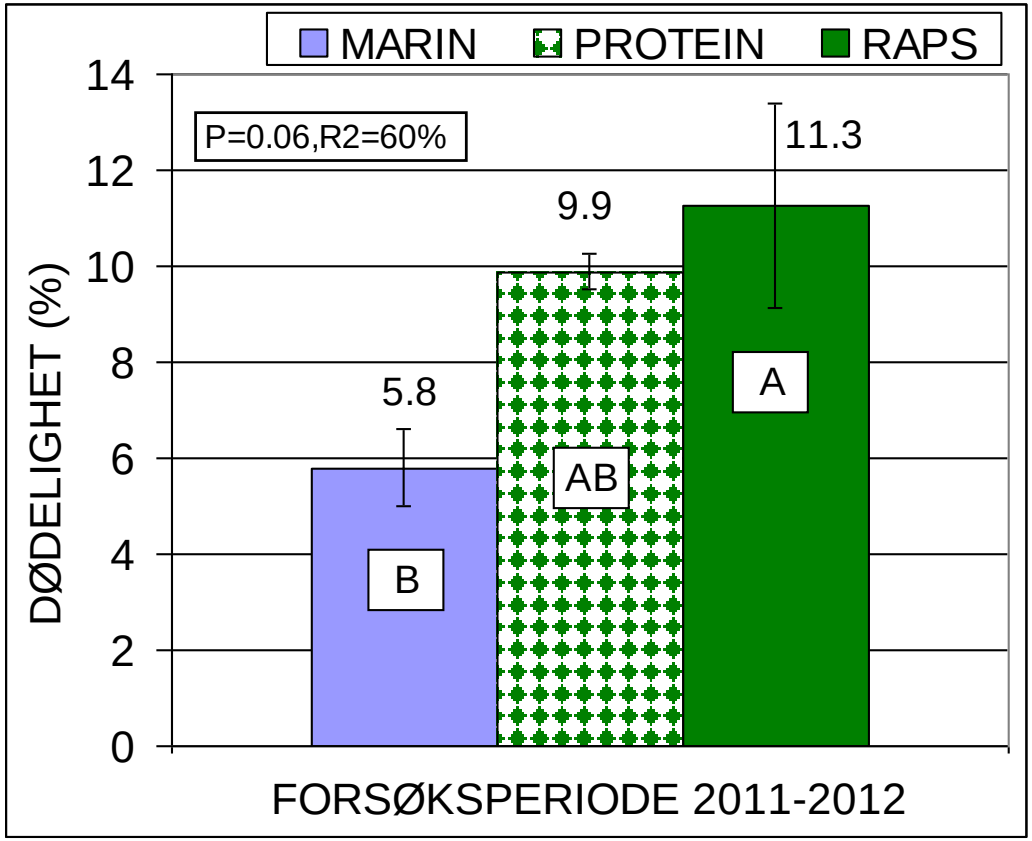
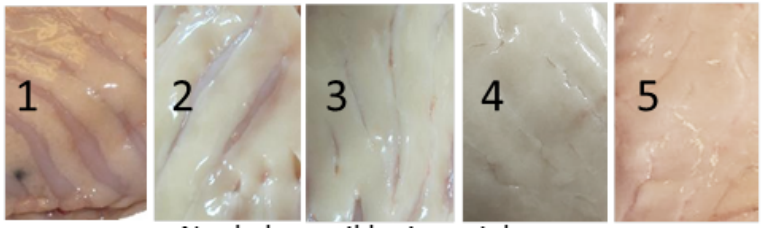
UTVIKLING I USPESIFIKK DØDELIGHET VINTEREN 2011



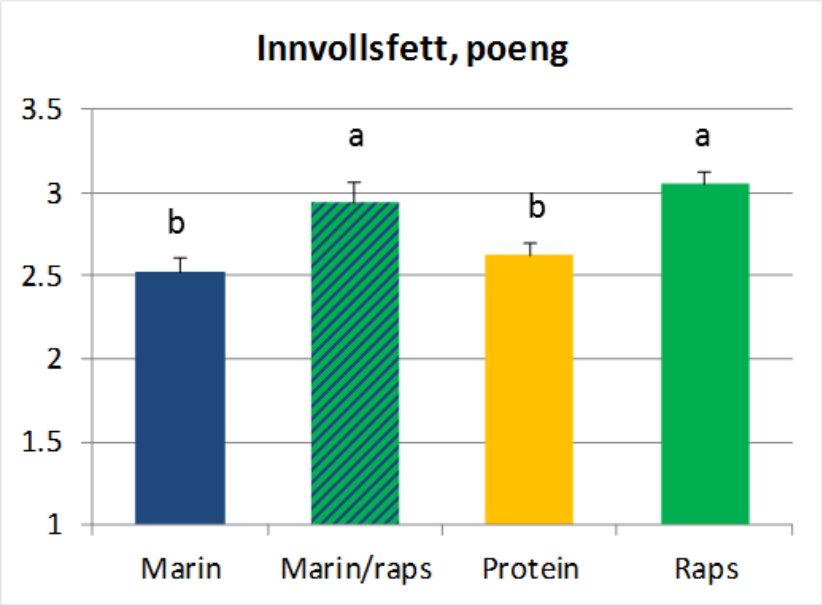
AKKUMULERT USPESIFIKK DØDELIGHET GJENNOM HELE FORSØKSPERIODEN

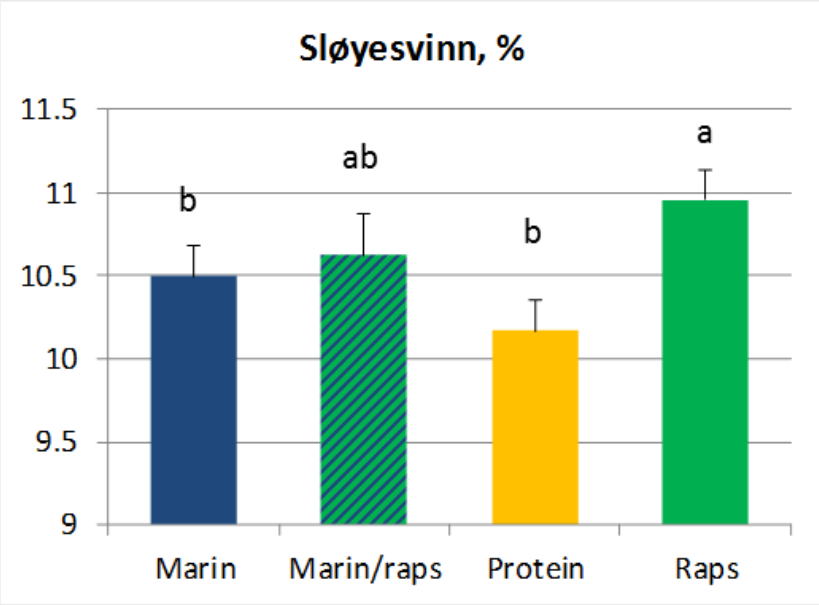


Innvollsfett og sløyesvinn



Ny skala, utviklet i prosjektet
Blindsekker synlige 1: Godt synlige; 2: synlige, 3: sprekker, 4: synlige gjennom fettet, 5: ikke synlige gjennom fettet.
Fungerte bra !

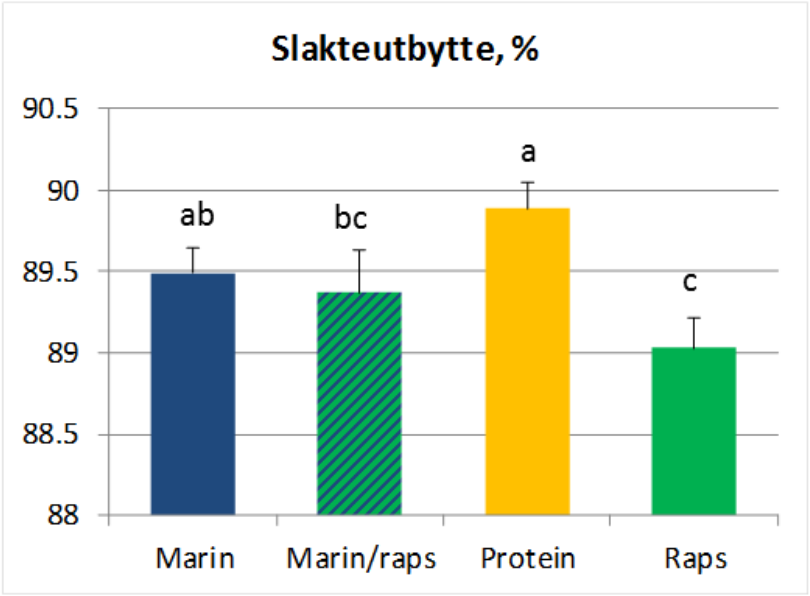


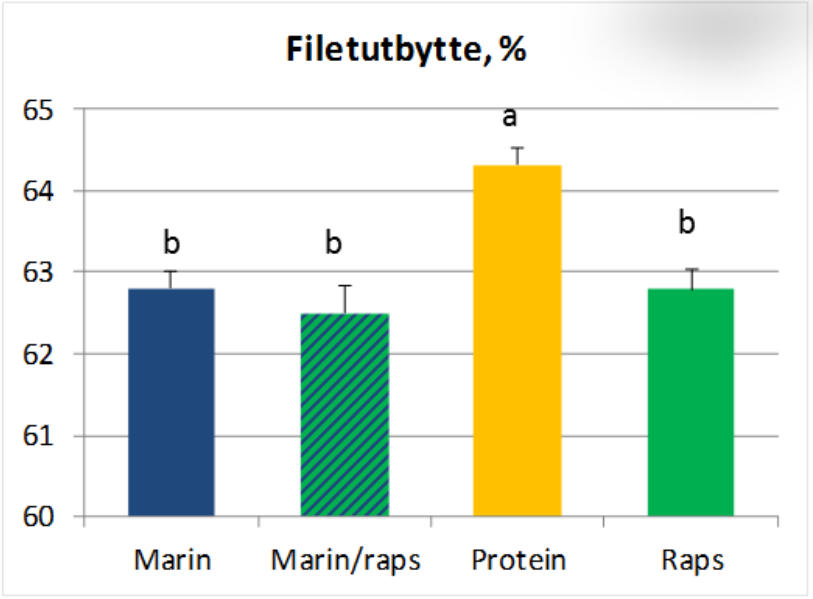


Laksen som fikk rapsfôret hadde mest innvollsfett og høyest sløyesvinn

Utbytte

Fin fisk – Omtrent samme vekta for alle fôra - 0ver 6 kilo i gjennomsnitt og noen over 10 kg

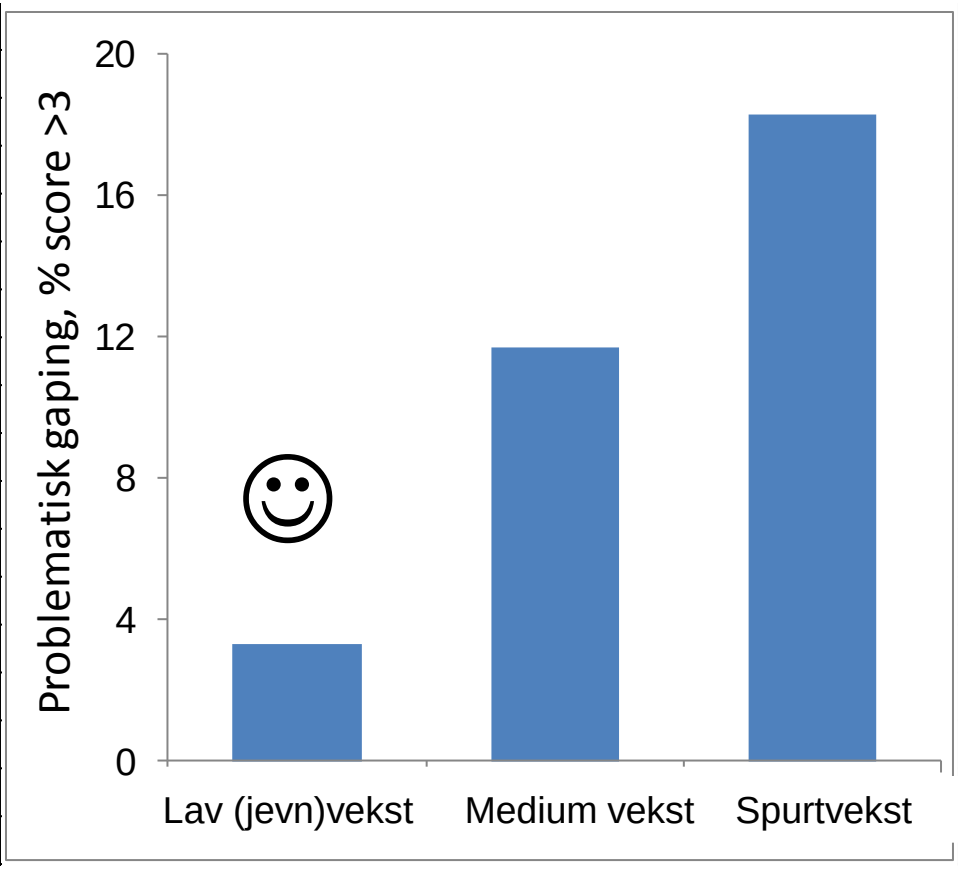




Proteinfôret ga høyest slakteutbytte og høyest filetutbytte. Rapsfôret lavest

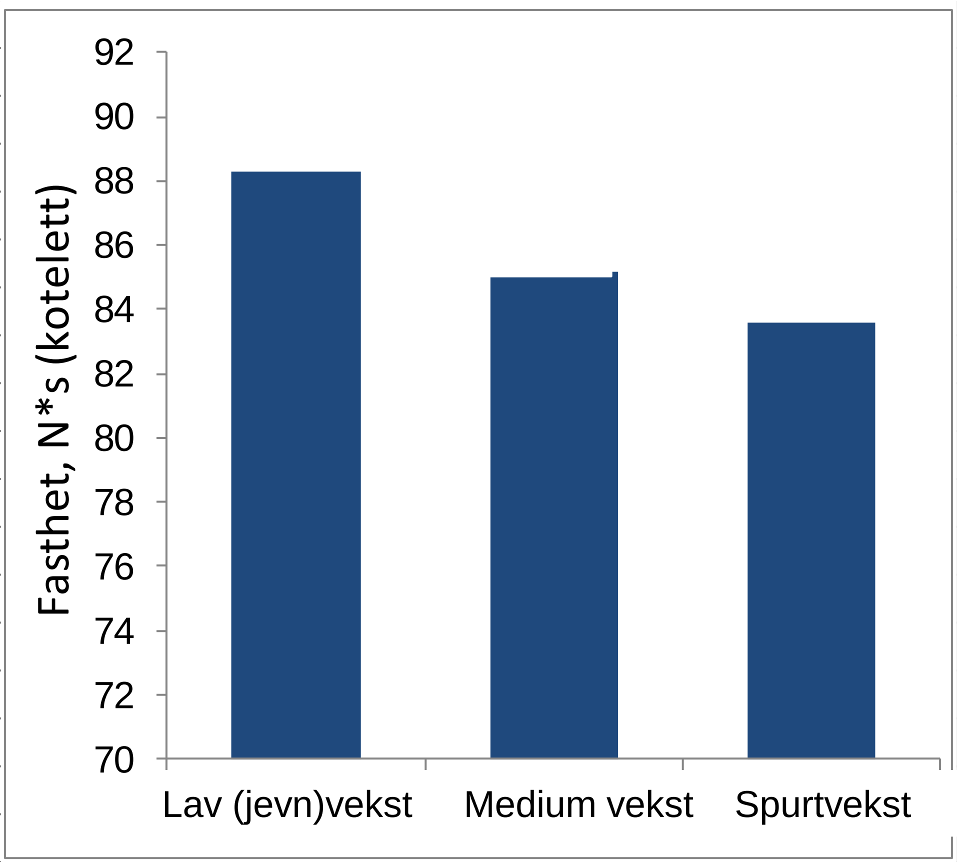
Resultater oktober

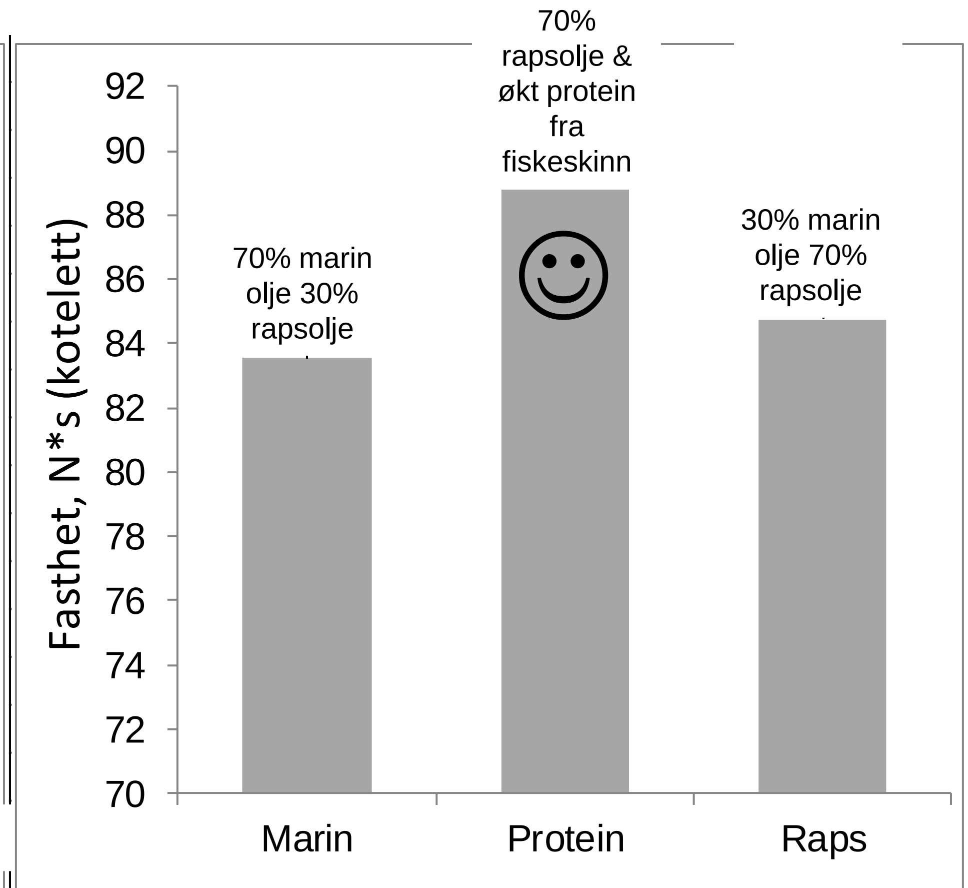
Filetspalting, vist som andel laks med problematisk gaping (% fisk). Resultatene viser at spurtveksten kombinert med høy (ektrem..) fettdeponering til laks med spurtvekst førte til betydelig gaping - nærmere 20% av fisken mens mindre enn 5% av laksen med jevn vekst hadde gaping. En liten og mest sannsynlig ubetydelig positiv effekt av ekstra tilsetning av protein i fôret



Resultater oktober

Fasthet i rå kotelett viste samme mønster som problematisk filetspalting, men her var det en mer fremtredende effekt av ekstra tilsetning av protein i fôret

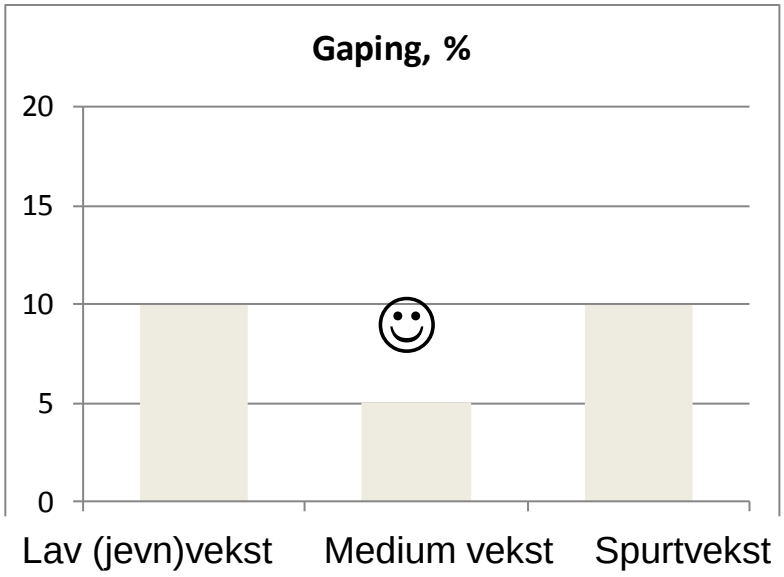




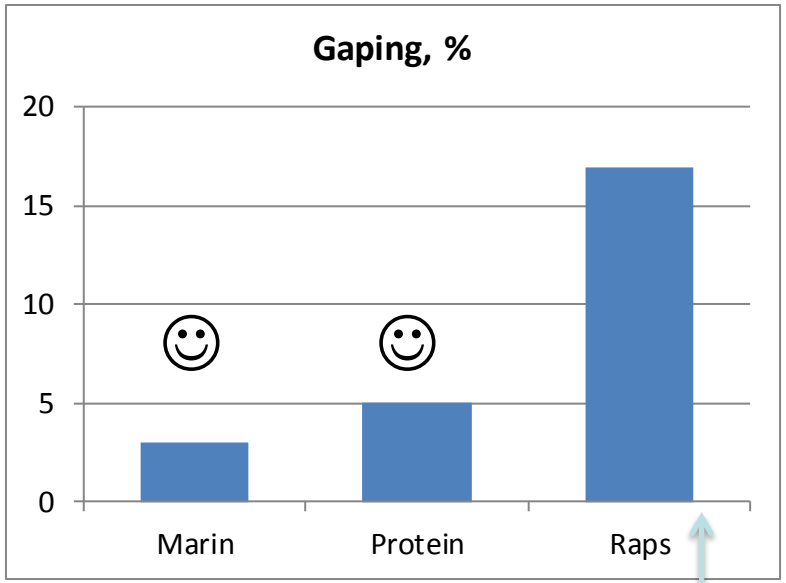
Væsketap viste samme mønster

Resultater desember

Gaping, % fisk



- Hoved-diet, aug-des



UPS – denne ser ikke bra ut….
For 3 av 4 nøter var denne forskjellen ennå mer markant, mens for 4. rapsnota var det mindre gaping

Gaping og tekstur i mars

Målingene ble utført 6 dager etter slakting, n = 90 per fôrgruppe. Snittvekten var 6,57 kg.

- **Gaping** score > 3 i hht Andersen et al. 1994

Marin olje	1,9%^{ab}
Rapsolje + protein	0%^{b}
Rapsolje	3,9%^{a}

Tilleggskommentarer:

Generelt lite gaping

Laksen som fikk det feite fôret fra mai-aug (mest jevn vekst) hadde minst gaping

- **Fasthet, rå kotelett (N*s)**

Marin olje	92,3^{a}
Rapsolje + protein	95,6^{a}
Rapsolje	92,8^{a}

Tilleggskommentarer:

All fisken var fast i kjøttet – betydelig fastere enn i oktober

Fast tekstur

- Styrt fôrsammensetning (tenke nytt…)
- Bedre forståelse av laksens energiomsetning – hva skjer egentlig inne i cellene og kan vi styre omsetningen i ønsket retning (stimulere til fettforbrenning)
- ”Oksygenmangel” ?
- Tilpasse produksjonen (fôr/fôring mm) til årstid / temperatur / vekstmønster ?
- Helsestatus ?
- Slaktefôr ?

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Bløt filet ved vekstspurt

Bindevevsdannelsen henger etter

The rapid muscle growth, especially in turkey, is connected with atrophy of fibers and loss of connective integrity [Sosnicki & Wilson, 1991]. The connective tissue (endomysium) associated with individual muscle fibers cannot keep up with rapid muscle fiber growth and in result is less developed and immature [Swatland, 1990]. The fiber necrosis and focal myopathy (FM) incidence in poultry proves that muscle overgrow its own supporting system. It is not clear, in spite of similarities in the histopathological

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Vekstspurt

- Fôrsammensetningen spesielt kritisk
- Høyt nivå rapsolje kombinert med lavt proteinnivå ser ut til å være ugunstig
- Økt behov for Vitamin E, C, Se, Zn ?
- Økt behov spesifikke aminosyrer !
- Næringsbehov

max tilvekst ≠ behovet for max kvalitet

Nofima

Torunn Taksdal[1], Jannicke Wiik-Nielsen[1], Sveinung Birkeland[2], Paw Dalgaard[3], Turid Mørkøre[4]

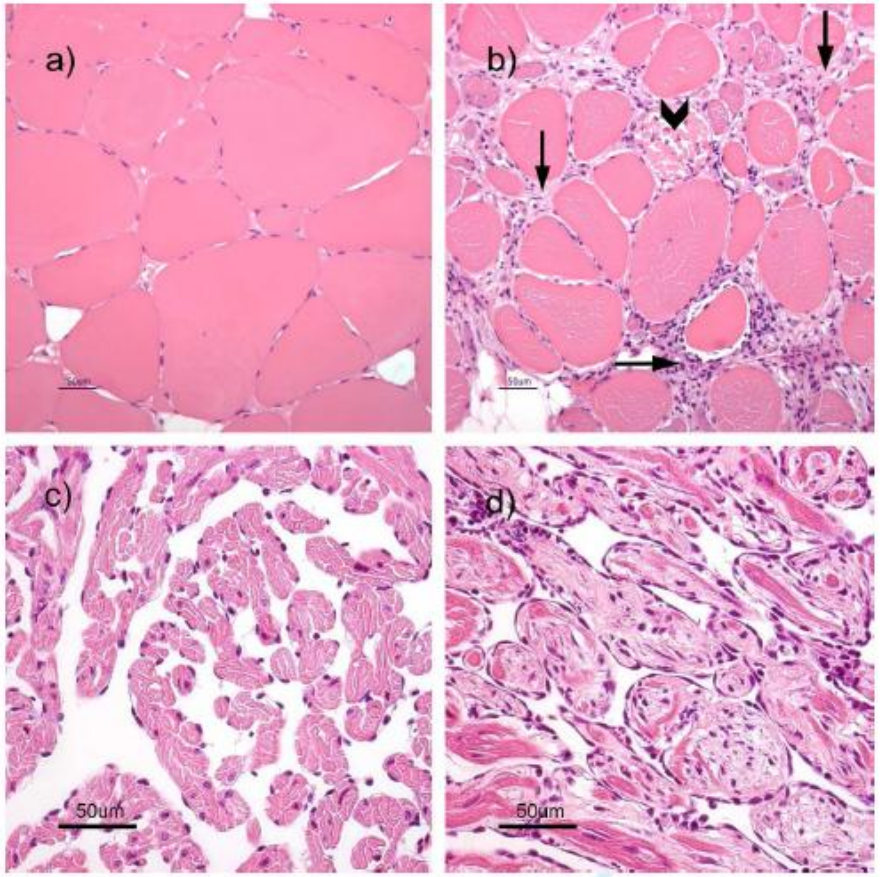


Figure 2. Light microscopy of clinically healthy, harvest-ready Atlantic salmon from a PD-affected fish farm. (a, b) White/anaerobic skeletal muscle with (a) no changes (score 0) and (b) severe changes (score 4) with necrosis of a single muscle fibre (arrowhead), inflammation (horizontal arrow) and fibrosis (vertical arrows). (c, d) Spongious myocardium with (c) no changes (d) subendocardial fibrosis, the muscle fibres appearing thickened due to the fibrosis and thickened endothelium (haematoxylin & eosin, bars = 50µm).

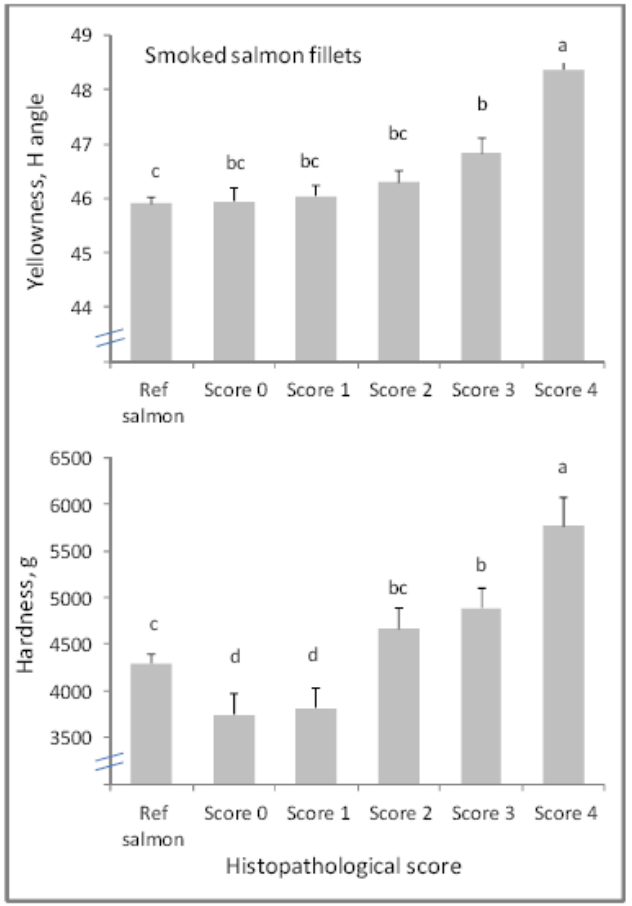
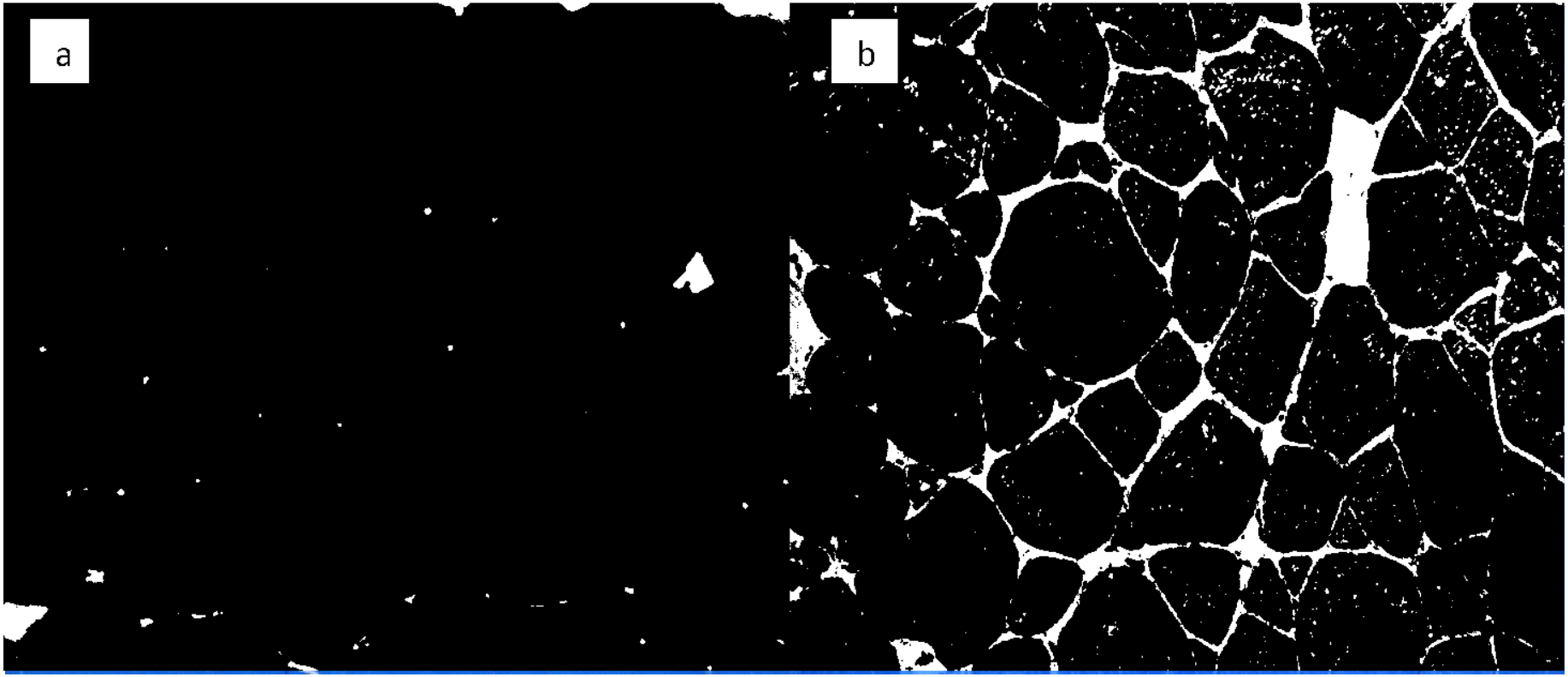
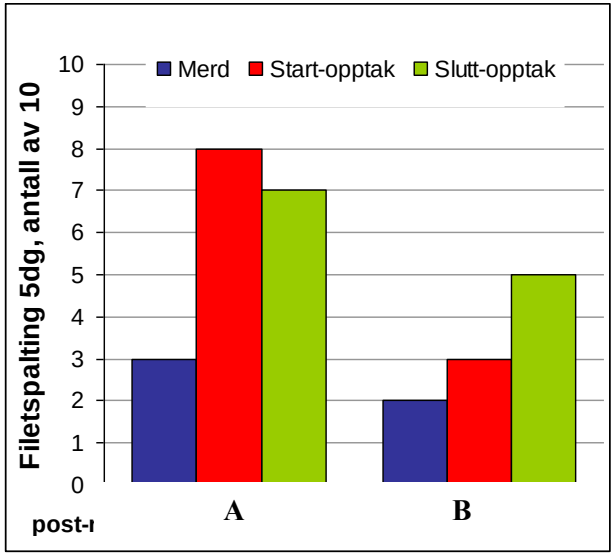


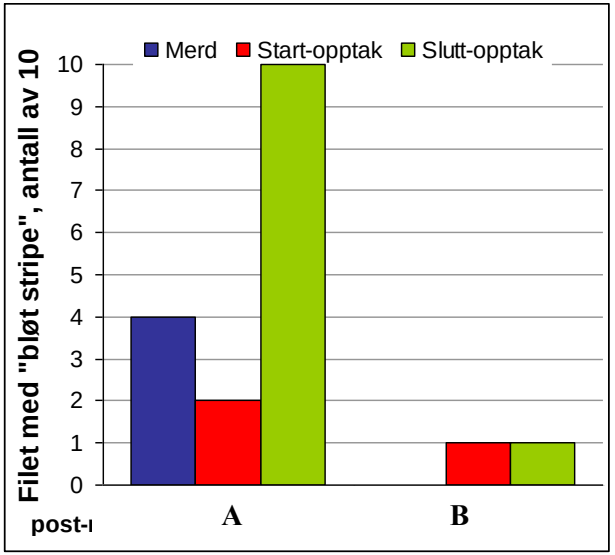
Figure 4. Yellowness and hardness of smoked fillets of 50 fish from a reference fish farm (Ref salmon) and 50 clinically healthy, harvest-ready Atlantic salmon from a PD-affected farm, the latter divided into bars according to the severity of muscle changes scored by light microscopy, from 0 = no changes to 4 = severe changes. Mean ± SE are shown. Different letters indicate significant differences between the yellowness and hardness for each score (P<0.05).

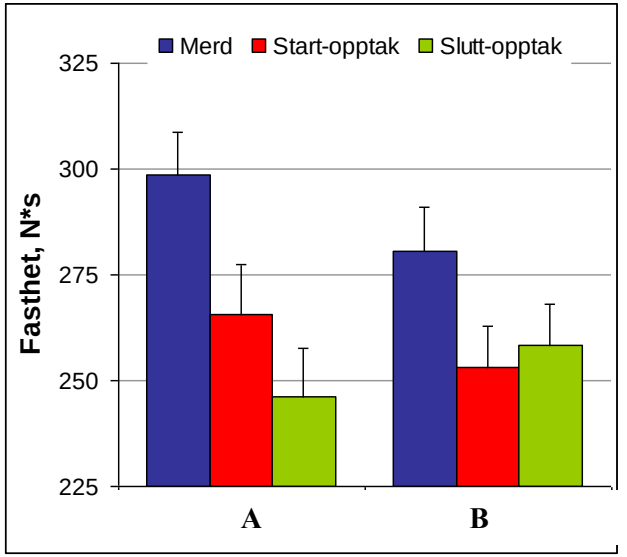
Stress ved slakting kan føre til «krakelering» av muskelen



Laks med god vekst
Analysert etter 5 dagers lagring







Mye kunnskap fra tradisjonelt husdyrhold er overførbart til lakseoppdrett

Flyter i vannet - spretten
Lite bindevev
Tåler høye nivåer av melkesyre

Nofima

- Myopathy in terrestrial species due to vitamin E and selenium deficiencies is well documented and often occurs in animals which undergo a sudden increase in muscular activity following a period of inactivity and poor nutrition (Anderson et al. 1977).

Pale, soft, exudative meat, PSE

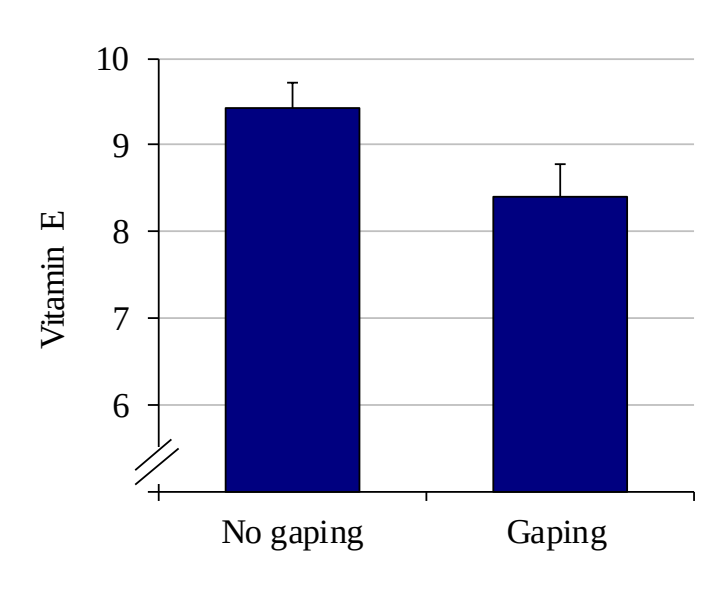
(PSS, porcine stress syndrome)

Art	Effekt	Observasjoner	Referanse
Gris	Redusert	1000mg Vit E i 46 dg reduserte utskillelse av Ca2+ og PSE frekvens. Årsak, hypotese VitE stabiliserer membran	Buckley et al. 1995
Gris	Redusert	Ekstra tilsetning av Trp (0.5%) i slaktefôr 5 dg ⇒ reduserte PSE fra 9% til 6%	Anon 1991 (
Gris	Redusert	Ekstra tilsetning av Trp i slaktefôr ⇒redusert stressrespons og redusert PSE	Adeola&Ball 1992
Kalkun	Økt	Rask vekst (muskelfiber atrofi, tap av bindevevsstyrke)	Sosnicki & Wilson, 1991
Gris	Økt	Tryptofan (Trp) mangel⇒redusert produksjon av serotonin i hundyr	Henry et al. 1992
Gris	Økt	Stress ved slakting	Grandin 1989; Pedersen et al. 1993
Gris	Økt	Stress ved transport; bedre å gå fra mørke mot lys	Van putten et al. 1982
Gris	Økt	Blande dyregrupper ved transport/slakting (sosial uro)	Karlsson& Lundstrøm 1992

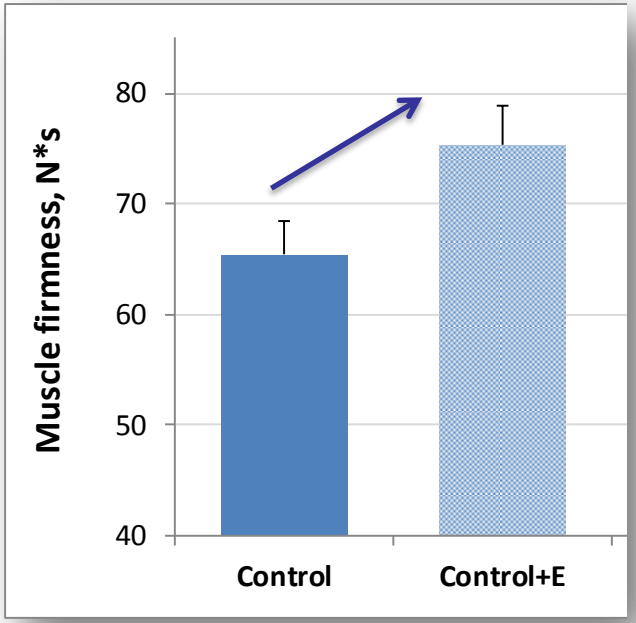
Nofima

Vitamin E

Vitamin E i muskel lavt i laks med spalting



Økt vitamin E i fôret før slakting (2,5 mån) ga fastere filet

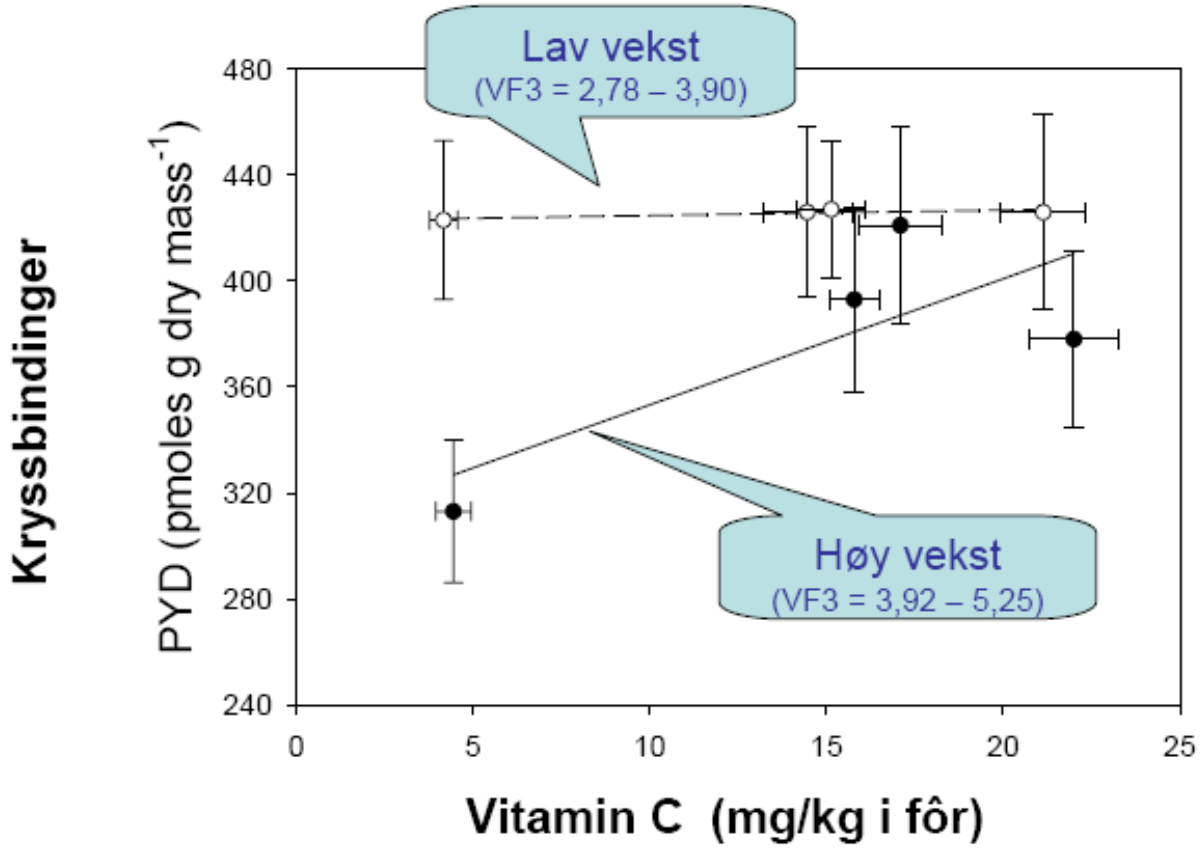


Nofima

Takk for meg !

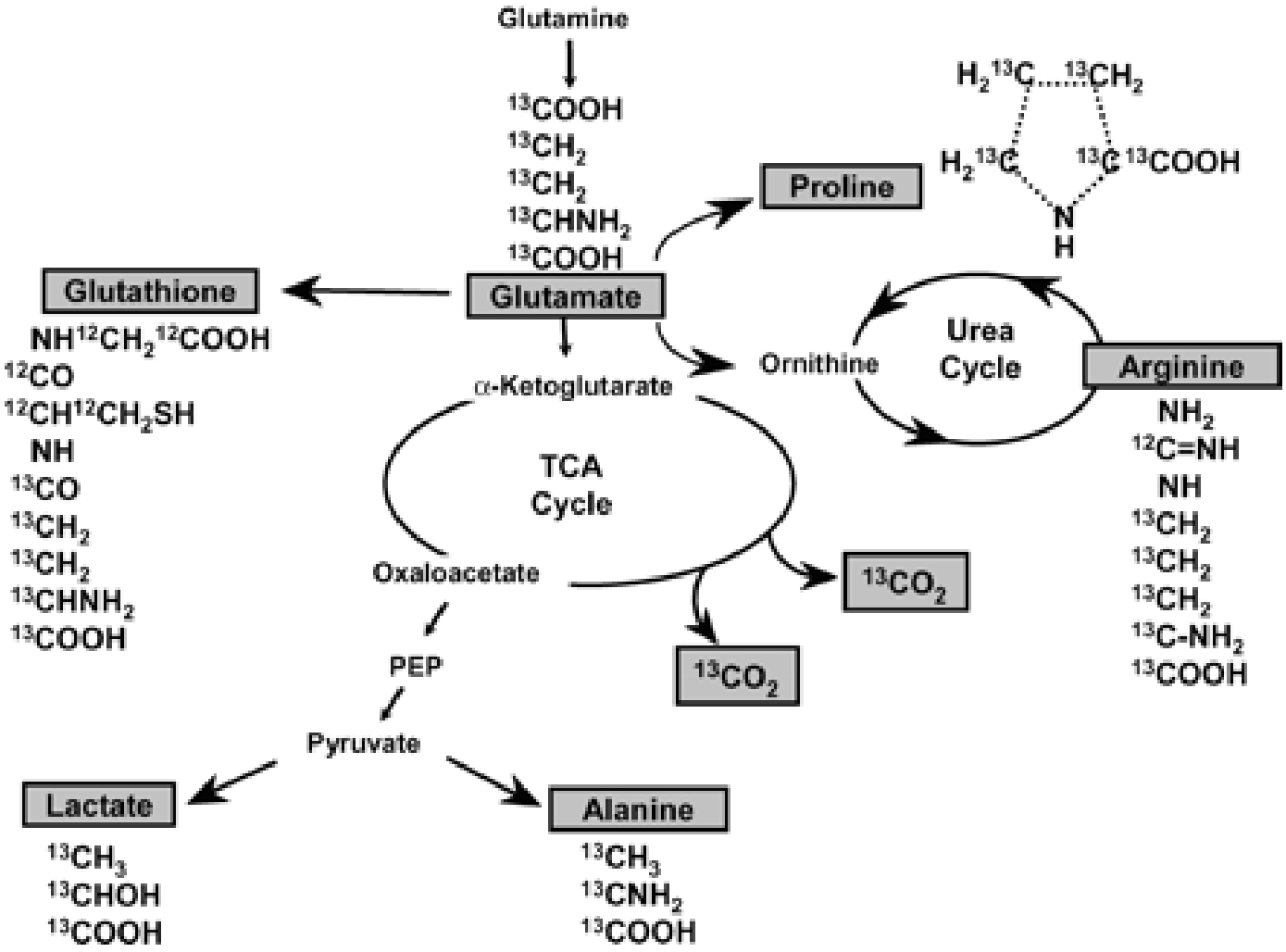
Fôringsforsøk med med smålaks (160 g – 675 g)

Vitamin C innhold og kryssbindinger i kollagen

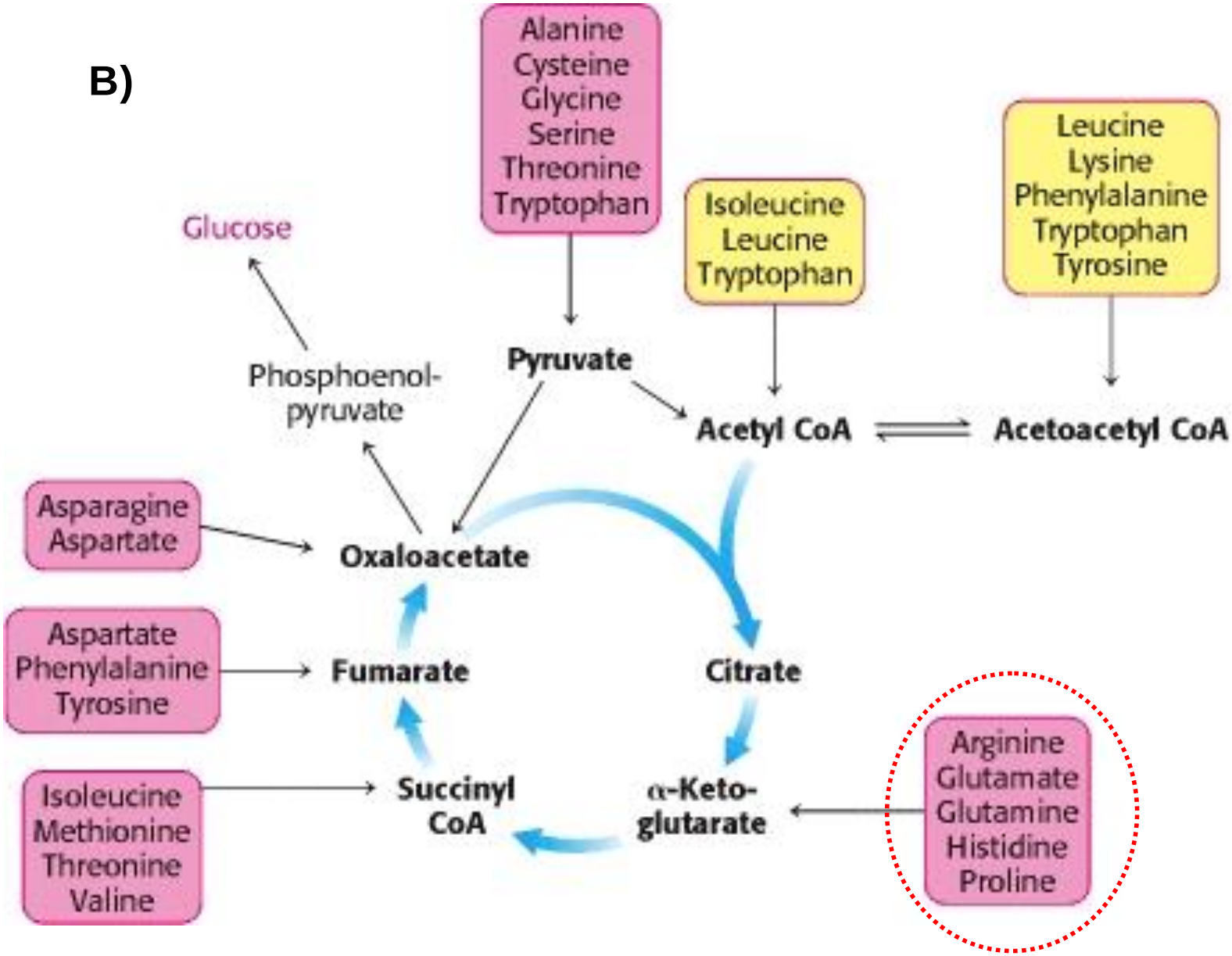


- **Kollagenmengden påvirker fastheten**
- **Flere kryssbindinger i kollagen gir økt fasthet**
- **Veksthastighet påvirker fasthet på filét**
- **Det er et samspill mellom innhold av vitamin C og veksthastighet på fasthet i filét**

Kilde: Sigholt & Bickerdike 2008


Glutamine
^{13}COOH
^{13}CH$_2$
^{13}CH$_2$
^{13}CHNH$_2$
^{13}COOH
Proline
H$_2$^{13}C.....^{13}CH$_2$
H$_2$^{13}C
^{13}C^{13}COOH
N
H
Glutathione
NH^{12}CH$_2$^{12}COOH
^{12}CO
^{12}CH^{12}CH$_2$SH
NH
^{13}CO
^{13}CH$_2$
^{13}CH$_2$
^{13}CHNH$_2$
^{13}COOH
Glutamate
Ornithine
Urea
Cycle
Arginine
NH$_2$
^{12}C=NH
NH
^{13}CH$_2$
^{13}CH$_2$
^{13}CH$_2$
^{13}C-NH$_2$
^{13}COOH
α-Ketoglutarate
TCA
Cycle
Oxaloacetate
^{13}CO$_2$
^{13}CO$_2$
PEP
Pyruvate
Lactate
^{13}CH$_3$
^{13}CHOH
^{13}COOH
Alanine
^{13}CH$_3$
^{13}CNH$_2$
^{13}COOH

B)


Alanine
Cysteine
Glycine
Serine
Threonine
Tryptophan
Isoleucine
Leucine
Tryptophan
Leucine
Lysine
Phenylalanine
Tryptophan
Tyrosine
Glucose
Phosphoenol-
pyruvate
Pyruvate
Acetyl CoA
Acetoacetyl CoA
Asparagine
Aspartate
Oxaloacetate
Aspartate
Phenylalanine
Tyrosine
Fumarate
Citrate
Isoleucine
Methionine
Threonine
Valine
Succinyl
CoA
α-Keto-
glutarate
Arginine
Glutamate
Glutamine
Histidine
Proline

Nofima