

# Raw material properties of organically produced salmon

Magnus Åsli and Turid Mørkøre





Nofima is a business oriented research institute working in research and development for the aquaculture, fisheries and food industry in Norway.

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Main office in Tromsø  
Muninbakken 9–13  
P.O. box 6122  
NO-9291 Tromsø  
Norway  
Tel.: +47 77 62 90 00  
Fax: +47 77 62 91 00  
E-mail: [nofima@nofima.no](mailto:nofima@nofima.no)

Internet: [www.nofima.no](http://www.nofima.no)

# Report

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<i>Summary:</i> <p>The fillet quality of organically and conventionally produced salmon were analyzed and evaluated in autumn 2011. Fillets from two weight classes (3-4 kg and 5-6 kg, round weight) were obtained from two independent fish farmers who produce both conventional and organic salmon.</p> <p>The organically produced salmon had firmer texture measured both by physical and sensory evaluation (after heat treatment), the fillets were more robust, and had a redder meat color compared to the conventional salmon. The differences were however relatively small, and further studies may reveal if organic salmon generally are firmer and redder than conventional salmon.</p> <p>The total level of fillet fat, protein content and amino acid composition did not differ between organic and conventional salmon, but the organically produced fish had a higher proportion of omega-3 (EPA/DHA) fatty acids compared with the conventionally produced fish.</p> <p>Due to a greater content of omega-3 fatty acids in the organic salmon, it may be interesting to examine the storage stability of this product.</p>		

## **Preface**

The demand for organically produced salmon has been increasing in recent years by well-paying consumers. The demand has been driven by an increased awareness of sustainable fisheries, resource management and welfare issues. Compared to conventional fish farming, organic production has different requirements for feed ingredients, disease control, biological light regimes, stock densities, disinfectants, as well as procedures for chemical impregnation of net pens.

The feed used for organic salmon farming should consist of organically produced ingredients and raw material from sustainable aquatic organisms not suited for human consumption. Different feed ingredients and farming practices may affect the biological processes and chemical composition of salmon, which in turn can alter quality-related properties. It is not given that the current processing practice of conventional salmon is optimal for the quality of organically produced salmon.

The growth rate as well as pigmentation of the flesh will vary between organically and conventionally produced salmon. Salmon is dependent on receiving carotenoids through their diet in order to obtain the desired coloration according to the specific market niche request.

In conventional salmon farming, the most common pigment source is synthetically produced astaxanthin; while in organic production, the pigment source must be of natural origin such as shrimp carapace, algae, fungi and bacteria culture. Currently, there is no information available to elucidate whether the product characteristics of organically produced salmon differ from conventionally produced salmon, but it is conceivable that there may be differences. For example it is known that the feed composition (eg. fat content /fatty acid profile) and growth rate may affect properties such as flavour, texture, odour and colour.

The aim of this project was to investigate and compare the raw material properties of organically produced and conventionally produced Atlantic salmon.

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# 1 Materials and methods

## 1.1 Fish material and farm locations

The fish were put to sea in central and northern Norway in the autumn of 2009, and harvested in early August (farmer A) and the end of September (farmer B) 2011. Each farmer contributed with fillets from two weight classes as shown in Table 1.

Table 1 Fish material used for study, two weight classes (round weight)

	Conventional salmon		Organic salmon	
	Farmer A	Farmer B	Farmer A	Farmer B
3-4 kg	17 fillets	17 fillets	17 fillets	17 fillets
5-6 kg	17 fillets	17 fillets	17 fillets	17 fillets
Sum	34 fillets	34 fillets	34 fillets	34 fillets

## 1.2 Chemical composition

Chemical composition of the Norwegian quality cut (NQC), (Kjeldahl crude protein, amino acids, total fat, fatty acid profile, and ash) were analyzed by BioLab, Bergen. The pH was measured directly in the fish muscle, using a muscle electrode connected to a pH meter (330i, WTW, Germany) by Nofima Ås.

## 1.3 Colour and pigments

The colour (SalmoFan) was determined photometrically in the NQC using PhotoFish<sup>®</sup> technology as described by Folkestad et al. (2008), and chemically analyzed pigments were analyzed by BioLab, Bergen. The SalmoFan<sup>®</sup> colour scale is a common way to evaluate the colour of salmon. The scale ranges from 20 to 35 where the colour intensity increases with increasing values. The pigments in the feed originated from different sources, Phaffia (farmer A) and Panaferd (farmer B). Different analytical methods were used to determine the chemical amount of caretonoids in the muscle. Free amount of astaxanthin (mg/kg) is reported for the conventionally produced fish and for the organically produced fish fed with Phaffia, while astaxanthin and total amount of identified carotenoids are reported for the organically produced fish that were fed Panaferd (mg/kg).

## 1.4 Water holding capacity

A 15 gram muscle pieces obtained directly anterior to the dorsal fin were placed on a cellulose absorber pad and stored for three days at 4 °C as described by Mørkøre et al. (2007). The liquid loss was determined as the percent of weight lost from the muscle during storage.

## 1.5 Texture and industry test

**Texture** was measured instrumentally (TA-XT2, Stable Micro Systems Ltd., Surrey, England) by pressing a flat-ended cylinder (12.5 mm diameter) into the fillet perpendicular to the muscle fibers at 1 mm/sec until reaching 90% of the initial fillet height. The force (Newton) used to penetrate 60% through the muscle is reported. This parameter is known to correlate with sensory perceived fillet firmness.

**The industry test** was carried out in accordance to the FHF leaflet “Guide for evaluating fillet texture in Atlantic salmon” (FHF, 2009).

*Gaping* was measured before- (Andersen et al. 1994) and after handling. The fillets were scored on a scale from 0 to 5, where a score of 0 indicates no gaping, and 5 indicates extreme gaping.

*Fillet elasticity* is a measurement of how quickly the fillet returns to its original form after being folded from caudal to cervical part of fillet. The fillets were scored on a scale from 0 to 2, where a score of 0 indicates an elastic fillet that restores quickly, and a score of 2 indicates an inelastic fillet that remains folded.

*Softness during finger test* is an expression of fillet firmness. The evaluation was performed by pressing the index finger with 1 kg pressure into the fillet below the dorsal fin for two seconds. The fillets were scored on a scale from 0 to 2, where score 0 indicates a firm fillet where the surface was restored immediately, and score 2 indicates a soft fillet where the finger easily penetrated the fillet, causing a rupture between the muscle segments.

## 1.6 Sensory assessment

Eleven trained assessors evaluated salmon fillets according to a standardized method (ISO 6564: 1985 (E)). The fillets were cut in 3 cm thick pieces, placed in coded bags, vacuum packed and heated at 80 °C for 11 minutes, before they were served in a randomized order. The assessors evaluated the samples according to 22 attributes, and scored them on a scale from 0 to 9, where 0 indicates no intensity and 9 indicates strong intensity.

Table 2 Sensory attributes used by the sensory panel in the evaluation of heated salmon

		Attribute	
Odour	Flavour	Appearance	Texture
Fresh*	Fresh*	Colour strength	Hardness/firmness
Metal	Metal	Colour tone	Juiciness
Sea	Sea	Whiteness	Fattiness
Fish oil	Fish oil		Fibrousness
Vegetable oil	Vegetable oil		
Rancid	Rancid		
	Bitter		
	Stale		
	Aftertaste		

\* sweet/sour

## 2 Results

### 2.1 Filleting and time of analysis

The fish from farmers A and B were filleted at different times post mortem (pre- and post-rigor, respectively). All fillets were analyzed 6 days after slaughter. Due to the large variation in fillet weight from farmer B, weight class 3-4 kg, the largest and smallest fillets were removed from the dataset in order to ensure equal basis for comparison (n=7/group). The differences in fillet weight between farmers are due to different degree of fillet trimming.

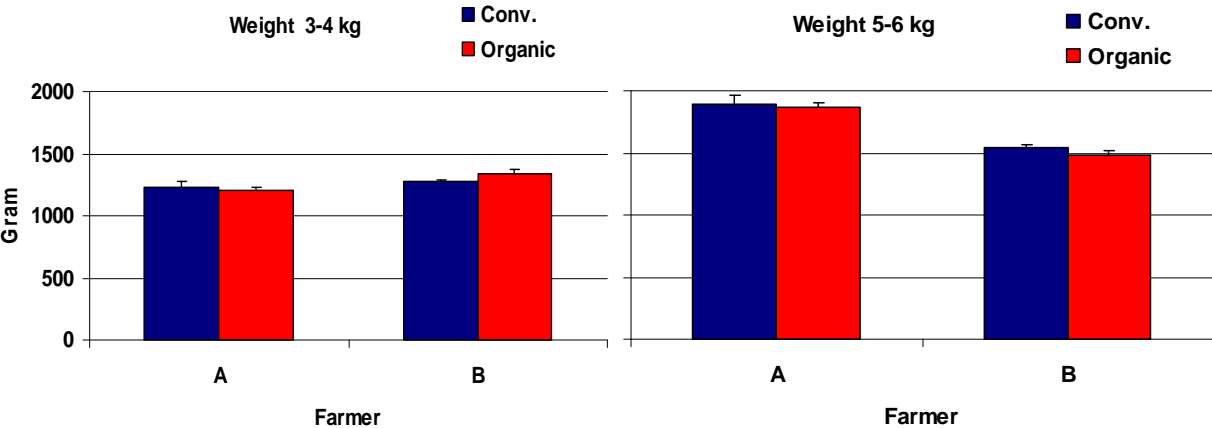


Figure 1 The left figure show weight of fillets from weight class 3-4 kg (round weight), and the right figure show fillet weight from weight class 5-6 kg



## 2.2 Chemical composition

The results from farmers A and B are pooled, since there were no differences in chemical composition between these groups. The protein content was, as expected, 20% for all groups and the fat level varied between 14.1 and 15.1%. The ash content was approximately 1%, and the dry matter 35.5%. The pH was significantly higher ( $P < 0.05$ ) in the organically produced fillets, indicating that the organically farmed salmon contained lower levels of glycogen in the muscle while alive, hence less lactate in the muscle post mortem.

Table 3 Chemical composition (%) in NQC, and pH in front of the dorsal fin

	3-4 kg		5-6 kg	
	Conventional	Organic	Conventional	Organic
Protein	20.0±0.2	20.0±0.3	20.1±0.2	20.2±0.8
Fat	14.8±1.2	14.1±1.4	15.1±1.0	14.4±2.0
Ash	1.0±0.1	1.2±0.1	1.1±0.0	1.1±0.0
Dry matter	35.7±1.4	35.3±1.1	36.3±0.8	35.6±1.2
pH	6.26±0.01	6.35±0.02*	6.17±0.02	6.26±0.03*

\* Significantly different ( $p < 0.05$ )

## 2.3 Amino acids

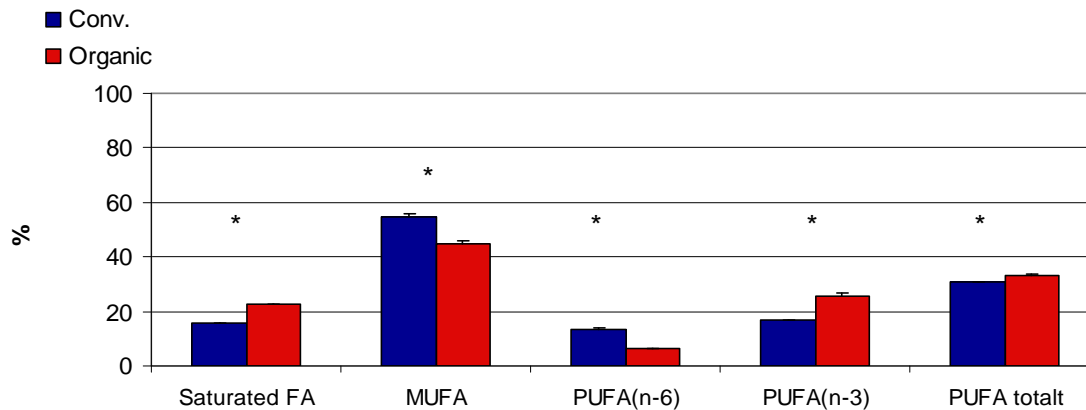
There were no significant differences in the amount of hydroxyproline or any other analyzed amino acids between organic and conventionally produced salmon. Since the method for analysis of hydroxyproline yields several amino acids, these are also reported.

Table 4 Amino acids analyzed in the NQC

	3-4 kg		5-6 kg	
	Conventional	Organic	Conventional	Organic
Aspartic acid	1.77±0.01	1.82±0.09	1.80±0.06	1.83±0.07
Glutamic acid	2.48±0.02	2.56±0.15	2.49±0.09	2.57±0.11
<b>Hydroxyproline</b>	<b>0.05±0.00</b>	<b>0.05±0.01</b>	<b>0.04±0.01</b>	<b>0.03±0.00</b>
Serine	0.74±0.02	0.76±0.04	0.74±0.01	0.75±0.04
Glycine	0.98±0.01	0.99±0.04	0.95±0.02	0.95±0.02
Histidine	0.66±0.01	0.66±0.03	0.66±0.01	0.67±0.03
Arginine	1.19±0.02	1.19±0.04	1.16±0.04	1.21±0.07
Treonine	0.84±0.01	0.86±0.04	0.85±0.02	0.87±0.04
Alanine	1.20±0.00	1.22±0.04	1.19±0.01	1.15±0.02
Proline	0.64±0.01	0.64±0.02	0.63±0.02	0.62±0.02
Tyrosine	0.69±0.02	0.69±0.01	0.70±0.01	0.74±0.05
Valine	1.01±0.02	1.01±0.04	1.01±0.03	1.02±0.05
Methionine	0.61±0.01	0.62±0.02	0.61±0.02	0.62±0.03
Isoleucine	0.91±0.01	0.91±0.03	0.91±0.03	0.92±0.03
Leucine	1.26±0.02	1.27±0.06	1.26±0.04	1.28±0.06
Phenylalanine	0.81±0.01	0.81±0.03	0.81±0.02	0.82±0.05
Lysine	1.66±0.02	1.71±0.08	1.67±0.05	1.72±0.08

## 2.4 Fatty acid profile

The fatty acid (FA) profiles were almost identical for the two weight classes produced organically and conventionally, so the results are presented as an average. There were significant differences ( $p < 0.05$ ) in all fatty acid groups between organically and conventionally produced salmon. The organic fillets had a greater content of long polyunsaturated fatty acids, characteristic for marine fish, while the conventionally produced fish possessed more fatty acids typical for plant oils.



\* Significantly different ( $p < 0.05$ )

*Figure 2 Fatty acid composition in NQC*

The C16:0 FA is characteristic for certain fish species in the northern Atlantic, and 22:1 n-11 is typical for species such as capelin. The conventionally produced fish had a higher proportion of C18:1 n-9, and 18:2 n-6 which is typical of vegetable oils such as rapeseed/canola. The organic fish had higher levels n-3 fatty acids, mainly EPA (20:5 n-3) and DHA (22:6 n-3) derived from marine oils.

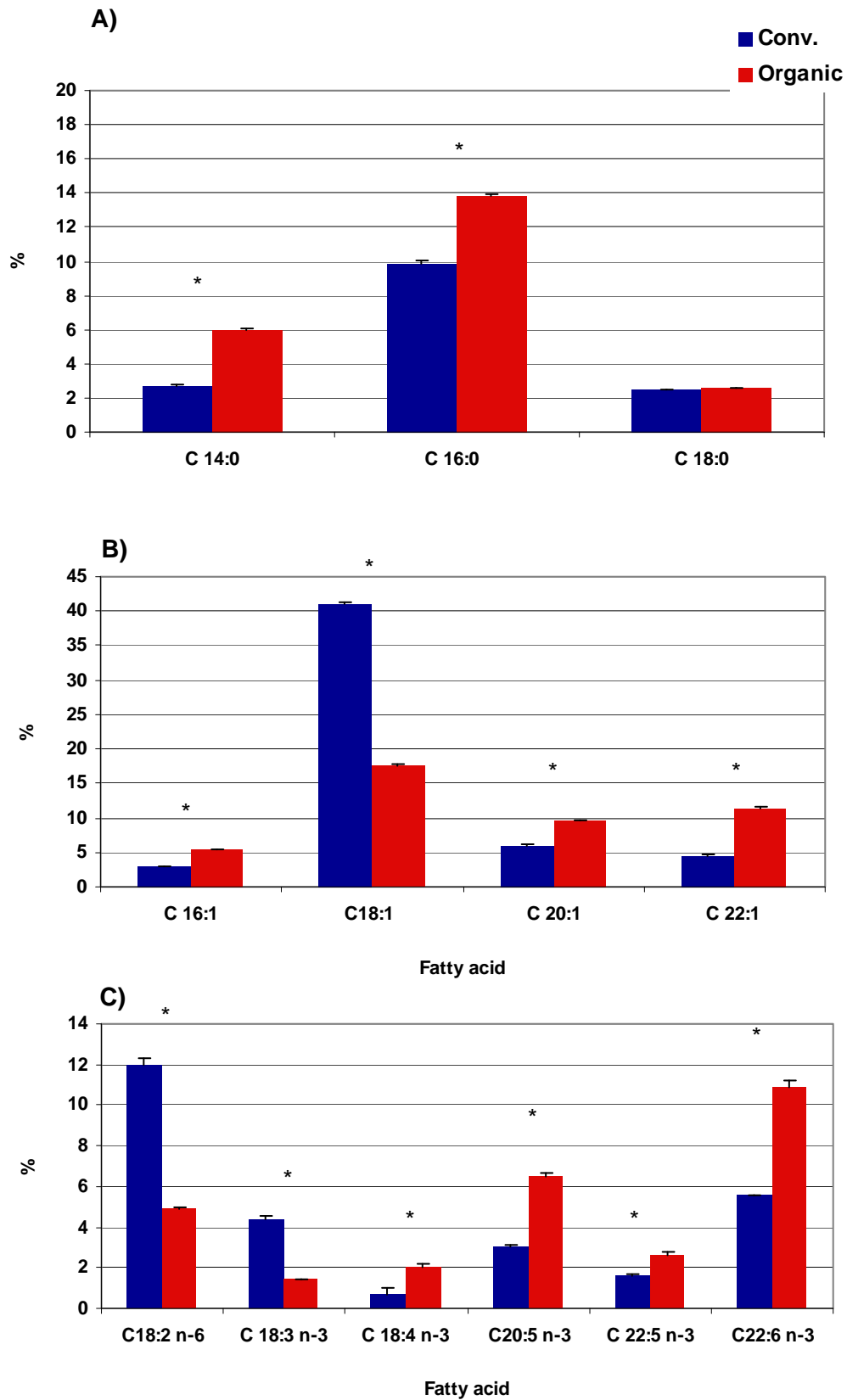


Figure 3 A) Saturated fatty acids B) Monounsaturated fatty acids C) Polyunsaturated fatty acids

## 2.5 Pigments and colour

### 2.5.1 Pigments

The levels of carotenoids (mg/kg) were slightly higher in the organic fillets compared with the conventional fillets.

Table 5 Amount of carotenoids (mg/kg) analyzed in the NQS

	Farmer A		Farmer B	
	Conventional	Organic	Conventional	Organic
<b>3-4 kg</b>				
Carotenoids	6.1	7.2	6.2	7.3
- of which astaxanthin	6.1	7.2	6.2	4.6
<b>5-6 kg</b>				
Carotenoids	6.8	7.3	6.5	8.1
- of which astaxanthin	6.8	7.3	6.5	4.6

### 2.5.2 Colour/SalmoFan

In concordance with the caretonoid contents, there was a tendency for redder colour of the organic fillets, albeit not statistically different from the conventionally produced fish.

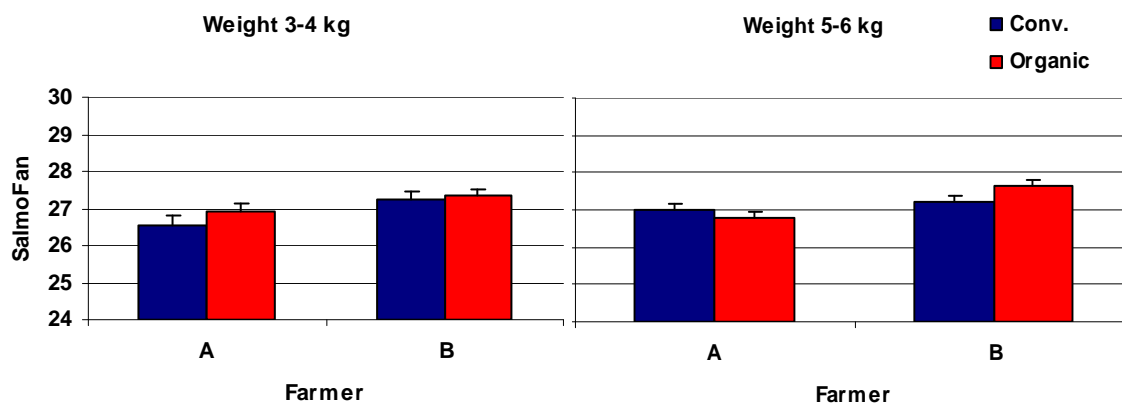
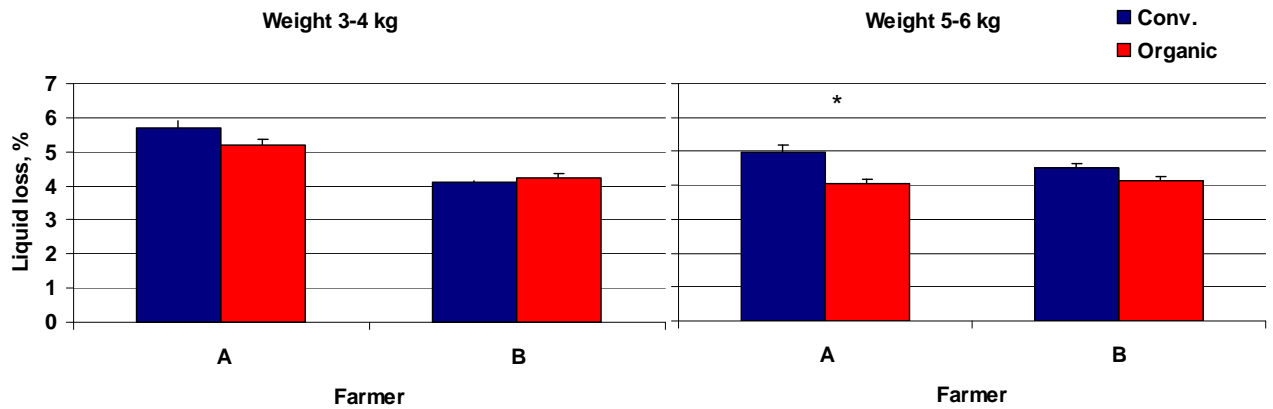


Figure 4 Redness of salmon fillets shown as SalmoFan score

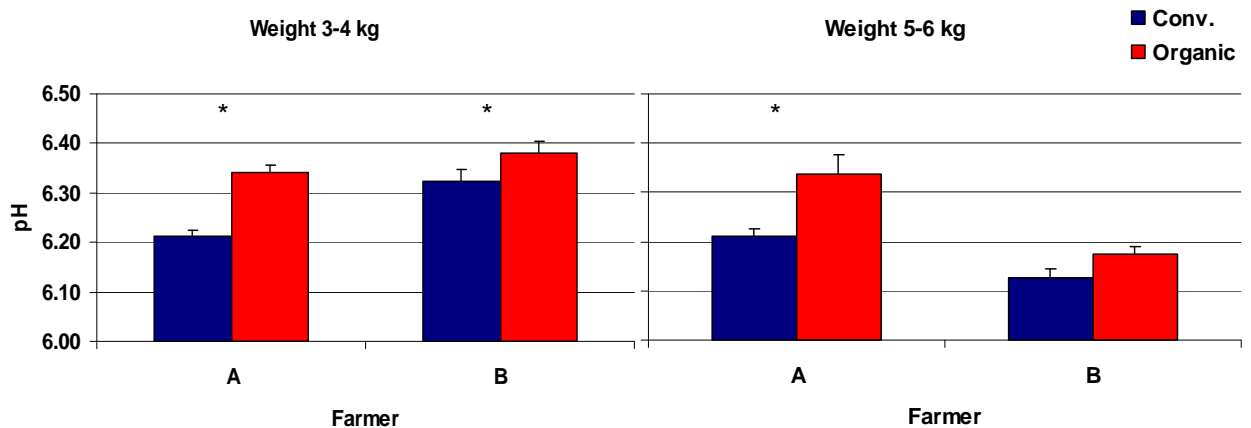
## 2.6 Water holding capacity

Liquid loss after three days of storage was lower for the organic salmon from farmer A in weight class 5-6 kg. The remaining groups were not statistically different, but there was a clear tendency for improved water holding capacity in the organic fish. Furthermore, the improved water holding capacity coincided with a higher pH in the organic fish.



\* Significantly different ( $p < 0.05$ )

Figure 5 Liquid loss (%) after three days of chilled storage



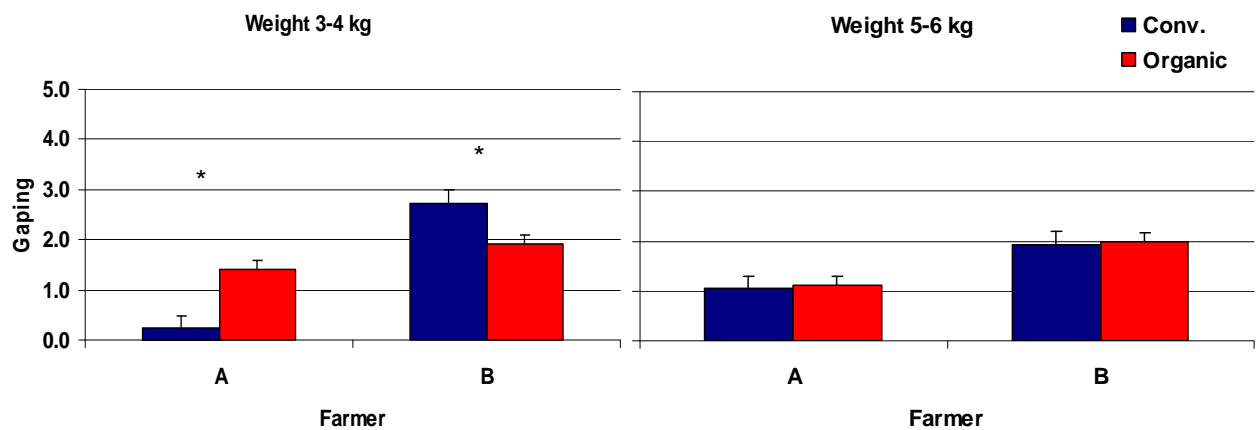
\* Significantly different ( $p < 0.05$ )

Figure 6 pH measured in the NQS six days post mortem

## 2.7 Texture and industry test

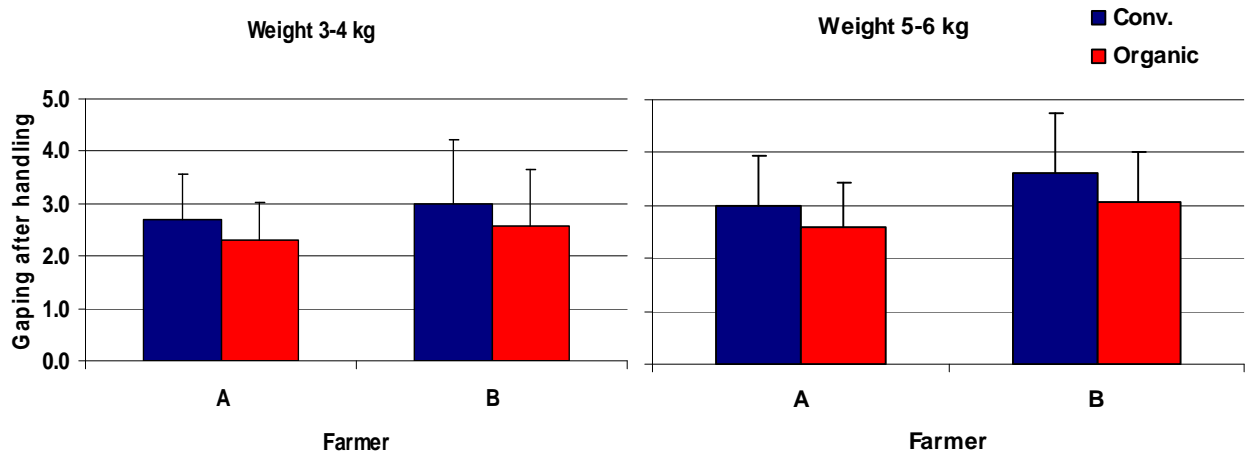
### 2.7.1 Gaping before and after handling

The gaping score recorded before handling showed no systematic variation between the groups. Some of the fish, particularly the conventional fish, 3-4 kg, farmer B, had a relatively high average gaping score of 2.6. Gaping score after handling gave no significant differences between the groups, although there was a tendency for less gaping in the organic group.



\* Significantly different ( $p < 0.05$ )

Figure 7 Gaping score (0–5) prior to handling of fillets

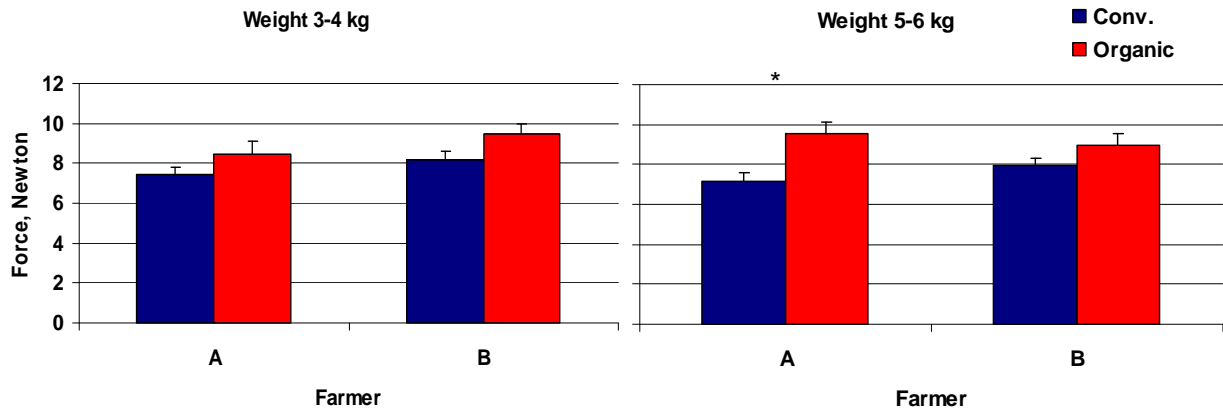


\* Significantly different ( $p < 0.05$ )

Figure 8 Gaping score after handling (0-5)

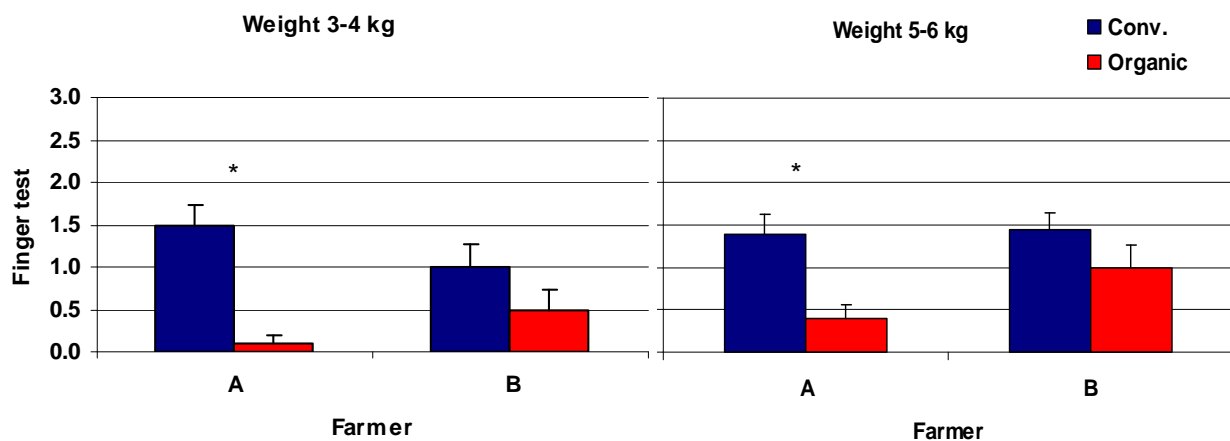
### 2.7.2 Instrumentally measured texture, "finger test" and elasticity

The organic fillets had consistently firmer texture measured both instrumentally and by pressing a finger into the fillet. However, it must be noted that all fillets had acceptable firmness.



\* Significantly different ( $p < 0.05$ )

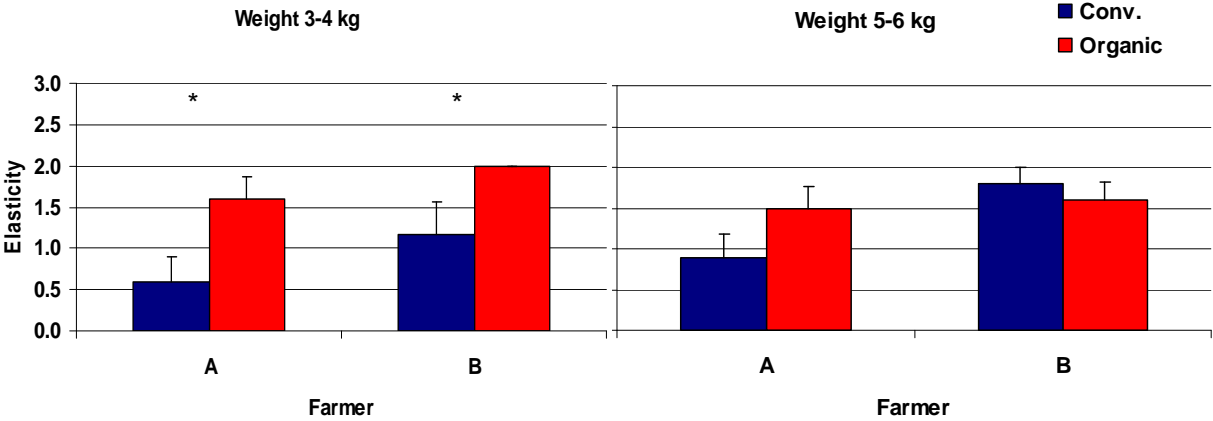
Figure 9 Instrumentally measured texture reported as the force required to penetrate 60 % through the fillet



\* Significantly different ( $p < 0.05$ )

Figure 10 The finger test show how easy a finger penetrated the muscle. Low score indicate firm muscle, high score indicate soft muscle

The organic fillets tended to be less elastic compared with the conventionally produced fillets, and the differences were statistically significant in the 3-4 kg weight class.



\* Significantly different (p<0.05)

Figure 11 Elasticity is a measurement of how fast the fillet returns to its original shape. Low score indicate an elastic fillet, high score indicate an inelastic fillet



### 2.8 Sensory

The sensory analysis revealed that the organic salmon tended to have a stronger red colour and firmer texture, which coincides with the chemically, photometrical and instrumental measurements. Rancid odour was somewhat more pronounced in the organic salmon, but smelled less of fish oil. It should, however, be noted that these parameters were low, and none of the groups can be characterized as rancid. These results coincide with the higher amounts of polyunsaturated fatty acids found in marine oils, which can lead to a more rapid oxidation process, and shorter shelf life compared to conventional farmed fish.

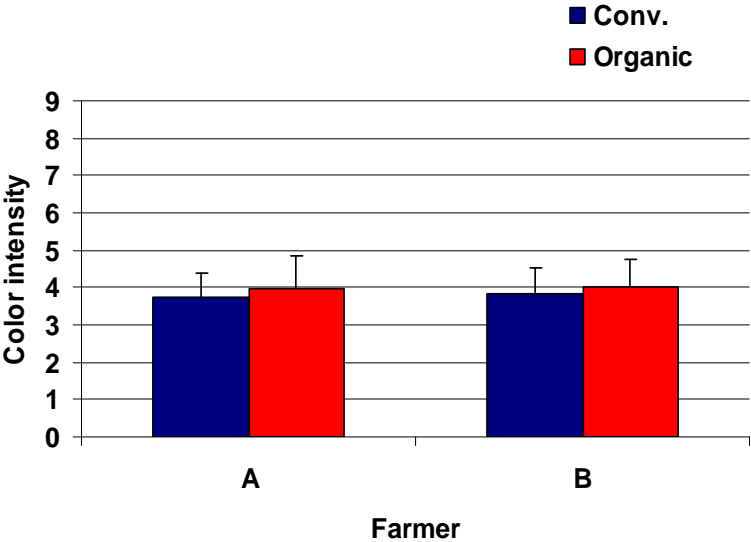


Figure 12 Red color intensity evaluated by trained sensory panel

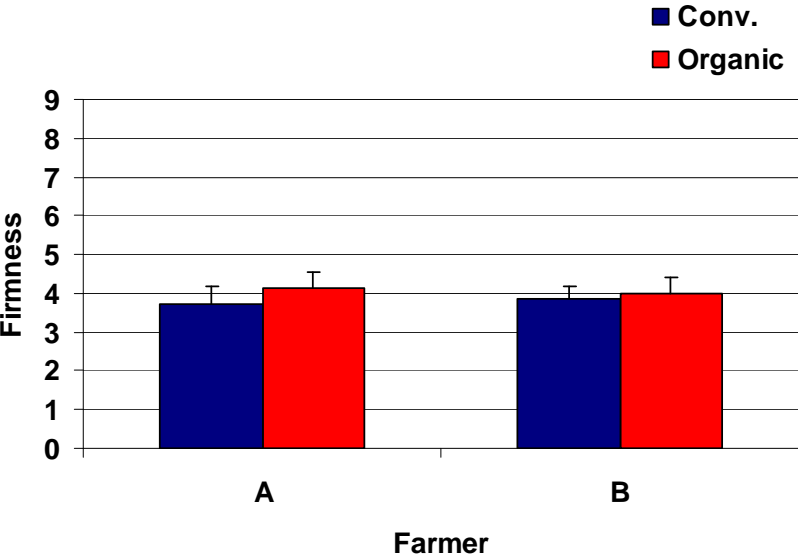


Figure 13 Firmness evaluated by trained sensory panel

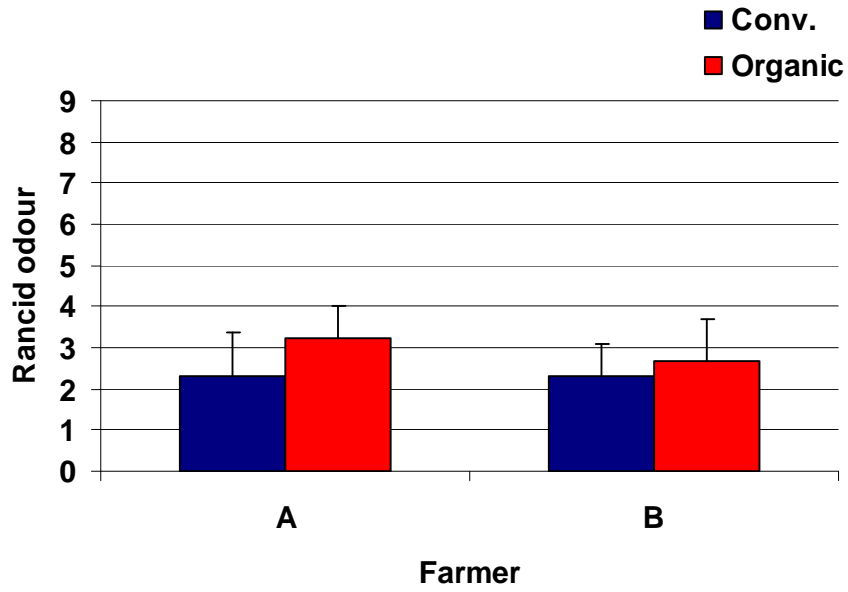


Figure 14 Rancid odour evaluated by trained sensory panel

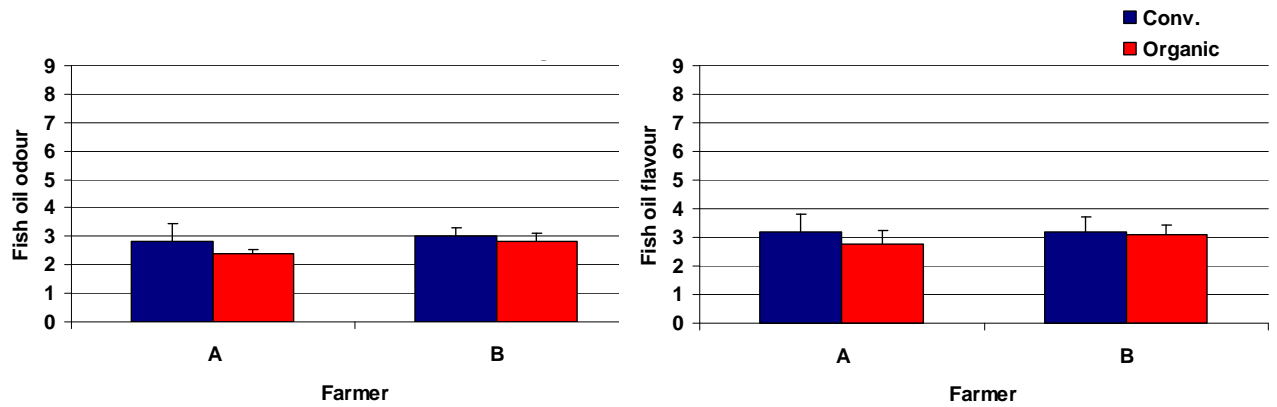


Figure 15 Fish odour, and fish flavour evaluated by trained sensory panel

### **3 Conclusion**

Organic salmon had firmer texture, a redder color, less liquid loss during storage, and greater amounts of the beneficial polyunsaturated fatty acids EPA and DHA compared to conventionally produced salmon. These characteristics favor the organic salmon, but further studies are needed to elucidate whether organic salmon has the same shelf life as conventional salmon, or if a higher level of EPA and DHA results in shorter shelf life after chilled or frozen storage. Because the pigment source of organic salmon may be of different origin than that of conventionally produced salmon, one should also monitor color after smoking and further storage of processed products.

This pilot project was conducted over a relatively short period, and gives a picture of how fillet quality differs between organically and conventionally produced salmon in this given period. In future studies, it would be interesting to compare groups of conventionally and organically produced salmon over a longer period of time to determine whether there is variation in quality as a result of both biological as well as seasonal/environmental variations.

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