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Chemical composition of whole body and fillet of slaughter sized Atlantic salmon (*Salmo salar*) and rainbow trout (*Oncorhynchus mykiss*) farmed in Norway in 2020

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ABSTRACT

The fish is the end-product in fish farming, but updated data on the composition of slaughter sized farmed salmon and trout are still scarce. The body composition of farmed salmonids changes over time as farming technology, farming routines, feed and genetics develops. Knowledge of the body composition of the farmed fish thus depends on data on today's produced fish. The body composition also varies with time of the year, geography, feed composition and feed intake. Analysis of samples representative of the whole Norwegian production of salmon and trout requires fish collected from the different geographic areas of production, sampled at different times throughout the year, and fish fed feeds from different feed producers.

Atlantic salmon and rainbow trout was collected in summer and in winter. Salmon was collected at four different locations, and trout at two different locations at each sampling time. Whole body and fillet of salmon and trout was analyzed. This study reports the average content of energy, dry matter, ash, crude protein, crude lipids, iron, potassium, calcium, copper, magnesium, sodium, zinc and phosphorus in whole body and fillet of Atlantic salmon and rainbow trout produced in Norway in 2020. Moreover, are the amino acid profiles and the fatty acid profiles given.

1. Introduction

In Norwegian aquaculture, Atlantic salmon is the dominating species with an annual traded volume of close to 1.4 million tonnes. Rainbow trout is the second largest species, with nearly 97.000 tonnes sold annually (data from 2020; Directory Of Fisheries, 2021). Data on the chemical composition of the farmed fish at slaughter size are required for evaluation of the economic and environmental sustainability of the farming and for monitoring and improving the utilization of the feed resources in the production (Aas et al., 2019; Ytrestøyl et al., 2015). It is also an important determinant for nutritional studies and optimization of the feed for the farmed fish, and the main measure for the value of farmed fish in the human diet.

The body composition of both Atlantic salmon and rainbow trout changes during the life cycle of the fish and during the year, and due to genetics, feed intake, growth rate, geography and environmental conditions (Austreng et al., 1987; Grisdale-Helland et al., 2013; Kiessling et al., 2001; Mørkøre and Rørvik, 2001; Rye and Gjerde, 1996; Thodesen et al., 2001). The fat content can also be affected by the feed composition and feed intake, and the fatty acid composition in the fish reflects the fatty acid composition in the feed (Dessen et al., 2017; Dumas et al., 2007; Einen et al., 1998, 1999; Hardy et al., 1987; Lee et al., 2019; Rønsholdt, 1995; Torstensen et al., 2000). Clearly, chemical analyses of fish from one single fish trial or one production are not representative of all slaughtered salmon or trout.

The body composition of salmon and trout has changed over time as breeding has changed the genetics of the fish (Gjedrem et al., 2012). The farming technology and routines are under constant development as is also the feed. Increasing knowledge on nutritional requirements, availability and cost of ingredients, and an increasing awareness of the resource utilization are all factors that contribute to development of the feed.

Salmonids change in body composition as the fish grow, depositing increasing amounts of fat with increasing body size (Shearer, 1984; Shearer et al., 1994). Timing of the slaughtering thus affects the body composition, in particular the fat content, of both Atlantic salmon and

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rainbow trout. Changes in the market may have a direct impact on slaughter size as a farmer may choose to slaughter the fish earlier, or keep the fish in the pens longer, than usual. The COVID-19 pandemics caused delivery and transport challenges for goods on the global market in 2020, and this may have had an impact on timing of the slaughtering of some of the salmon and trout in Norway.

The composition of whole body of slaughter sized farmed salmon has been analyzed previously with the aim to represent salmon produced in Norway (Aas et al., 2019; Shearer et al., 1994; Ytrestøyl et al., 2015). This requires a sampling scheme to cover variations in geography, time of the year, and feed type used prior to slaughtering. Updated data on composition of fillet of Norwegian farmed salmon and trout can be found in a publicly available database (Seafood Data). These data are from analysis of NQC (Norwegian quality cut), which differs in composition form the whole fillet.

Aas et al. (2019) analyzed the chemical composition of whole body of slaughter sized salmon sampled to be representative for all salmon slaughtered in Norway in 2016. In that study, fillet was not analyzed. In the present study, whole body and fillet of slaughter sized Atlantic salmon produced in Norway in 2020 were analyzed. In addition, were whole body and fillet of slaughter sized rainbow trout analyzed. The samples were analyzed for main nutrients and were intended to represent the average farmed salmon and trout. The data were collected as part of a study of the utilization of feed resources in Norwegian farming of salmon and trout in 2020 (Aas et al., 2022a, 2022b).

2. Materials and methods

2.1. Rearing conditions

All sampled fish were from commercial farms. Details in the rearing conditions at each farm is beyond the scope of this study. All farmers were considered to operate according to today's common practices, and to be representative for commercial Norwegian fish farming in 2020.

2.2. Sampling

Slaughter sized salmon was collected for chemical analysis of whole body and fillet. Samples were collected during harvesting at commercial fish farms in June (summer) and in November (winter), from one location in the southern part of Norway, two locations in Mid Norway and one location in Northern Norway. The sampling times were chosen based on experience from Aas et al. (2019). The fish were either collected at the slaughter factory directly after killing according to the company's slaughter procedures, or at the sea cage, killed by a sharp blow to the head. Fish for fillet analysis were bled immediately after killing, whereas fish for whole body analysis were not bled.

At each site and at each sampling time, ten salmon were collected for whole body analysis, and ten for analysis of fillet, aiming at fish of 5.1–5.6 kg body weight to be close to the average for harvested salmon in Norway. By a mistake only 5 fish were sampled for whole body analysis at one sampling, resulting in a total of 75 salmon for whole body analysis, and 80 salmon for fillet analysis. The salmon were transported on ice to Nofima at Sunndalsøra and stored at 4 °C. Weight and fork length was registered. The salmon for fillet analysis were filleted within three days after sampling. Filleting was done manually, backbone and belly bone was removed, skin was kept on the fillet, and the left side fillet of each fish was used for the analyzes. The fillets and whole fish were frozen and cut into slices with a meat saw and homogenized with a meat grinder while still frozen. The ten (or five) fish from each sampling were pooled into in total eight pooled samples of salmon for whole body analysis and eight for fillet analysis and kept at − 20 °C until freeze drying and chemical analysis.

Slaughter sized trout were collected and prepared as described for the samples of salmon but aiming at trout of body size 4.1–4.6 kg. Samples were collected at two locations in May/June (summer) and two locations in November/December (winter). The trout were sampled at one location in the southern part and one location in the northern part of the county Vestland, where trout farming in Norway is mainly located, at each time. At each site and at each sampling time, ten trout were collected for whole body analysis, and ten for analysis of fillet, in total 40 trout for whole body analysis and 40 trout for fillet analysis. The ten fish from each sampling were pooled into a total of four pooled samples for whole body analysis and four samples for fillet analysis.

Table 1
Total number (n), number of males and females, body weight, fork length and condition factor of salmon and trout sampled for analysis of whole body and fillet composition. Fillet yield is given for fish sampled for fillet analysis. Data on body weight, fork length, condition factor and fillet yield are given as mean ± S.E.M.

	Salmon for whole body analysis	Salmon for fillet analysis	Trout for whole body analysis	Trout for fillet analysis
n	75	80	40	40
No of males	35	39	22	23
No of females	40	41	18	17
Weight (g)	5 345 ± 56	5 331 ± 51	4 382 ± 80	4 118 ± 110
Fork length (cm)	72.5 ± 0.3	73.1 ± 0.3	61.2 ± 0.4	59.9 ± 0.5
Condition factor	1.40 ± 0.01	1.37 ± 0.01	1.91 ± 0.03	1.91 ± 0.03
Fillet yield (%)	–	62.4 ± 0.3	–	60.7 ± 0.7

2.3. Chemical analysis

Homogenized samples of whole body and fillet were analyzed for dry matter (105 °C until constant weight), ash (five hours at 550 °C), gross energy (1271 Bomb calorimeter, Parr, Moline, IL, USA), crude lipid (SOXTEC hydrolyzing and extraction systems, Foss, Hilleroed, Denmark), nitrogen (Kjeltec Auto System, Tecator, Höganäs, Sweden) and minerals (by inductive coupled plasma mass spectroscopy, ICP-MS, at Eurofins, Moss, Norway). The amino acids were analyzed with an amino acid analyzer (Biochrom 30, Biochrom Cambridge, UK). Tryptophan was analyzed after basic hydrolysis (Hugli and Moore, 1972). The remaining amino acids were analyzed according to Davies (2002). Fatty acids were analyzed according to Mason and Waller (1964) after lipid extraction (Folch et al., 1957). Crude lipid and fatty acids were analyzed 'as is'. For the remaining analyzes, the samples were freeze dried prior to analysis.

2.4. Statistical analysis

The sampling schedule was designed to achieve representative samples to document the average of slaughter sized salmon and trout, and not to reveal differences in body composition. However, the chemical composition is given for fish sampled at summer and winter, and as a mean. The data were tested with a one-way ANOVA (t-test) and significant differences ($P < 0.05$) were ranked with Duncan's multiple range test with time of year as class variable. The statistical analysis was performed with the SAS computer software (SAS1985, SAS Institute Inc, Cary, NC, USA).

3. Results and discussion

The mean body weight and fork length of salmon analyzed for whole body composition was 5345 g and 72.5 cm, respectively, giving a condition factor (weight, g/length^3, cm) of 1.40 (Table 1). The mean body weight, fork length and condition factor of salmon collected for fillet analysis was 5331 g, 73.1 cm and 1.37, respectively. The distribution of males:females was 35:40 for salmon for whole body analysis and 39:41

Table 2
Chemical analysis of dry matter (%), ash (%), crude lipid (%), crude protein (Nx6.25; %), energy (MJ/kg) and selected minerals (mg/kg) in whole body and fillet of Atlantic salmon collected during summer and winter. Data are given as mean ± S.E.M. (n = 4), in wet weight ('as is').

	Whole body				Fillet			
	Summer	Winter	Mean	p-value	Summer	Winter	Mean	p-value
Dry matter	41.6 ± 0.21	41.8 ± 0.23	41.7 ± 0.15	0.468	41.2 ± 0.52	41.4 ± 0.44	41.3 ± 0.32	0.787
Ash	1.9 ± 0.1[b]	2.2 ± 0.1[a]	2.0 ± 0.1	0.027	1.6 ± 0.1[b]	2.2 ± 0.1[a]	1.9 ± 0.1	0.002
Crude lipids	23.0 ± 0.3	22.8 ± 0.6	22.9 ± 0.3	0.782	21.3 ± 0.7	21.3 ± 0.9	21.3 ± 0.5	0.971
Crude protein	16.7 ± 0.3	16.8 ± 0.1	16.8 ± 0.1	0.631	18.7 ± 0.5	19.0 ± 0.3	18.8 ± 0.3	0.618
Energy	12.7 ± 0.2	13.1 ± 0.2	12.9 ± 0.1	0.096	12.7 ± 0.3	12.6 ± 0.1	12.7 ± 0.1	0.722
Iron	10.9 ± 0.5	15.1 ± 2.6	13.0 ± 1.5	0.165	4.3 ± 0.5[b]	10.1 ± 1.7[a]	7.2 ± 1.4	0.017
Potassium	2 730 ± 73	2 752 ± 27	2 741 ± 36	0.790	2 852 ± 38[b]	3 221 ± 116[a]	3 036 ± 90	0.024
Calcium	2 801 ± 132	2 897 ± 183	2 849 ± 106	0.688	1 036 ± 51	1 168 ± 120	1 102 ± 65	0.348
Copper	2.2 ± 0.2	2.4 ± 1.1	2.3 ± 0.5	0.864	0.0	0.0	0.0	
Magnesium	252 ± 12	248 ± 4	250 ± 6	0.730	227 ± 8	249 ± 7	238 ± 6	0.085
Sodium	696 ± 50	694 ± 29	695 ± 27	0.965	407 ± 25	439 ± 28	423 ± 18	0.434
Zinc	34.8 ± 2.2	28.4 ± 1.8	31.6 ± 1.8	0.065	5.1 ± 0.4	–[A]	–[A]	
Phosphorus	3 104 ± 79	3 171 ± 92	3 137 ± 58	0.599	2 250 ± 35[b]	2 561 ± 59[a]	2 406 ± 67	0.004

[a, b] Significant differences (P < 0.05) within a row are indicated with different letters.
[A] Concentration of zinc in fillet collected in winter were below the limit of determination.

Table 3
Amino acid concentration (%) in whole body and fillet of Atlantic salmon collected during summer and winter. The amino acids are given as dehydrated residuals in wet weight ('as is'; mean ± S.E.M., n = 4).

	Whole body				Fillet			
	Summer	Winter	Mean	p-value	Summer	Winter	Mean	p-value
Essential amino acids								
Arg	0.90 ± 0.02[a]	0.85 ± 0.01[b]	0.88 ± 0.01	0.029	1.01 ± 0.02[a]	0.93 ± 0.01[b]	0.97 ± 0.02	0.030
His	0.40 ± 0.01[a]	0.37[b]	0.38 ± 0.01	0.001	0.45 ± 0.01[a]	0.41[b]	0.43 ± 0.01	0.022
Ile	0.65 ± 0.01[a]	0.61[b]	0.63 ± 0.01	0.010	0.74 ± 0.02	0.70 ± 0.01	0.72 ± 0.01	0.150
Leu	1.01 ± 0.02	0.98 ± 0.01	0.99 ± 0.01	0.122	1.13 ± 0.03	1.11 ± 0.02	1.12 ± 0.02	0.477
Lys	1.22 ± 0.02[a]	1.14 ± 0.01[b]	1.18 ± 0.02	0.004	1.38 ± 0.03	1.31 ± 0.03	1.34 ± 0.02	0.087
Met	0.44 ± 0.01	0.42 ± 0.01	0.43 ± 0.01	0.190	0.50 ± 0.01	0.48 ± 0.01	0.49 ± 0.01	0.253
Phe	0.60 ± 0.01	0.60	0.60 ± 0.01	0.448	0.66 ± 0.02	0.66 ± 0.01	0.66 ± 0.01	0.963
Thr	0.61 ± 0.01	0.59	0.60 ± 0.01	0.087	0.67 ± 0.02	0.66 ± 0.01	0.66 ± 0.01	0.339
Trp	0.15	0.15	0.15	0.133	0.18 ± 0.01	0.18	0.18	0.562
Val	0.76 ± 0.01[b]	0.81 ± 0.01[a]	0.79 ± 0.01	0.015	0.85 ± 0.02[b]	0.91 ± 0.01[a]	0.88 ± 0.02	0.047
Non-essential amino acids								
Ala	0.85 ± 0.02	0.86 ± 0.01	0.85 ± 0.01	0.556	0.93 ± 0.02	0.93 ± 0.01	0.93 ± 0.01	0.911
Asx[A]	1.39 ± 0.03[a]	1.32 ± 0.01[b]	1.35 ± 0.02	0.041	1.57 ± 0.03	1.48 ± 0.02	1.52 ± 0.02	0.065
Cys	0.12b	0.16a	0.14 ± 0.01	< 0.001	0.13[b]	0.18[a]	0.16 ± 0.01	< 0.001
Glx[A]	1.99 ± 0.05	1.89 ± 0.01	1.94 ± 0.03	0.102	2.24 ± 0.05	2.13 ± 0.03	2.19 ± 0.03	0.079
Gly	0.87 ± 0.04	0.86 ± 0.01	0.87 ± 0.02	0.900	0.90 ± 0.03	0.85 ± 0.02	0.88 ± 0.02	0.192
Pro[B]	0.79 ± 0.02[a]	0.62 ± 0.01[b]	0.70 ± 0.03	< 0.001	0.84 ± 0.03[a]	0.62 ± 0.01[b]	0.73 ± 0.04	0.001
Ser	0.56 ± 0.01	0.54	0.55 ± 0.01	0.368	0.61 ± 0.01	0.58 ± 0.01	0.60 ± 0.01	0.095
Tyr	0.49 ± 0.01	0.48	0.49 ± 0.01	0.348	0.55 ± 0.02	0.54 ± 0.01	0.55 ± 0.01	0.543
Sum	13.79 ± 0.29	13.23 ± 0.08	13.51 ± 0.17	0.110	15.34 ± 0.34	14.66 ± 0.18	15.00 ± 0.22	0.121

[a, b] Significant differences (P < 0.05) within a row are indicated with different letters.
[A] Asn og Gln are converted to Asp and Glu, respectively, during chemical analysis. Asx represents Asn + Asp and Glx represents Gln + Glu.
[B] The proline concentration in whole body and fillet sampled in summer was higher than expected.

for salmon for fillet analysis (Table 1).

For trout collected for whole body analysis, the body weight, fork length and condition factor were 4382 g, 61.2 cm and 1.91, respectively. The corresponding measures of trout collected for fillet analysis was 4118 g, 59.9 cm and 1.91, respectively. The distribution of males:females was 22:18 for trout for whole body analysis and 23:17 for trout for fillet analysis (Table 1). For all samples, the distribution of males:females was close to 50:50, and thus assumed to be representative to the distribution in the cages.

The fillet yield, achieved with manual filleting, was 62.4 % for salmon and 60.7 % for trout. This is somewhat lower yield than what is commonly reported for filleting machines. The conversion factor for salmon of this trim ('Trim A'; backbone off, bellibone off) defined by the Norwegian Directory of Fisheries is 1.579 when converting from fillet to round fish (Directory Of Fisheries, 2022). This corresponds to a fillet yield of 63 %, which is very close to the yield achieved manually in this study (Table 1). The conversion factor is not given for rainbow trout, but the fillet yield of trout is expected to be slightly lower than for salmon.

3.1. *Chemical composition of whole body and fillet of slaughter sized Atlantic salmon*

The composition of whole body and fillet of Atlantic salmon produced in Norway in 2020 is given in Tables 2–4. The sampling scheme was not aimed to reveal differences among summer and winter, but some differences were found. For zinc, the concentration was below determination level in the analysis in all fillet samples collected in winter. The same was found for trout (Table 5).

Compared to the whole body chemical composition data reported by Aas et al. (2019) only minor changes were observed. The dry matter, lipid and energy content show a minor increase. Among the minerals, phosphorus content has not changed but calcium was slightly reduced. In the 4 kg salmon reported by Shearer et al. (1994) dry matter and lipid was lower, protein similar and ash slightly higher, and so was calcium and phosphorus. The difference may be explained by difference in size and condition factor, but also by changes in the feed.

The amino acid profile of salmon in 2020 was almost identical to the

Table 4
Fatty acid composition (%) in whole body and fillet of Atlantic salmon collected during summer and winter. Data are given as % of wet weight ('as is'), mean ± S.E.M. (n = 4).

	Whole body				Fillet			
	Summer	Winter	Mean	p-value	Summer	Winter	Mean	p-value
C14:0	0.6 ± 0.1	0.4	0.5 ± 0.1	0.115	0.5 ± 0.1	0.4	0.5	0.172
C16:0	2.2 ± 0.2	1.9 ± 0.1	2.0 ± 0.1	0.281	2.0 ± 0.2	1.8 ± 0.1	1.9 ± 0.1	0.420
C16:1 n-7	0.6 ± 0.1	0.5	0.5	0.109	0.5	0.5	0.5	0.211
C16:2 n-6	0.1	0.1	0.1	0.368	0.1	0.0	0.0	0.384
C18:0	0.0[b]	0.6[a]	0.3 ± 0.1	< 0.001	0.0[b]	0.5[a]	0.3 ± 0.1	< 0.001
C18:1 n-9	6.5 ± 1.0	8.0 ± 0.2	7.2 ± 0.6	0.186	5.9 ± 0.9	7.5 ± 0.3	6.7 ± 0.5	0.144
C18:1 n-7	0.6	0.6	0.6	0.397	0.5	0.6	0.5	0.262
C18:2 n-6	2.8 ± 0.1	2.9 ± 0.1	2.9 ± 0.1	0.425	2.6 ± 0.1	2.7 ± 0.1	2.7 ± 0.1	0.405
C18:3 n-3	1.2 ± 0.2	1.3 ± 0.1	1.2 ± 0.1	0.648	1.1 ± 0.2	1.2	1.2 ± 0.1	0.646
C20:0	0.1	0.1	0.1	0.191	0.1	0.1	0.1	0.131
C20:1 n-11	0.2	0.1	0.2	0.244	0.2	0.1	0.1	0.257
C20:4 n-3	0.1 ± 0.1	0.0	0.1	0.385	0.1 ± 0.1	0.0	0.1	0.283
C20:1 n-9	0.9 ± 0.2	0.7	0.8 ± 0.1	0.289	0.8 ± 0.2	0.6	0.7 ± 0.1	0.363
C20:2 n-6	0.2	0.2	0.2	0.965	0.2	0.2	0.2	0.957
C20:4 n-6	0.1	0.1	0.1	0.372	0.1	0.0	0.1	0.429
C20:3 n-3	0.1	0.1	0.1	0.800	0.1	0.1	0.1	0.806
C22:1 n-7	0.2	0.2	0.2	0.097	0.2	0.2	0.2	0.119
C22:1 n-11	0.9 ± 0.4	0.4	0.6 ± 0.2	0.228	0.8 ± 0.4	0.4	0.6 ± 0.2	0.261
C22:1 n-9	0.1	0.1	0.1	0.471	0.1	0.1	0.1	0.460
C20:5 n-3 (EPA)	0.6	0.6	0.6	0.243	0.6	0.5	0.6	0.117
C24:1 n-9	0.1	0.1	0.1	0.519	0.1	0.1	0.1	0.598
C22:5 n-3	0.3	0.3	0.3	0.144	0.3	0.2	0.3	0.152
C22:6 n-3 (DHA)	1.0 ± 0.2	0.8 ± 0.1	0.9 ± 0.1	0.400	1.0 ± 0.2	0.7 ± 0.1	0.9 ± 0.1	0.315
Sum EPA + DHA	1.6 ± 0.2	1.4 ± 0.1	1.5 ± 0.1	0.341	1.6 ± 0.2	1.3 ± 0.1	1.4 ± 0.1	0.243
Sum n-3	3.3 ± 0.1	3.1 ± 0.1	3.2 ± 0.1	0.118	3.2 ± 0.2	2.9 ± 0.1	3.0 ± 0.1	0.141
Sum n-6	3.2 ± 0.1	3.3 ± 0.1	3.3 ± 0.1	0.596	3.0 ± 0.2	3.1 ± 0.1	3.1 ± 0.1	0.534
Sum saturated fatty acids	3.0 ± 0.3	3.1 ± 0.1	3.1 ± 0.1	0.782	2.8 ± 0.3	2.9 ± 0.2	2.8 ± 0.2	0.668
Ratio n-6/n-3	1.0	1.1	1.0	0.051	0.9[b]	1.1[a]	1.0	0.005

[a, b] Significant differences (P < 0.05) within a row are indicated with different letters.

Table 5
Chemical analysis of dry matter (%), ash (%), crude lipid (%), crude protein (Nx6.25; %), energy (MJ/kg) and selected minerals (mg/kg) in whole body and fillet of rainbow trout collected during summer and winter. Data are given as mean ± S.E.M. (n = 2), in wet weight ('as is').

	Whole body				Fillet			
	Summer	Winter	Mean	p-value	Summer	Winter	Mean	p-value
Dry matter	44.6 ± 2.17	45.8 ± 0.59	45.2 ± 0.98	0.655	41.12	42.5 ± 0.88	41.8 ± 0.53	0.270
Ash	1.6 ± 0.1	2.2 ± 0.2	1.9 ± 0.2	0.064	1.4[b]	2.3 ± 0.1[a]	1.8 ± 0.3	0.009
Crude lipid	24.0 ± 2.7	28.5 ± 0.2	26.3 ± 1.7	0.235	22.2 ± 0.5	23.5 ± 1.5	22.8 ± 0.8	0.502
Crude protein	16.6 ± 0.4	15.6	16.1 ± 0.3	0.156	18.6 ± 0.9	18.3 ± 0.7	18.4 ± 0.5	0.823
Energy	13.8 ± 1.0	14.1 ± 0.3	14.0 ± 0.4	0.764	12.9 ± 0.1	13.0 ± 0.2	13.0 ± 0.1	0.580
Iron	11.6 ± 3.4	13.1 ± 0.7	12.4 ± 1.5	0.706	3.3 ± 0.3b	7.3 ± 0.5a	5.3 ± 1.2	0.023
Potassium	2 426 ± 27	2 290 ± 110	2 358 ± 61	0.355	2 746 ± 54	3 206 ± 272	2 976 ± 174	0.238
Calcium	4 474 ± 617	2 899 ± 90	3 687 ± 521	0.128	901 ± 18	929 ± 58	915 ± 26	0.692
Copper	1.8[a]	1.2 ± 0.1[b]	1.5 ± 0.2	0.026	0.0	0.0	0.0	
Magnesium	261 ± 17	225 ± 7	243 ± 13	0.176	210 ± 3	242 ± 17	226 ± 12	0.205
Sodium	653 ± 88	590 ± 45	621 ± 44	0.589	369 ± 35	456 ± 61	412 ± 38	0.344
Zinc	16.5 ± 0.5	12.0 ± 1.4	14.2 ± 1.4	0.095	2.5 ± 2.5	_[A]	_[A]	
Phosphorus	3 614 ± 321	2 969 ± 202	3 291 ± 242	0.655	2 054 ± 35	2 368 ± 76	2 211 ± 97	0.064

[a, b] Significant differences (P < 0.05) within a row are indicated with different letters.
[A] Concentration of zinc in fillet collected in winter were below the limit of determination.

profile reported by Aas et al. (2019). An exception was higher proline concentration in both salmon and trout found in samples collected in summer. This was not found in the previous study (Aas et al., 2019). The amino acid composition can be affected by inclusion level of plant ingredients (Mente et al., 2003; Sissener et al., 2013) and proline takes part in several metabolic pathways. However, we do not have an explanation for the high proline concentration found in samples collected during summer in both salmon and trout.

The fatty acid profile was very similar to the data reported by Aas et al. (2019). Fatty acid composition of the fish reflects that of the feed used.

3.2. *Chemical composition of whole body and fillet of slaughter sized rainbow trout*

The composition of whole body and fillet of rainbow trout produced in Norway in 2020 is given in Tables 5–7. As for salmon (Table 2), the zinc concentration in the fillet samples of trout collected in winter was below determination level (Table 5).

The composition reported by Shearer (1984) was clearly different from what we found in 2020. He found a dry matter below 35 % compared to 45 % in our study. The mineral content showed several differences, and calcium and phosphorus was clearly higher in the data from Shearer (1984). Feed, genetic material and growth was very different in 1984 and may all have contributed to the change. The body composition is also affected by feed intake (Grisdale-Helland et al.,

Table 6
Amino acid concentration (%) in whole body and fillet of rainbow trout collected during summer and winter. The amino acids are given as dehydrated residuals in wet weight ('as is'; mean ± S.E.M., n = 2).

	Whole body				Fillet			
	Summer	Winter	Mean	p-value	Summer	Winter	Mean	p-value
Essential amino acids:								
Arg	0.864	0.83	0.852	0.553	1.002	0.932	0.972	0.135
His	0.401	0.351	0.382	0.088	0.461	0.422	0.441	0.295
Ile	0.601	0.571	0.591	0.158	0.712	0.67	0.691	0.179
Leu	0.942	0.922	0.931	0.686	1.081	1.081	1.081	0.894
Lys	1.164	1.092	1.123	0.218	1.352	1.301	1.332	0.183
Met	0.413	0.401	0.411	0.805	0.501	0.471	0.491	0.151
Phe	0.581	0.58	0.581	0.925	0.65[b]	0.67[a]	0.661	0.014
Thr	0.561	0.541	0.551	0.317	0.64	0.631	0.64	0.672
Trp	0.13	0.131	0.13	0.763	0.15[b]	0.17[a]	0.161	0.023
Val	0.721	0.771	0.752	0.068	0.811b	0.901a	0.853	0.029
Non-essential amino acids:								
Ala	0.803	0.811	0.801	0.826	0.932	0.922	0.921	0.768
Asx[A]	1.334	1.262	1.293	0.266	1.54	1.482	1.512	0.133
Cys	0.13	0.14	0.14	0.151	0.131	0.170	0.151	0.070
Glx[A]	1.897	1.813	1.854	0.374	2.19	2.155	2.172	0.487
Gly	0.888	0.841	0.864	0.704	0.789	0.914	0.855	0.333
Pro[B]	0.792[a]	0.581[b]	0.686	0.013	0.885[a]	0.65[b]	0.767	0.041
Ser	0.532	0.521	0.531	0.875	0.601	0.591	0.601	0.628
Tyr	0.441	0.441	0.441	0.739	0.52	0.511	0.52	0.614
Sum	13.16 ± 0.47	12.58 ± 0.18	12.87 ± 0.26	0.368	14.917	14.65 ± 0.20	14.78 ± 0.11	0.334

[a, b] Significant differences ($P < 0.05$) within a row are indicated with different letters.
[A] Asn og Gln are converted to Asp and Glu, respectively, during chemical analysis. Asx represents Asn + Asp and Glx represents Gln + Glu.
[B] The proline concentrations in whole body and fillet sampled in summer was higher than expected.

Table 7
Fatty acid composition (%) in whole body and fillet of rainbow trout collected during summer and winter. Data are given as % of wet weight ('as is'), mean ± S.E.M. (n = 2).

	Whole body				Fillet			
	Summer	Winter	Mean	p-value	Summer	Winter	Mean	p-value
C14:0	0.4 ± 0.1	0.6 ± 0.1	0.5 ± 0.1	0.189	0.3	0.5 ± 0.1	0.4 ± 0.1	0.291
C15:0	0.0	0.1	0.0	0.113	0.0	0.0	0.0	0.198
C16:0	2.2 ± 0.3	2.6	2.4 ± 0.2	0.302	2.0	2.2 ± 0.2	2.1 ± 0.1	0.361
C16:1 n-9	0.0	0.1	0.1	0.261	0.0	0.0	0.0	0.533
C16:1 n-7	0.6 ± 0.1	0.8 ± 0.1	0.7 ± 0.1	0.219	0.6	0.7 ± 0.1	0.6 ± 0.1	0.522
C16:2 n-6	0.0	0.1	0.1	0.179	0.0	0.1	0.1	0.341
C18:0	0.0[b]	0.8[a]	0.4 ± 0.2	0.002	0.0[b]	0.6[a]	0.3 ± 0.2	0.002
C18:1 n-11	0.0[b]	0.1[a]	0.0	< 0.001	0.0[b]	0.0[a]	0.0	< 0.001
C18:1 n-9	7.9 ± 0.5	9.7 ± 0.1	8.8 ± 0.6	0.072	7.2 ± 0.4	7.9 ± 0.6	7.5 ± 0.3	0.482
C18:1 n-7	0.5 ± 0.1	0.7	0.6 ± 0.1	0.070	0.5	0.6	0.6	0.255
C18:2 n-6	3.4 ± 0.4	3.7 ± 0.4	3.6 ± 0.2	0.700	3.2 ± 0.1	3.0 ± 0.1	3.1 ± 0.1	0.267
C18:3 n-3	1.9 ± 0.5	1.8 ± 0.1	1.9 ± 0.2	0.802	1.8 ± 0.1	1.5	1.6 ± 0.1	0.179
C20:0	0.1[b]	0.1[a]	0.1	0.030	0.1	0.1	0.1	0.444
C20:1 n-11	0.2	0.2	0.2	0.559	0.1	0.1	0.1	0.956
C20:1 n-9	0.4	0.6 ± 0.1	0.5 ± 0.1	0.117	0.4	0.5 ± 0.1	0.5 ± 0.1	0.429
C20:2 n-6	0.2	0.2	0.2	0.512	0.2	0.1	0.2	0.255
C20:3 n-6	0.1	0.1	0.1	0.839	0.1	0.0	0.1	0.335
C20:4 n-6	0.1	0.1	0.1	0.145	0.1	0.1	0.1	0.158
C20:3 n-3	0.1	0.1	0.1	0.913	0.1	0.1	0.1	0.414
C22:1 n-7	0.1	0.2	0.2	0.372	0.1	0.1	0.1	0.803
C22:1 n-11	0.2	0.3 ± 0.1	0.3	0.163	0.2	0.3 ± 0.1	0.2	0.382
C22:1 n-9	0.1[b]	0.1[a]	0.1	0.021	0.1	0.1	0.1	0.195
C20:5 n-3 (EPA)	0.5 ± 0.1	0.7 ± 0.1	0.6 ± 0.1	0.154	0.5	0.5	0.5	0.393
C24:0	0.1	0.1 ± 0.1	0.1	0.956	0.1	0.0	0.0	0.810
C24:1 n-9	0.0[b]	0.1[a]	0.1	0.027	0.0	0.1	0.1	0.437
C22:5 n-3	0.2	0.3	0.3	0.135	0.2	0.3	0.2	0.282
C22:6 n-3 (DHA)	0.9 ± 0.1	1.2 ± 0.1	1.1 ± 0.1	0.104	0.9[b]	1.0[b]	1.0	0.014
Sum EPA+DHA	1.4 ± 0.2	1.9	1.7 ± 0.2	0.079	1.4	1.6 ± 0.1	1.5 ± 0.1	0.140
Sum n-3	3.7 ± 0.7	4.1 ± 0.1	3.9 ± 0.3	0.610	3.5 ± 0.1	3.4 ± 0.2	3.4 ± 0.1	0.662
Sum n-6	3.8 ± 0.5	4.1 ± 0.4	4.0 ± 0.3	0.674	3.5 ± 0.1	3.4 ± 0.1	3.4 ± 0.1	0.193
Sum saturated fatty acids	2.8 ± 0.4	4.3	3.6 ± 0.5	0.076	2.6	3.6 ± 0.3	3.1 ± 0.3	0.073
Ratio n-6/n-3	1.0 ± 0.1	1.0 ± 0.1	1.0	0.669	1.0	1.0 ± 0.1	1.0	0.819

[a, b] Significant differences ($P < 0.05$) within a row are indicated with different letters.

2013).

As for salmon, the content of proline in trout sampled in summer was unexpectedly high (Table 6).

4. Concluding remarks

The present study documents the chemical composition of whole body and fillet of the average Atlantic salmon and rainbow trout produced in Norway in 2020. The data were intended for use in calculations of the utilization of feed resources in Norwegian aquaculture in 2020 (Aas et al., 2022a, 2022b). The data can also be used as a reference in studies of the fish' requirements, in evaluation of resource utilization, for estimates of production efficiency, for advice on human nutrition, or other contexts where the composition of the main nutrients of slaughter sized salmon and trout is asked for.

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CRediT authorship contribution statement

Turid Synnøve Aas: Project manager, data processing and calculations, writing of manuscript. **Torbjørn Åsgård:** Collection of samples, data processing, writing of manuscript. **Trine Ytrestøyl:** Methodology, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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