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SUOMEN KALATALOUS
FINLANDS FISKERIER

40

WESTMAN, KAI, OLLI SUMARI & JORMA J. LAINE: **Comparative dry diet feeding experiment on rainbow trout (Salmo gairdneri Richardson) in floating net-containers.**

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Sammandrag: Jämförande torrfoderförsök med regnbågslax (Salmo gairdneri Richardson) i flytande nätkassar.

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I. INTRODUCTION

The propagation of salmonids, especially rainbow trout (*Salmo gairdneri* Richardson), has increased considerably in Finland during the last few years. The introduction of dry pelleted diets in the early sixties has probably contributed to this trend. Dry diets were shown to be superior to wet food for the propagation of salmon and trout towars the end of the fifties, as a resuld of extensive research, especially in the U.S.A. (Brockway 1953, Willoughby 1953, Grassl 1958, Maxwell 1958, Schumacher 1958, Phillips et al. 1954, 1957, 1964, Hublou et al. 1959).

Pelleted dry diets are easier and more economical to prepare, store, transport and use than wet food. They are also efficient producers of fish and are available all the year round, their loss through leaching is negligible, feeding can be automatized and the quality can be controlled (Ruhdel 1964, Bruschek and Hemsen 1966, Eklund 1966, Halme and Orpana 1968). On the other hand, after prolonged feeding with dry diets various undesirable phenomena have been observed in fish even during the last few years. These include slight deficiency symptoms and weakness in the development of eggs (Phillips et al. 1964), anaemia (Grassl 1958, Schumacher 1958, Steffens 1968) and fatty liver (Faktorovich 1958, Klingler 1958, Mann 1961, Otte 1966).

The importance of fish as food is based primarily upon the fact that it is an excellent source of protein of high biological value (Geiger and Borgstrom 1961). As not only the amount of edible flesh but also its chemical composition can be influenced by nutrition, fish foods should not be judged solely by the methods generally used (i.e. gains in weight, mortality, health, condition factor and the conversion of food into fish) but also by the composition of the fish flesh produced. Thus the fattening of fish due to overfeeding and/or feeding with a high-calorie diet would not be considered as excellent true growth.

To date, very little information about dry diet feeding experiments on salmonids has been published in Finland. Laine et al. (1967 a) have published the results of a comparative feeding trial in which rainbow trout were propagated in floating net-containers and fed an imported floating dry fish food and two domestic non-floating dry diets. Aho (1968) has presented the results of long-term trials in which rainbow trout were fed on Ewos pellets in nets. Feeding experiments with some of these, imported diets have been conducted abroad (Deufel 1963, Wiesner 1963, Mann and Engelhardt 1964, Eklund 1966).

The purpose of the present study was to examine and compare the value of domestic and foreign commercial dry diets for rainbow trout in a feeding experiment in nets. Some of the diets used were still at an experimental stage. Comparisons have been made between growth, mortality, condition factors and flesh colour, the conversion of food into fish flesh, and food costs to produce one kilo of fish. Furthermore, the raw materials are discussed and the chemical composition of the diets has been analysed and compared with that of the propagated trout and their livers. A preliminary report on some of the results of this experiment has already been published (Westman and Sumari 1967).

II. MATERIAL AND METHODS

The experiment was conducted during summer 1966 at Pyhäjärvi (southern Finland) in Kalakas, a dystrophic pond with no inlets or outlets, and an area of c. 0.6 ha. The lake has a maximum depth of 13 m and even near the banks the depth is from 4 to 5 m.

A. Test fish and rearing nets

The test fish was rainbow trout (*Salmo gairdneri* Richardson). The spawn was of Danish origin and was hatched at Kissalampi Experiment Station (Board of Agriculture, Bureau of Fisheries Investigation) in spring 1965. The fish were not graded before the trial. They were transported to the lake on May 27, 1966, i.e. 10 days before the start of the actual trial. The fish were randomly divided into lots of 200 and stocked into 10 floating rearing nets 180 × 180 × 190 cm in size (Kalakas Oy, Helsinki). The volume of the part of the net in the water was approximately 5 m^3 and the mesh size 15 mm. The trout averaged 14.5 cm and 34.5 g. The density of fish per net was 1.4 kg/m^3. The net-containers covered with nets were anchored 0.5 metres apart from a floating feeding pier and 1.5 metres apart from each other (Fig. 1). Beneath each net the depth of free water was at least 5 metres. The water in the nets was changed mainly by the winds and the movements of the fish, as there was no noteworthy water circulation in the lake.

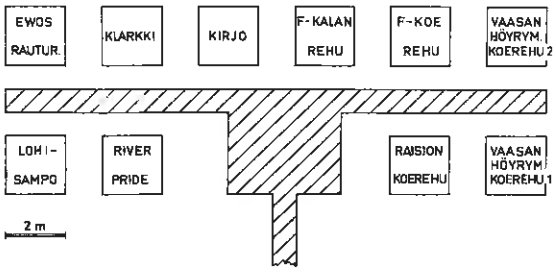

Fig. 1. The sites of the net-containers in the feeding experiment.

Kuva 1. Verkkoaltaiden sijoittelu kasvatuskokeessa. Ruokintalaituri viivoitettu.

Fig. 1. Skiss över nätkassarnas placering vid uppfödningsförsöket. Bryggan från vilken utfodring skedde skuggad.

B. Tested dry diets

Fish groups 1 to 6 were fed diets already on the market and groups 7 to 10 were fed commercial diets still at an experimental stage. The dry diets tested are listed in Table 1.

Groups 3 and 6 were given the same dry diet (River Pride has been on the Finnish market under the name of F-Kalarehu also), so actually only nine different dry diets were tested. The diet was chosen randomly for each group.

The total chemical composition, raw materials and composition of the vitamin supplements is presented in Tables 2,3 and 6 according to the information of the manufacturers or the importers. In Table 2 is also presented calories per kg of diet and the percentage of calories as protein. Dietary calories were calculated from the values recommended by PHILLIPS and BROCKWAY (1959), i.e. 8.0 kcal/g fat, 3.9 kcal/g protein and 1.6 kcal/g carbohydrates. The values were calculated on the basis of the information presented in Table 2. Calories as protein were

Group 1. Lohi-Sampo. Non-floating. Manufacturer Turun Muna Oy Rehutehdas, Turku, Finland.
Ryhmä 1. Lohi-Sampo. Uppoava. Valmistaja Turun Muna Oy Rehutehdas, Turku, Suomi.
Grup 1. Lohi-Sampo. Sjunkande. Tillvärkare Turun Muna Oy Rehutehdas. Åbo. Finland.

Group 2. Ewos Rauturehu F 52 B. Floating. Manufacturer AB Ewos, Södertälje, Sweden.
Ryhmä 2. Ewos Rauturehu F 52 B. Kelluva. Valmistaja AB Ewos, Södertälje, Ruotsi.
Grup 2. Ewos Forellfoder F 52 B. Flytande. Tillvärkare AB Ewos, Södertälje, Sverige.

Group 3. River Pride. Floating. Manufacturer M. Janssen (Accessories) Ltd. London, England.
Ryhmä 3. River Pride. Kelluva. Valmistaja M. Janssen (Accessories) Ltd, Lontoo, Englanti.
Grup 3. River Pride. Flytande. Tillvärkare M. Janssen (Accessories) Ltd, London, England.

Group 4. Klarkki (Clarks New Age Dry Fish Feed). Non-floating. Manufacturer Dansk Orredfoder A/S, Brande, Denmark.
Ryhmä 4. Klarkki (Clarks New Age Dry Fish Feed). Uppoava. Valmistaja Dansk Orredfored A/S, Brande, Tanska.
Grup 4. Klarkki (Clarks New Age Dry Fish Feed). Sjunkande. Tillvärkare Dansk Orredfoder A/S, Brande, Danmark.

Group 5. Kirjo. Non-floating. Manufacturer OTK Rehutehdas, Hämeenlinna, Finland.
Ryhmä 5. Kirjo. Uppoava. Valmistaja OTKn Rehutehdas, Hämeenlinna, Suomi.
Grup 5. Kirjo. Sjunkande. Tillvärkare OTK Rehutehdas. Tavastehus, Finland.

Group 6. F-Kalanrehu (= River Pride). Floating. The same manufacturer as for River Pride (group 3).
Ryhmä 6. F-Kalanrehu. (= River Pride). Kelluva. Sama valmistaja kuin River Pridella (ryhmä 3).
Grup 6. F-Kalanrehu (= River Pride). Flytande. Samma tillvärkare som River Pride har (grup 3).

Group 7. Raision Koerehu. Non-floating. Manufacturer Raision Tehtaat Oy, Raisio, Finland.
Ryhmä 7. Raision Koerehu. Uppoava. Valmistaja Raision Tehtaat Oy, Raisio, Suomi.
Grup 7. Raision Koerehu. Sjunkande. Tillvärkare Raision Tehtaat Oy, Raisio, Finland.

Group 8. F-Koerehu. Non-floating. Manufacturer Farmos Oy, Turku, Finland.
Ryhmä 8. F-Koerehu. Uppoava. Valmistaja Farmos Oy Turku, Suomi.
Grup 8. F-Koerehu. Sjunkande. Tillvärkare Farmos Oy, Åbo, Finland.

Group 9. Vaasan Höyrymyllyn Koerehu 1. Non-floating. Manufacturer Vaasan Höyrymyllyn Osakeyhtiö, Helsinki, Finland.
Ryhmä 9. Vaasan Höyrymyllyn Koerehu 1. Uppoava. Valmistaja Vaasan Höyrymylly Osakeyhtiö, Helsinki, Suomi.
Grup 9. Vasa Ångkvarns Koerehu 1. Sjunkande. Tillvärkare Vasa Ångkvarns AB, Helsingfors, Finland.

Group 10. Vaasan Höyrymyllyn Koerehu 2. Non-floating. The same manufacturer as above.
Ryhmä 10. Vaasan Höyrymyllyn Koerehu 2. Uppoava. Sama valmistaja kuin edellisellä.
Grup 10. Vasa Ångkvarns Koerehu 2. Sjunkande. Samma tillvärkare som ovanpå.

Table 1. Dry diets in the feeding experiment.
Taulukko 1. Kokeessa mukana olleet kuivarehut.
Tabell 1. Vid försöket prövade torrfoderpreparat.

calculated from crude protein and calories as carbodydrates from the nonprotein extracts. For River Pride = F-Kalanrehu no calculation of calories was made because of incomplete information on the total composition of the diet.

C. Feeding

The amount of food given to the fish was adjusted according to the feeding tables for dry diets in the New York State Fish Hatchery Feeding Chart (Deuel et al. 1952). Changes in the water temperature were taken into account once a week and changes caused by the growth of the fish were taken into account after June 5, June 29, August 12 and Sept. 16, when the fish were weighed. Although the feeding tables were followed as closely as possible, feeding was always stopped if it was observed that the fish did not accept the food. Throughout the experiment feeding was performed by the same person by hand.

The trout were fed twice a day every day of the week. Pellet sizes were changed according to the growth of the fish.

Composition of diets *Rehujen koostumukset* Foderpreparatens sammansättning		Lohi-Sampo	Evos Rautu-rehu	River-Pride	Klarkki	Kirjo	F-Kalan-rehu	Raision Koerehu	F-Koe-rehu	Vaasan Höyrym. Koe-rehu 1	Vaasan Höyrym. Koe-rehu 2
		1	2	3	4	5	6	7	8	9	10
Water — *Kosteutta* — Vattenhalt ...	%	9.0	7.0	—	9.0	6.3	—	9.8	8.0	8.0	8.0
Crude fat — *Raakarasvaa* — Råfett	»	5.0	4.0	4.5	8.0	3.4	4.5	6.0	2.5	6.5	6.5
Crude protein — *Raakavalkuaista* — Råprotein	»	35.0	30.0	35.0	40.0	43.0	35.0	28.7	39.0	38.0	38.0
Crude fibre—*Raakakuitua*—Råfiber	»	5.0	2.0	4.0	4.5	3.4	4.0	9.0	2.5	4.5	4.5
Nonprotein extracts — *Typettömiä uuteaineita* — Kväverfria extraktämnen	»	36.0	40.0	—	25.0	16.9	—	29.5	33.0	31.0	31.0
Ash — *Tuhkaa* — Aska	»	10.0	10.0	—	13.5	27.0	—	17.0	15.0	12.0	12.0
Melting crude protein — *Sulavaa raakavalkuaista* — Smältbart råprotein	»	33.0	24.0	—	35.0	35.4	—	25.3	—	33.0	33.0
Melting pure protein — *Sulavaa puhdasvalkuaista* — Smältbart renprotein	»	30.0	21.0	—	31.0	29.5	—	22.0	—	30.0	30.0
Food (kg) corresponding one food-unit — *Yhtä rehuyksikköä vastaava rehumäärä (kg)* — Foder (kg) motsvarande 1 foderenhet	»	1.01	0.98	—	1.12	1.25	—	1.15	—	1.01	1.01
Kcal/kg diet — *Kcal/kg rehua* — Kcal/kg foder	»	2 341	2 130	—	2 600	2 219	—	2 071	2 249	2 498	2 498
Percent of calories as protein — *Valkuaisen kaloripitoisuus prosentteina*— Procentuella kaloriinnehållet i protcinet	»	58.3	54.9	—	60.0	75.6	—	54.0	67.6	59.3	59.3

Table 2. Percentage composition of diets according to information supplied by the manufacturers, calculated calories per kilo, and percentage of calories in the form of protein.

Taulukko 2. Rehujen kokonaiskoostumukset valmistajien ilmoituksen mukaan sekä koostumusten perusteella lasketut rehujen kaloripitoisuudet ja valkuaisen prosentuaalinen kaloripitoisuus.

Tabell 2. Foderpreparatens sammansättning enligt tillverkarnas uppgifter samt på basen av sammansättningen beräknat kaloriinnehåll och det procentuella kaloriinnehållet i proteinet.

Before they were brought to the lake and between May 27 and June 1, the experimental rainbow trout had been fed with Klarkki and consequently fishgroup 4 served as the control group. A gradual change-over to the test diets was made between June 1 and June 5. During that period the food consisted of 50 per cent Klarkki and 50 per cent of the test diet. Feeding of group 10 was started straight away with the test diet on June 5, as it was impossible to get the diet to the lake earlier.

The fish were fed with the dry diets without meat supplementation. As there are no wild fish in Kalakas pond, the only possible food besides the pellets were plankton and so-called aerial nutrition. These, however, had no significance as regards the comparison of the test diets, since this kind of nutrition was equally available in all the nets.

The experiment began on May 5, and terminated on October 23, after a 141-day feeding period. It was not possible to conduct the experiment in duplicate, but as groups 3 and 6 were fed on the same pellets (River Pride = F-Kalanrehu), the growth of the fish in these groups gives some idea of the equality of the conditions prevailing in different parts of the experimental area.

D. Water samples for physical and chemical analyses

Water samples were taken near the nets at 0.5 metres with a Ruttner water sampler. The

Diet components *Rehujen raaka-aine koostumukset* Foderpreparatens halt av råämnen		Lohi-Sampo	Ewos Rautu-rehu	River-Pride	Klarkki	Kirjo	F-Kalan-rehu	Raision Koe-rehu	F-Koe-rehu	Vaasan Höyrym. Koer. 1	Vaasan Höyrym. Koer. 2
		1	2	3	4	5	6	7	8	9	10
Fishmeal — *Kalajauhoja* — Fiskmjöl ...	%	20.0	30.0	X	10.0	25.0	X	X	X	30.0	30.0
Fish extract—*Kalauutetta*—Fiskextrakt	»	—	—	—	5.0	—	—	—	—	—	—
Whale meat meal — *Valaanlihajauhoja* — Valköttmjöl	»	—	—	—	—	20.0	—	—	X	12.0	4.0
Meat+bonemeal—*Lihaluurehujauhoja* — Köttbenmjöl	»	—	—	—	—	—	—	—	X	—	—
Liver meal—*Maksajauhoja*—Levermjöl	»	2.0	—	X	12.0	3.0	X	X	—	4.0	4.0
Blood meal — *Verijauhoja* — Blodmjöl	»	—	—	—	3.0	—	—	—	—	—	—
Milk powder — *Maitojauhetta* — Mjölkpulver	»	—	—	—	—	2.0	—	X	X	—	—
Whey meals — *Herajauhoja* — Vasslemjöl	»	—	5.6	—	7.0	—	—	—	—	3.0	3.0
Skimmed milk powder — *Kurrijauhoja*—Skummjölkpulver	»	—	—	—	—	—	—	—	X	—	—
Crustacean meal — *Äyriäistjauhoja* — Kräftdjursmjöl	»	—	—	—	—	5.0	—	—	—	—	—
Shrimp meal — *Katkarapujauhoja* — Räkmjöl	»	8.0	—	—	11.0	—	—	X	—	—	8.0
Fish oil — *Kalaöljyä* — Fiskolja	»	—	—	—	2.0	—	—	—	—	—	—
Fish liver oil—*Kalanmaksaöljyä*—Fiskleverolja	»	2.0	—	—	—	—	—	—	—	3.0	3.0
Fat — *Rasvaa* — Fett	»	—	—	—	—	—	—	—	—	3.0	3.0
Preserved animal fat — *Stabiloitua eläinrasvaa* — Stabiliserat animaliskt fett ..	»	—	—	X	—	—	X	—	—	—	—
Wheat meal — *Vehnäjauhoja* — Vetemjöl	»	—	—	X	8.0	6.0	X	—	X	—	—
Wheat bran — *Vehnäleseitä* — Vetekli ..	»	—	—	—	—	—	—	X	—	—	—
Wheat — *Vehnäalkioita* — Vetegrobber	»	—	—	—	—	—	—	X	—	—	—
Oatmeal — *Kaurajauhoja* — Havremjöl	»	—	56.8	—	—	—	—	X	—	18.0	18.0
Soya bean meal — *Soijajauhoja* — Sojamjöl	»	10.0	—	X	11.0	7.0	X	X	X	5.0	5.0
Grass leaf meal — *Viherjauhoja* — Grönmjöl	»	—	—	X	—	10.0	X	X	—	8.0	8.0
Flax meal — *Pellavajauhoja* — Linmjöl	»	—	—	—	—	3.0	—	—	—	—	—
Kelp meal — *Leväjauhoja* — Algmjöl ..	»	5.0	—	—	—	—	—	—	X	8.0	8.0
Lucerne meal — *Sinimallasjauhoja* — Lucernmjöl	»	10.0	—	—	—	—	—	—	—	—	—
Corn wash—*Maissirankkia*—Majsdrank	»	—	—	—	13.5	—	—	—	—	—	—
Coco groats — *Kookosroubetta* —Kokosgröpe	»	—	—	—	—	0.5	—	X	—	—	—
Molasses — *Melassia* — Melass	»	—	—	X	4.0	1.0	X	X	—	—	—
Malt extract — *Mallasuutetta* — Maltextrakt	»	16.0	—	—	—	—	—	—	—	—	—
Lecithin — *Lesitiiniä* — Lecitin	»	—	—	—	1.0	—	—	—	—	—	—
Distiller's dried solubles — *Rehubiivaa*—Foderjäst	»	20.0	—	—	10.0	6.0	—	X	—	6.0	6.0
Dried brewer's yeast — *Hiivaa* — Jäst	»	—	5.5	X	—	—	X	—	X	—	—
Feed lime — *Rehukalkkia* — Foderkalk	»	—	2.0	—	—	—	—	X	—	—	—
Chalk meal — *Rehuliitujauhoja* — Foderkrita	»	—	—	—	—	0.5	—	—	—	—	—
Feed phosphate — *Rehufosfaattia* — Foderfosfat	»	—	—	—	0.5	—	—	X	—	—	—
Dicalcium phosphate — *Dikalsium fosfaattia* — Dikalciumfosfat	»	—	—	X	—	0.5	X	—	—	—	—
Calcium lignosulphonate — *Kalsium lignosulfonaattia* — Kalciumlignosulfonat	»	2.0	—	—	—	—	—	—	—	—	—
Salt — *Suolaa* — Salt	»	2.0	—	X	1.0	0.999	X	X	X	2.0	2.0
Potassium iodide — *Kaliumjodidia* — Kaliumjodid	»	0.003	—	X	—	0.001	X	—	—	—	—
Manganese oxide — *Mangaanioksidia* — Manganoxid	»	—	—	X	—	—	X	—	—	—	—

Continue — *Jatkuu* — Forts.

	1	2	3	4	5	6	7	8	9	10
Sodium ferrite — *Natriumferriittiä* — Natriumferrit ..... »	—	—	X	—	—	X	—	—	—	—
Vitamin supplement — *Vitamiiniseosta* — Vitaminblandning ..... »	3.0	0.5	X	1.0	10.0	X	X	X	1.0	1.0
Colouring matter—*Väriainetta*—Färgämnen ..... »	—	0.2	—	—	—	—	—	—	—	—
Binding substances — *Sideainetta* — Bindemedel ..... »	—	—	—	—	—	—	—	X	—	—

Table 3. Diet components according to information supplied by the manufacturers.
Taulukko 3. Rehujen raaka-ainekoostumukset valmistajien ilmoitusten mukaan.
Tabell 3. Foderpreparatens halt av råämnen enligt tillverkarnas uppgifter.

temperature and pH of the water were determined on the spot. Dissolved oxygen content, conductivity, total hardness, $KMnO_4$ consumption and colour of the water were determined at the laboratory of the Bureay of Fisheries Investigation.

The temperature of the water was measured twice a day from samples taken at 0.5 metres.

E. Fish samples

For sampling, the nets were raised, so as to collect all the fish in a small volume of water. An unselected sample was netted up.

The sampled fish were anaesthetized with M.S. 222 (tricaine methanesulfonate, Sandoz Ltd., Basel, Switzerland). The fish were measured and weighed individually.

Each fish was measured to the nearest millimetre from the tip of the chin to the end of the stretshed tail fin. The fish were weighed to the nearest gram on a triple beam scale.

F. Comparison of the growth of the fish

The experiment was divided into four different periods. They have been numbered as follows: I (June 5—June 29), II (June 29—August 12), III (August 12—September 16) and IV (September 16—October 23). In the beginning of the experiment and at the end of each period a random sample of fish was measured and weighed. The initial sample consisted of 20 per cent, on June 29, August 12 and September 16 10 per cent and at the end of experiment on October 23, 50 per cent of the total stock in each fish group.

To evaluate the significance of the differences in gains in weight and length between different diets and the control diet Klarkki, the usual Student's t-test was used. Evaluations were made on the basis of samples taken at the end of the experiment. Calculations were made at the Computing Centre, University of Helsinki.

G. Utilization of the diets by the fish

Conversion of food into fish was calculated on the basis of the gain in weight of the fish surviving to the end of the experiment; in calculating their food consumption the amount of food consumed by the trout which died during the experiment was deducted from the whole.

In order to compare the utilization of the diets, it was calculated how much calories and proteins were required to produce one kilo of fish.

H. Determinations of the costs to produce one kilo of fish

On the basis of the conversion ratios obtained in the experiment, the costs to produce one kilo

of fish were calculated. Inquiries regarding prices of diets were made directly from the importers and manufacturers in February 1967. The calculation was based in each case on the retail price of the 4 mm pellet size. Prices for F-Koerehu and Vaasan Höyrymyllyn Koerehu 1 and 2 were estimated by the manufacturers. It was not possible to get a price for Raision Koerehu, as it has been produced only to order.

I. Determination of the condition factors

At the end of the experiment condition factors for the fish samples were calculated from FULTON's equation

$$K = \frac{100 \times \text{weight of the fish (g)}}{(\text{total length of the fish (cm)})^3}$$

(ROUNSEFELL and EVERHART 1960).

According to BROWN (1957), the growth of salmonids has only a slight influence on the ratio of length to weight. Consequently the factor K can be used to calculate the length-weight ratios of rainbow trout of different sizes.

J. Evaluation of the flesh colouration

At the end of the experiment a sample of ten fish was taken from each net to compare the mean colouration of the flesh. The fish were split and rinsed with water. The evaluation was made according to the intensity of the flesh colouration and not to the attraction of the colour.

K. Chemical analyses of the diets and the fish

Chemical analyses of the diets were made at the end of the experiment. Unselected samples of pellets were taken from each of the diets and stored in a dry place. For the analyses the diets were ground and homogenized with an Ultra-Turrax homogenizer.

For the chemical analyses of the fish, samples of each fish group were taken as described earlier. The fish were stored frozen at —18°C. The analyses was made in duplicate and for each sample six fish were taken and homogenized. The analyses were made from whole fish, gutted fish (gills and intestines removed) and fish livers.

The same analyses were made on the diets and the fish, as follows: water content (AOAC 1965), fat content by a modification of GERBER's method (POHJA et al. 1956), protein content by a modification of KJELDAHL's method (COCKS and van REDE 1966) and ash content (AOAC 1965). The analyses were made at the Institute of Meat Technology, University of Helsinki.

III. PHYSICO-CHEMICAL CHARACTERISTICS OF THE CULTIVATING WATER

The pH of the water before the experiment was 5.9 at 0.5 metres. In order to raise the pH, the lake was sprinkled with lime. By mistake this was done too effectively and for a couple of weeks (June 25—July 9) the pH rose to 9.0—9.5, after which it gradually sank and at the end of the experiment was 7.2, measured from 0.5 metres. The effect of liming was also observable in the raised values of electrical conductivity and total hardness (Table 4).

At the beginning of the experiment the dissolved oxygen content at 0.5 metres was 11.0 mg/l (saturation value 110 %) and at the end of the experiment 8.3 mg/l (saturation value 72 %).

Owing to the large mesh size of the nets there was so little slime formation during the experiment that the exchange of the water was presumably not affected in any of the nets. Water samples for oxygen determinations were not taken inside the nets but nothing in the behaviour of the fish (accelerated breathing, restless movements, etc. JONES 1964) gave reason to suspect oxygen deficiency in the nets.

The temperature of the water was very high at the beginning of the experiment (Fig. 3). Between July 20 and 25, it was +24°C in the afternoon. The high temperature did not cause extra mortality but made the fish unwilling to eat.

	Before the experiment *Ennen koetta* Före försöket	After the liming *Kalkituksen jälkeen* Efter kalkningen	At the end of the experiment *Kokeen päätyttyä* Efter försöket
pH	5.9	9.0—9.5	7.2
O_2 mg/l	11.0	—	8.3
Degree of oxygen saturation % — *Kyllästysarvo*, % — Mättnadsgrad, %	110	—	72
Conductivity μS — *Johtokyky* — Ledningsförmåga	16	85	55
Colour mg Pt/l — *Väri* — Färg	5	—	20
$KMnO_4$ mg/l	18	—	14
Total hardness dH° — *Kokonaiskovuus* — Total hårdhet	0.1	2.2	1.7

Table 4. Water analyses from the pond Kalakas. Sampling depth 0.5 metres.
Taulukko 4. Kalakas-lammesta tehdyt vesianalyysit. Näytteet otettu 0.5 metrin syvyydestä.
Tabell 4. Vattenanalyser i träsken Kalakas. Provtagning på 0.5 meters djup.

IV. RESULTS AND DISCUSSION

A. Composition of the diets

Results of the chemical analyses of the diets are presented in Table 5. The residue represents the total amount of nonprotein extracts and fibre combined. It can be seen from the table that the diets were on the whole quite comparable in composition. The percentage of water varied from 5.3 to 14.5, fat content from 0.8 to 8.5, protein content from 26.8 to 42.8, ash content from 7.3 to 16.0, nonprotein extract and fibre content from 32.7 to 59.0. The unusually high water content of Raision Koerehu (14.5 per cent) suggests that the sample got moist for some reason during the experiment.

Ewos Rauturehu differed most from the other diets as regards chemical composition. The percentages of fat (0.8), protein (26.8) and ash (7.3) were far lover than those of the other diets and correspondingly the percentage of nonprotein extracts and fibre was higher. Vaasan Höyrymyllyn Koerehu 1 and Kirjo had low fat contents (1.8 and 2.7 per cent) and Klarkki a rather high fat content (8.5 per cent) as compared with the other diets. For some diets the composition given by the manufacturers (Table 2) differed greatly from the results of the analysis presented in Table 5. Special attention was paid to the exceptionally high ash content given for Kirjo (27 per cent) which was as much as 11 per cent higher than the analysed value, and the low fat content (2.5) for F-Koerehu. Differences between the values given and analysed may have been caused by differences in the water content and also in the methods.

Most of the manufacturers also stated the

Diet *Rehu* Foderpreparat	Water *Vesi* Vatten %	Fat *Rasva* Fett %	Protein *Valkuainen* Protein %	Ash *Tuhka* Aska %	Nonprotein extracts and fiber *Typettömät uuteaineet ja kuitu* Kvävefria extraktämnen och fiber %
Lohi-Sampo	6.3	4.4	42.8	13.7	32.8
Ewos Rauturehu	6.1	0.8	26.8	7.3	59.0
River Pride	9.6	5.5	38.0	14.2	32.7
Klarkki	6.2	8.5	38.9	12.0	34.4
Kirjo	5.3	2.7	41.5	16.0	34.5
F-Kalanrehu	9.6	5.5	38.0	14.2	32.7
Raision Koerehu	14.5	4.8	35.5	12.5	32.7
F-Koerehu	6.1	4.8	39.4	14.8	34.9
Vaasan Höyrymyllyn Koerehu 1	6.5	1.8	40.5	15.0	37.2
Vaasan Höyrymyllyn Koerehu 2	7.1	3.8	39.3	13.5	32.7

Table 5. Chemical analysis of the diets. Nonprotein extracts and fibre by difference.
Taulukko 5. Rehujen kokonaiskoostumus analyysin mukaan. Typettömien uuteaineiden ja kuidun määrä = jäännösprosentti.
Tabell 5. Foderpreparatens sammansättning enligt utförda analyser. Kvävefria extraktämnen och mängden fiber = kvarstodsprocent.

amounts of crude fibre and nonprotein extracts (Table 2), which were not analysed. Crude fibre values for Ewos Rauturehu and F-Koerehu were rather low (2.0 and 2.5 per cent) and for Raision Koerehu high (9.0 per cent). Kirjo had an especially low percentage of nonprotein extract (16.9).

The high protein content (average 38 per cent) in the diets tested is based on the fact that relatively large amounts of protein are needed for energy, because rainbow trout are inefficient utilizer of carbohydrates (PHILLIPS and BROCKWAY 1956, PHILLIPS et al. 1963) and excessive dietary fat may cause various undesirable phenomena (PHILLIPS and PODOLIAK 1957, KLINGLER 1958, OTTE 1966). In general, it can be stated that the quality and dietary efficiency of the protein determine the value of a diet.

The calorie contents of the diets were high, over 2 000 kcal/kg (Table 2). The value was highest in Klarkki (2 600 kcal/kg) and in Vaasan Höyrymyllyn Koerehu 1 and 2 (2 498 kcal/kg) and lowest in Raision Koerehu (2 071 kcal/kg). All diets contained over 50 per cent of calories as protein, Kirjo having as much as 75.6 per cent of calories as protein (Table 2).

A great many raw materials were included in the diets, on an average, 13 (7—17) different raw materials had been used in producing a diet. In all diets fishmeal or fish extract was quantitatively the main single ingredient of animal origin (Table 3). Amounts of this ingredient varied from 15 to 30 per cent. Liver and whey meals had also been used in most diets. The amounts of liver meal varied from 2 to 12 per cent and of whey meal from 3 to 17 per cent. Whale meat meal was the second most important animal ingredient after fishmeal in Kirjo and Vaasan Höyrymyllyn Koerehu 1.

Various cereals were the main ingredients of plant origin. The amounts varied from 15 to 57 per cent. In Ewos Rauturehu the amount of oatmeal was especially high (56.8 per cent). Animal concentrates are superior to plant con-

Vitamins *Vitamiinit* Vitaminer		Lohi-Sampo	Ewos Rauturehu
Fat soluble — *Rasvaliukoiset* — Fettlösliga			
A	iu/kg *ky/kg* ie/kg	15 000	27 500
D	»	1 200	3 000
E	mg/kg	35	110
K (menadion)	»	—	11
Water soluble — *Vesiliukoiset* — Vattenlösliga			
B_1 (thiamine)	mg/kg	15	27.5
B_2 (riboflavin)	»	18	7
B_6 (pyridoxine)	»	7	27.5
B_{12} (cyanocobalamine)	»	0.022	0.03
Para-aminobenzoic acid	»	—	110
Pantothenic acid	»	24	—
Calcium pantothenate	»	—	105
Folic acid	»	4	17
Choline	»	340	1 300
Niacin	»	80	330
Biotin (vitamin H)	»	—	1.5
Inositol	»	550	—
Nicotinic acid	»	—	—
Pyridoxine hydrochloride	»	—	—
C	»	370	530

Table 6. Composition of the vitamin supplement added to the diets according to information supplied by the manufacturers.

Taulukko 6. Rehuihin lisätyn vitamiiniseoksen vitamiinikoostumus valmistajien ilmoituksen mukaan.

Tabell 6. Vitaminsammansattningen hos i foderpreparaten tillsatta vitaminblandningar enligt tillverkarnas uppgifter.

centrates for rainbow trout (PHILLIPS and BROCKWAY 1956, KITANIKADO et al. 1964, MANN 1967) but the latter are used to reduce costs.

Yeast had been added to all diets; in Lohi-Sampo the amount of yeast was as high as 20 per cent. Fat or fishliver oil had been added to five diets in amounts between 2 and 3 per cent. Crustacean meal, which, being rich in xanthophyll pigments, causes the colouration of fish flesh, was an ingredient of five of the diets (from 4 to 11 per cent). In Ewos Rauturehu artificial colouring matter was used as a substitute for crustacean meal.

Amounts of vitamin concentrates added to the diets varied from 0.5 to 10 per cent. There was an average of 10 (5—16) different vitamins in the concentrates (Table 6). Every concentrate contained vitamins A and D, all but Kirjo vitamin E and all but Raision Koerehu vitamin B_{12}. Special attention was paid to the lack of panthothenic acid, B_1 and choline in some of the vitamin concentrates of the diets, as these vitamins are considered essential for rainbow trout (DAVIS 1953 pp. 72—75, LEITRITZ 1960 pp. 77—78).

The diets contained about the same amounts of added vitamins except Ewos Rauturehu, in which the amounts of vitamins were two-four fold and significantly higher than is needed for rainbow trout (Table 7).

B. Growth of the fish

1. Growth results at the end of the experiment

Weights and lengths of fish fed with Lohi-Sampo and Vaasan Höyrymyllyn Koerehu 1 and 2 did not differ significantly from those of fed with the control diet Klarkki (Table 8). The weights and lengths of fish fed on the other diets differed significantly from the controls ($P < 0.001$).

The frequency distribution of the weights of the fish samples are presented in Fig. 2.

River Pride	Klarkki	Kirjo	F-Kalanrehu	Raision Koerehu	F-Koerehu	Vaasan Höyrymyllyn Koerehu 1	Vaasan Höyrymyllyn Koerehu 2
X	8 000	10 000	X	12 000	X	12 000	12 000
X	1 000	2 250	X	2 000	X	1 000	1 000
X	25	—	X	30	X	30	30
—	—	—	—	—	—	—	—
X	—	10	X	5	X	—	—
X	—	14	X	8	X	15	15
—	—	5	—	—	X	—	—
X	0.02	0.02	X	—	X	0.02	0.02
—	—	—	—	—	X	—	—
—	20	20	—	20	—	20	20
X	—	—	X	—	X	—	—
X	—	4	X	—	X	—	—
X	—	100	X	—	X	—	—
—	—	80	—	—	X	—	—
X	—	0.3	X	—	—	—	—
—	—	20	—	—	—	—	—
—	—	—	X	—	—	—	—
X	—	—	X	—	—	—	—
X	—	450	X	—	X	—	—

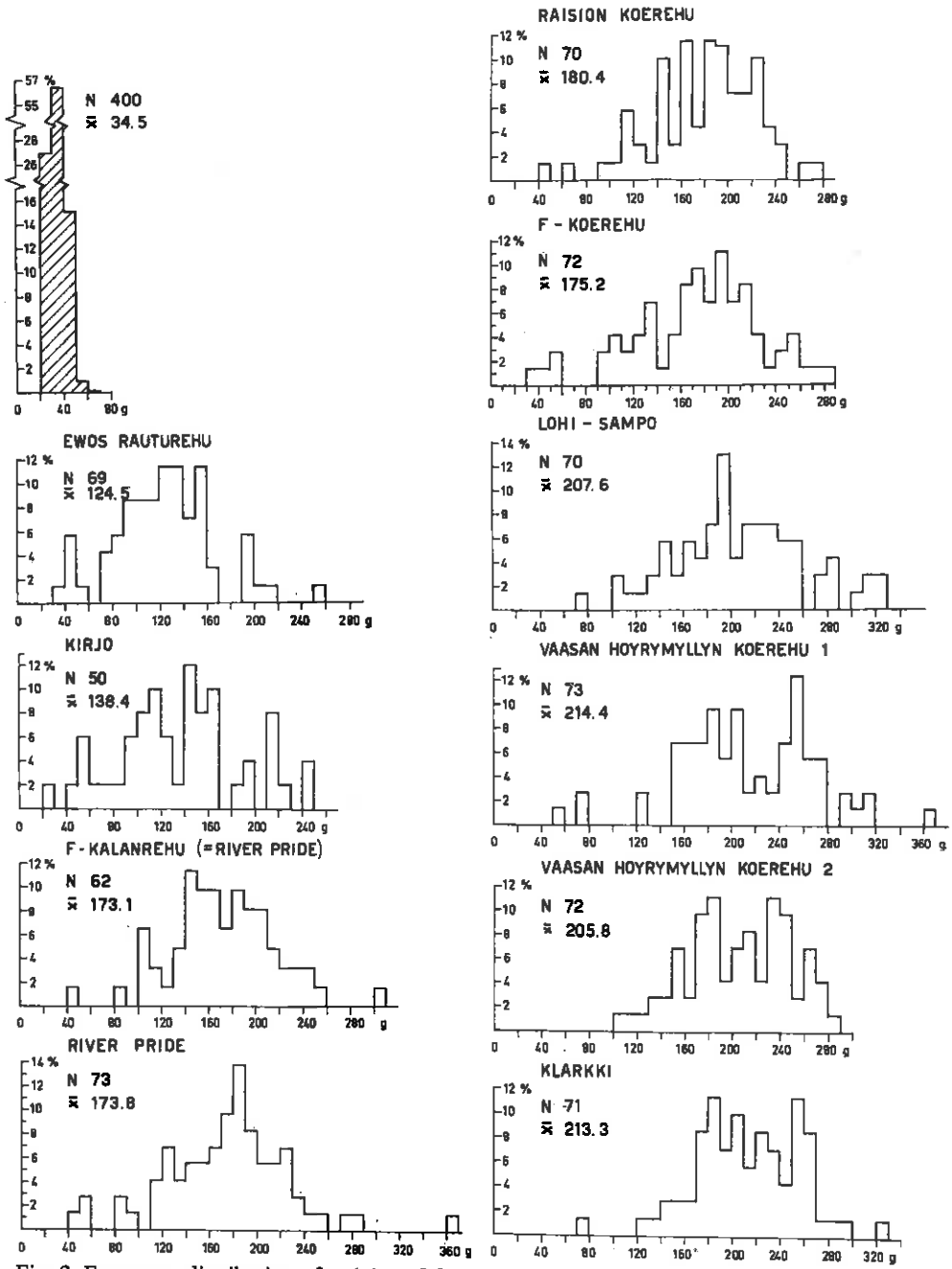

Fig. 2. Frequency distribution of weights of fish samples taken at the beginning (hatched) and end of the experiment.

Kuva 2. Kokeen alkaessa (viivoitettu) ja päättyessä otettujen kalanäytteiden painojen jakautumat.

Fig. 2. Fördelningen av vikten på fiskproven från början (skuggat) resp. slutet av försöket.

There were great differences in the ranges of the weights of fish fed with different diets. The smallest range (100—290 g) was in Vaasan Höyrymyllyn Koerehu 2 (Fig. 2) and the greatest (40—370 g) in River Pride. Similarly, Vaasan Höyrymyllyn Koerehu 2 had the smallest range of length and River Pride the greatest. At the end of the experiment the smallest fish had a length of 14.9 cm and weighed 26 g, and the largest fish was 30.1 cm and weighed 362 g.

The growth of the fish, except for some of the poorest results, was fairly typical for rainbow trout during the second summer. For example, LAINE et al. (1967 a) under comparable conditions obtained mean weights of 133, 154 and 171 g in three rainbow trout groups. The fish were weighed on September 15. In this experiment the mean weights at that time were between 101 and 165 g (Table 9).

2. Gains in weight and length during the experiment

At the beginning of the experiment and at the end of each period a random sample of fish was measured and weighed, as mentioned under

Vitamins *Vitamiinit* Vitaminer	RUHDELL 1964	EINSELE 1965
Fat soluble—*Rasvaliukoiset* — Fettlösliga		
A .. iu/kg, *ky/kg* ie/kg	7 000—11 000	6 000—8 000
D ..... »	1 500— 2 000	—
E ..... mg/kg	20	—
Water soluble — *Vesiliukoiset* — Vattenlösliga		
B_1 (thiamine) ... mg/kg	10	20—30
B_2 (riboflavin) .. »	8—15	12—15
B_6 (pyridoxine).. »	—	5
B_{12} (cyanocobalamine) ..... »	—	0.03
Pantothenic acid »	—	20
Choline ..... »	—	300
Niacin ..... »	—	0.65
Biotin ..... »	—	0.3
Folic acid ..... »	5—10	4
C ..... »	200—250	—

Table 7. Vitamin requirements of rainbow trout, according to RUHDELL (1964) and EINSELE (1965).

Taulukko 7. Kirjolohen vitamiinitarve RUHDELL*in (1964) ja* EINSELE*n (1965) mukaan.*

Tabell 7. Regnbågslaxens behov av vitamin enligt RUHDELL (1964) och EINSELE (1965).

Diet *Rehu* Foderpreparat	n	Lenght *Pituus* Längd (cm) $\bar{x}$	$S_{\bar{x}}$	s	t	P	Weight *Paino* Vikt (g) $\bar{x}$	$S_{\bar{x}}$	s	t	P
Lohi-Sampo	70	25.4	±0.3	2.2	—0.85	0.10 < P < 0.50	207.6	±6.6	55.0	— 0.67	0.10 < P < 0.50
Ewos Rauturehu	69	21.9	±0.3	2.6	—9.87	P < 0.001	124.5	±5.2	43.1	—12.00	P < 0.001
River Pride	73	24.0	±6.3	2.6	—4.27	P < 0.001	173.8	±6.3	53.7	— 4.80	P < 0.001
Klarkki	71	25.6	±0.2	1.8	0.00	—	213.3	±5.3	44.4	0.00	—
Kirjo	50	22.5	±0.4	3.0	—6.63	P < 0.001	138.4	±7.4	52.4	— 8.23	P < 0.001
F-Kalanrehu	62	24.0	±0.3	2.2	—4.77	P < 0.001	173.1	±5.7	44.9	— 5.17	P < 0.001
Raision Koerehu	70	24.3	±0.2	2.0	—4.36	P < 0.001	180.4	±5.4	45.0	— 4.36	P < 0.001
F-Koerehu	72	24.2	±0.3	2.6	—3.92	P < 0.001	175.2	±6.3	53.6	— 4.62	P < 0.001
Vaasan Höyrym. Koerehu 1	73	25.5	±0.3	2.3	—0.34	P < 0.50	214.4	±6.7	57.0	+ 0.12	
Vaasan Höyrym. Koerehu 2	72	25.4	±0.2	1.8	—0.76	0.10 < P < 0.50	205.8	±5.1	43.0	— 1.02	0.10 < P < 0.50

Table 8. Mean lengths ($\bar{x}$) and weights ($\bar{x}$), standard deviations (s), standard errors of the means ($S_{\bar{x}}$) and t-values for significance of differences between groups of rainbow trout, based on samples taken at the end of the experiment. The comparison diet is Klarkki.

Taulukko 8. Kirjolohien keskipituudet ($\bar{x}$) ja keskipainot ($\bar{x}$), hajonnat (s) ja keskiarvojen keskivirheet ($F_{\bar{x}}$) sekä Studentin t-testin tulokset kasvatuskokeen päättyessä otettujen kalanäytteiden perusteella. Vertailurehuna on Klarkki.

Tabell 8. Medellängder ($\bar{x}$) och medelvikter ($\bar{x}$) hos regnbågslaxen, variationer (s) och medelfel ($S_{\bar{x}}$) för medelvärdena samt resultaten av Student t-test på basen av fiskprov, som tagits sedan uppfödningsförsöket avslutats. Kontrollfoder Klarkki.

Diet *Rehu* Foderpreparat	Mean length *Keskipituus* Medellängd (cm)					Mean weight *Keskipaino* Medelvikt (g)					Increase of the mean length *Keskipituuden lisäys* Medellängdens ökning 5.6—23.10		Increase of the mean weight *Keskipainon lisäys* Medelviktens ökning 5.6—23.10	
	5.6	29.6	12.8	16.9	23.10	5.6	29.6	12.8	16.9	23.10	cm	%	g	%
Lohi-Sampo	14.5	15.0	18.1	23.0	25.4	34.5	44.7	81.5	164.6	207.6	10.9	75.2	173.1	501.7
Ewos-Rauturehu	14.5	14.3	16.6	20.5	21.9	34.5	38.3	59.8	111.5	124.5	7.4	51.0	90.0	260.9
River Pride	14.5	15.6	18.7	22.4	24.0	34.5	44.8	93.1	147.3	173.8	9.5	65.5	139.3	403.8
Klarkki	14.5	15.1	18.4	22.6	25.6	34.5	43.8	84.5	153.0	213.3	11.1	76.6	178.8	518.2
Kirjo	14.5	15.0	15.9	19.9	22.5	34.5	37.5	46.1	101.3	138.4	8.0	55.2	103.9	301.2
F-Kalanrehu	14.5	16.1	18.5	22.1	24.0	34.5	49.2	85.4	136.5	173.1	9.5	65.5	138.6	401.7
Raision Koerehu	14.5	15.4	17.8	21.9	24.3	34.5	44.9	71.7	133.1	180.4	9.8	67.6	145.9	422.8
F-Koerehu	14.5	14.5	18.0	22.2	24.2	34.5	37.3	73.5	136.3	175.2	9.7	66.9	140.7	407.9
Vaasan Höyrym. Koerehu 1	14.5	15.6	18.7	23.2	25.5	34.5	47.0	91.0	163.3	214.4	11.0	75.9	179.9	521.4
Vaasan Höyrym. Koerehu 2	14.5	15.2	18.4	23.0	25.4	34.5	42.2	80.6	162.7	205.8	10.9	75.2	171.3	496.5

Table 9. Mean lengths (cm) and weights (g) of rainbow trout and their absolute and relative gains during the course of the experiment.

Taulukko 9. Kirjolohien keskipituudet (cm) ja keskipainot (g) eri mittaus- ja punnituskerroilla sekä niiden todelliset ja prosentuaaliset lisäykset kasvatuskokeen aikana.

Tabell 9. Medellängder (cm) och medelvikter (g) hos regnbågslax vid olika uppmätnings- och uppvägningsprov samt absolut och procentuell ökning av dessa värden under uppfödningsförsöket.

Materials and Methods. The results are presented in Table 9. In order to get a better idea of the growth of the fish, the absolute and relative increases in the mean lengths and weights during the experiment have been calculated (Table 9). Gains in mean weights are also presented graphically (Fig. 3). Absolute and relative increases in the mean weights during the different periods have been calculated (Table 9). Because the periods were of different durations the daily increases in the weights have been calculated to make comparisons between the different periods easier (Table 10).

When the growth of the fish was examined, it was found unexpectedly that except in the groups fed with River Pride and F-Kalanrehu the trout had grown best at the end of the summer (period III, August 12-September 16). This may have been due to the changes in the temperature and pH of the water during the experiment.

The inferior growth during the first period (June 5—June 29) as compared with the second and third periods may have been due to the low pH value of the water (pH 5.9). BERZINS (1962) has reported the following pH limits for rainbow trout: lethal rates 5.5 and 9.2, comfort range 5.5—6.2, and optimal range 6.2—8.4 (see also BANDT 1936, SCHIEMENZ 1937, SVÄRDSON 1961, JONES 1964).

The second period of the experiment (June 29—August 12) was affected by the sudden change of pH and the high temperature of the water. For a fortnight after liming (June 25—July 9) the pH rose to about 9. As a result the fish stopped eating completely for a week and the simultaneous mortality was high (further details later). The occasional high temperature of the water (Fig. 3) also made the fish unwilling to eat, which influenced their growth.

During the third period (October 12—September 16) environmental conditions were most favourable and the growth of the fish was most rapid in all groups except River Pride and F-Kalanrehu (Fig. 3, Table 10).

During the last period (September 16—October 23) the temperature of the water dropped much below the optimal temperature for rainbow trout, which is, according to GARSIDE

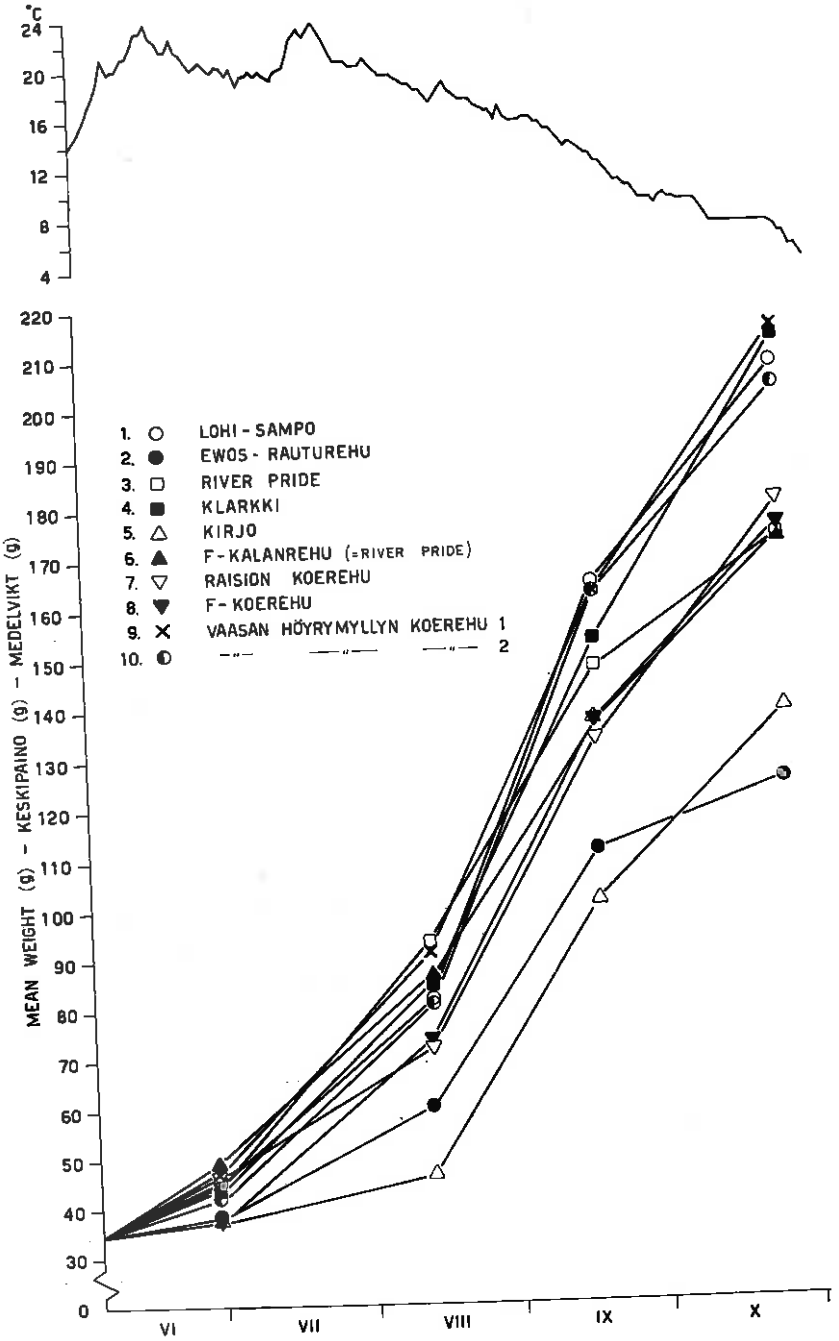

Fig. 3. Mean weights of the rainbow trout during the feeding experiment.
Kuva 3. Eri rehuvalmisteilla ruokittujen kirjolohien keskipainot kasvatuskokeen aikana.
Fig. 3. Medelvikten hos de på olika foderpreparat uppfödda regnbågsforellerna.

Diet *Ruu* Foderpreparat	I Period — *Jakso* — Period 5—29.6				II Period — *Jakso* — Period 29.6—12.8				III Period — *Jakso* — Period 12.8—16.9				IV Period — *Jakso* — Period 16.9—23.10			
	g	g/day *vrk* dygn	%	%/day *vrk* dygn	g	g/day *vrk* dygn	%	%/day *vrk* dygn	g	g/day *vrk* dygn	%	%/day *vrk* dygn	g	g/day *vrk* dygn	%	%/day *vrk* dygn
Lohi-Sampo	10.2	0.4	29.6	1.2	36.8	0.8	82.3	1.9	83.1	2.4	102.0	2.9	43.0	1.1	26.1	0.7
Ewos Rauturehu ..	3.8	0.2	11.0	0.5	21.5	0.5	56.1	1.3	51.7	1.5	86.5	2.5	13.0	0.3	11.7	0.3
River Pride	10.3	0.4	29.9	1.2	48.3	1.1	107.8	2.5	54.2	1.5	58.2	1.7	26.5	0.7	18.0	0.5
Klarkki	9.3	0.4	27.0	1.1	40.7	0.9	93.0	2.1	68.5	2.0	81.1	2.3	60.3	1.6	39.4	1.0
Kirjo	3.0	0.1	8.7	0.4	8.6	0.2	22.9	0.5	55.2	1.6	119.7	3.4	37.1	1.0	36.6	1.0
F-Kalanrehu	14.7	0.6	42.6	1.8	36.2	0.8	73.6	1.7	51.1	1.5	59.8	1.7	36.6	1.0	26.8	0.7
Raision Koerehu ..	10.4	0.4	30.1	1.3	26.8	0.6	59.7	1.4	61.4	1.8	85.6	2.4	47.3	1.2	35.5	0.9
F-Koerehu	2.8	0.1	8.1	0.3	36.2	0.8	97.0	2.2	62.8	1.8	85.4	2.4	38.9	1.0	28.5	0.8
Vaasan Höyrym. Koerehu 1	12.5	0.5	36.2	1.5	44.0	1.0	93.6	2.3	72.3	2.1	79.5	2.3	51.1	1.3	31.3	0.8
Vaasan Höyrym. Koerehu 2	7.7	0.3	22.3	0.9	38.4	0.9	91.0	2.1	82.1	2.3	101.9	2.9	43.1	1.1	26.5	0.7

Table 10. The absolute and relative, total and daily gains in mean weight of rainbow trout during the successive feeding periods.

Taulukko 10. Kirjolohien keskipainon todellinen ja prosentuaalinen, kokonais- ja päivittäinen lisäys eri ruokintajaksoina.

Tabell 10. Absolut och procentuell ökning av regnbågslaxens medelvikt totalt och per dag under olika uppfödningsperioder.

and TAIT (1958), +11—16°C and, according to AYERS et al. (1964), +13—18°C (cf. CALDERON 1965). Consequently the growth of the fish during this period was poorer than in the preceding period.

3. Discussion of the differences in growth

Floating dry diets are usually more expensive than non-floating ones, but losses during feeding are generally smaller. Although the fish were fed as carefully as possible, the floating Ewos Rauturehu, River Pride and F-Kalanrehu were found to drift out of the nets to some extent owing to the winds and especially to the movements of the fish. As the diets considered were not available in non-floating form the extent to which this drifting influenced the results cannot be accurately assessed. LAINE et al. (1967 a) also found that rainbow trout fed on a floating dry diet in nets grew considerably slower than fish fed on non-floating diets.

It should be pointed out that to produce a floating pellet it is necessary to employ either an extrusion or expansion cooking process, both of which require a considerable amount of heat (PEARSON 1968). The heat may have a detrimental effect on the heat-labile vitamins and proteins, thus resulting in inferior growth of the fish fed on the diet.

During certain periods some of the fish groups gained weight as fast as or faster than the group fed on the control diet Klarkki, while during other periods they grew considerably slower than the control group (Table 10, Fig. 3). The inferior growth of the trout fed on Kirjo, F-Koerehu and Ewos Rauturehu in the beginning of the experiment was especially striking. This may have been due to the different appearance of these pellets compared with Klarkki, so that the fish took a longer period to get used to these diets. According to LABAS (1959), the appearance, i.e. pellet size, form and colour and also the sinking speed of the pellet, induces strong conditioned reflexes in salmonids (see also WOLF 1953, SHARON 1965). If the diet is changed and the new diet differs considerably from the former in the above-mentioned respects, the fish may dislike the new diet for a long time. The above-mentioned Kirjo and Ewos Rauturehu differed considerably from Klarkki in colour. Floating Ewos Rauturehu differed from Klarkki very

much not only in colour, but also in pellet form. Furthermore, Kirjo was significantly harder than the control diet. At the beginning of the experiment it was noticed that the trout spat out Kirjo pellets, which may be regarded is evidence that the hardness, taste and form of the pellet were of great importance. This behaviour did not continue for long but, as more precise observations were not made, the degree to which it accounted for the inferior growth of these fish at the beginning of the experiment cannot be assessed.

Compared with Klarkki, trout fed on River Pride and F-Kalanrehu gained in weight especially well in the beginning but growth became inferior towards the end of the experiment. This may have been due to the composition of these diets, which was better suited for smaller than for bigger rainbow trout or to some other unknown factor which cannot be studied in this connection.

Owing to the many raw materials and vitamins in the diets it is very difficult to determine which factors have been of special importance for the growth of the fish. Lohi-Sampo, Vaasan Höyrymyllyn Koerehu 1 and 2 and Klarkki, which gave the best growth results, had as a common factor higher calorie contents than the other diets (Table 2). They also contained about the same percentage of calories in the form of protein (58.3—60.0). Their fat contents (5.0—8.0 per cent) were higher and ash contents (10.0—13.5 per cent) lower than in most other diets. The protein contents were also relatively high (35.0—40.0 per cent).

In some feeding experiments a high fat content has been demonstrated to have a sparing of dietary protein, resulting in increased fish growth (Phillips et al. 1962) but in other experiments the supplemental fat calories have been deposited as body fat, causing an increase in fish weight but not in true growth (Phillips and Brockway 1959). This might be due to differences in the quality of fats used for trout.

As stated earlier, diets must have a comparatively high content of protein but it is difficult to state the optimal protein content for fish because it depends not only on the quality, biological value and digestibility of the protein but also on other characteristics of the diet, and the age of the fish and on the propagation conditions (Phillips and Brockway 1956, Shanks et al. 1962, Miegel 1964, Mann 1967, Wurzel and Hönig 1967).

Differences in the growth of the test fish fed on different diets may be caused by differences in the quality and proportions of the raw materials or in the preparation methods and storage of the diets. Inferior growth may also be due to shortage or quantitative imbalance of essential amino acids (Phillips and Balzer 1957, Shanks et al. 1962), deficiency of essential vitamins (Phillips and Brockway 1956, Ruhdel 1964), poor digestibility of the diets (Phillips and Brockway 1956, 1959, Barrington 1957) or too rapid leaching in the water (Combs and Burrows 1958). Improper preparation methods or storage (Phillips and Brockway 1956, Petterson et al. 1966) may also spoil the diet. However, these factors cannot be discussed here.

It should be pointed out that although the rapid increase in pH slowed down the growth of the fish, this can be ignored in the comparison of the different diets, because the effect on all fish groups was apparently the same. The pH became even throughout the surface of the lake shortly after the liming and the fish started to eat in all the nets at approximately the same time after the rise of pH.

C. Utilization of the diets by the fish

1. The conversion ratio

The conversion of food into fish and the amount of each diet required to produce one kilo of fish compared with Klarkki are presented in Table 11.

The best conversion ratios were obtained with Vaasan Höyrymyllyn Koerehu 2 (1.67), Lohi-Sampo and Klarkki (both 1.68). According to

Diet *Rehu* Foderpreparat	Conversion ratio *Ravintokerroin* Foderkoeffi-cient	Consumption of diet compared with Klarkki *Rehun kulutus Klarkkiin verrattuna* Foderför-brukning jäm-förd med Klarkki	Price of the diets *Rehun hinta* Fodrets pris	Costs to produce one kilo of fish *Tuotetun kala-kilon hinta* Kostnader för produktionen av ett kg fisk	Calories required per kilo fish produced *Kalakilon kas-vattamiseen tarvittu kalori-määrä* Kaloribehov för produk-tionen av ett kilo fisk	Proteins required per kilo fish pro duced *Kalakilon kasvattamiseen tarvittu valkuaismäärä* Proteinbehov för produk-tionen av ett kg fisk
Lohi-Sampo	1.68	0.0	0.80	1.40	3 933	588
Ewos Rauturehu	2.74	+64.0	1.40	3.80	5 836	822
River Pride	2.28	+35.7	1.07	2.40	—	798
Klarkki	1.68	—	1.00	1.70	4 368	672
Kirjo	2.00	+19.0	0.80	1.70	4 438	860
F-Kalanrehu	2.22	+32.1	1.07	2.40	—	777
Raision Koerehu	1.84	+ 9.5	—	—	3 811	528
F-Koerehu	2.03	+20.8	1.15	2.30	4 566	792
Vaasan Höyrym. Koerehu 1	1.80	+ 7.1	0.85	1.50	4 496	684
Vaasan Höyrym. Koerehu 2	1.67	— 0.6	0.85	1.40	4 172	635

Table 11. Conversion ratios, relative consumption of diets compared with Klarkki, retail prices (mk/kg) of different diets, costs to produce one kilo of fish (mk/kg), calories (kcal/kg) and proteins (g/kg) required per kilo of fish produced.

Taulukko 11. Rehujen ravintokertoimet, prosentuaalinen kulutus Klarkkiin verrattuna, vähittäismyyntihinnat (mk/kg), tuotetun kalakilon hinta (mk/kg) sekä kalakilon kasvattamiseen tarvittu kalorimäärä (kcal/kg) ja valkuaisainemäärä (g/kg)

Tabell 11. Foderpreparatens foderkoefficienter, procentuell förbfukning i relation till Klarkki, minutpris (mk/kg), priset på producerad fisk (mk/kg) samt mängden kalorier (kcal/kg) resp. äggvitemängd (g/kg) som behövts för produktionen av ett kg fisk.

PHILLIPS and BROCKWAY (1959), the conversion ratio decreases as the calorie content of the diet increases. This was also the case in the present experiment. The above mentioned three diets as well as Vaasan Höyrymyllyn Koerehu 1 had the highest calorie contents (Table 2).

The poorest conversion of food into fish were obtained with the floating diets, viz. Ewos Rauturehu, River Pride and F-Kalanrehu. This may partly be due to the observed fact that the floating diets drifted, to some extent from the nets. LAINE et al. (1967 a) also obtained a considerably poorer conversion ratio for the floating than the non-floating dry diets. In experiments in nets, AHO (1968) reports that he has obtained such conversion ratios as 2.0, 2.2, 2.9 and 3.2 for sinking Ewos dry diets (F 52 BP and F 52 CP).

There were also differences in the sinking rates of the different diets. Consequently, it is possible that quickly sinking diets may have passed through the nets even though the food was given in small lots.

The conversion ratios obtained are in reasonable agreement with the values previously reported by SCHUMACHER (1958), DEUPEL (1963), WIESNER (1963), PHILLIPS et al. (1964), MANN and ENGELHARDT (1964), LAINE et al. (1967 a), STEFFENS (1968) and AHO (1968). For 19 different dry diets studied they obtained conversion ratios ranging from 1.21 to 3.2. The calculated mean was 1.95.

The greatest difference between the abovementioned experiments and the present study is that, except for those made by LAINE et. al. (1967 a) and (AHO 1968), they were not conducted in nets but in ponds, concrete troughs, etc., where the fish were able to take pellets even when these had sunk to the bottom. It is to be pointed out that the results of different feeding trials, especially gain in weight and conversion of food into flesh, are only roughly comparable. The growth of the fish and the conversion ratio are greatly influenced by such factors as temperature of the water, dissolved oxygen content, pH, quantity of food given, calorie content of the diet, and age, size and racial characters of the

fish, which vary greatly in different experiments. These factors have been discussed at length by BROWN (1957), JONES (1964) and PALOHEIMO and DICKIE (1965, 1966 a, 1966 b).

On the whole, the conversion ratios obtained in this experiment were for most diets those excepted under the conditions prevailing.

2. Calories and proteins required to produce one kilo of fish

The conversion ratio shows how much food in kilos is required to produce one kilo of fish. This is of great importance when information on production costs is needed. The conversion ratio is also sometimes used as a measure of the efficiency of the diet to produce fish but a low conversion ratio does not necessarily indicate better utilization compared with a diet of higher conversion ratio. As a matter of fact, its utilization may be greatly inferior, as the conversion of food into fish flesh depends largely on the calorie content of the diet, as was mentioned before. As a measure of the efficiency of a diet in producing fish flesh it is preferable to compare, for instance, the growth of the fish and the relationship between the calorie and protein contents of the diet (PHILLIPS and BROCKWAY 1959) or to compare the calorie content of the diet and the fish flesh produced (LAGLER et al. 1963).

In order to compare the utilization of the diets, calculations were made of the amounts of calories and proteins required to produce one kilo of fish. The results are presented in Table 11.

The numbers of calories required to produce one kilo of fish were lowest with Raision Koerehu (3 811 kcal/kg) and Lohi-Sampo (3 933 kcal/kg) and clearly highest with Ewos Rauturehu (5 836 kcal/kg). Proteins required to produce one kilo of fish were lowest with Raision Koerehu (528 g) and Lohi-Sampo (588 g) and highest with Kirjo (860 g) and Ewos Rauturehu (822 g). According to the analyses made at the end of the experiment, there was about 20 per cent of protein in the whole fish on a wet weight basis (details later). Thus to produce the amount of protein in one kilo of fish, 2.5—4 times as much dietary protein was required, indicating that a high percentage of protein was used to produce energy or deposited as fat.

However, Raision Koerehu, which was the most efficient diet on the basis of proteins and calories required to produce one kilo of fish, was one of the most inefficient to increase the total body protein of the fish (Table 17). This may have been due to a too low protein and/or calorie content in the diet.

As there was a possibility that the floating Ewos Rauturehu, River Pride and F-Kalanrehu drifted from the nets, it is difficult to draw any conclusions about their efficiency. As to Kirjo and also F-Koerehu, the results obtained possibly indicate that the protein was of a type not very suitable for rainbow trout and/or that the percentage of calories supplied as fat was too low. In the latter event a relatively high percentage of protein would have been used to produce energy as compared to the other diets, with the consequence that the percentage of protein would have been insufficient for growth. This is supported by the fact that the percent fat in Kirjo and F-Koerehu (2.5 and 3.4) was considerably lower than in the other diets. The percentages of calories as protein (75.6 and 67.6) were very high. As mentioned before, in some feeding experiments PHILLIPS et al. (1962) observed that supplemental fat calories led to a saving of dietary proteins, which became available for increased growth.

The calories and proteins required to produce one kilo of fish in this experiment corresponded well with the results obtained by STEFFENS (1968) with rainbow trout fingerlings fed on various pellets. In aquaria less than 4 000 kcal and in ponds 4 500 kcal were required to produce one kilo of trout. Per kilo of fish below 600 g crude protein was fed in aquaria and from 600 to 700 in ponds.

Diet *Rehu* Foderpreparat	5.6	21.7	23.10
Lohi-Sampo	200	140	135
Ewos Rauturehu	200	138	122
River Pride	200	147	138
Klarkki	200	144	130
Kirjo	200	94	83
F-Kalanrehu	200	122	109
Raision Koerehu	200	142	134
F-Koerehu	200	149	134
Vaasan Höyrym. Koerehu 1 ...	200	148	137
Vaasan Höyrym. Koerehu 2 ...	200	146	140

Table 12. The numbers of fish in the nets at the beginning and end of the experiment and when the mortality had ceased after liming.

Taulukko 12. Kalamäärät eri altaissa kokeen alkaessa ja päättyessä sekä kalkituksen aiheuttaman kuolleisuuden loputtua.

Tabell 12. Fiskmängderna i olika nätkassar då försöket inleddes resp. avslutades samt sedan den dödlighet upphört, som föranletts av kalkning.

D. Costs to produce one kilo of fish

There were considerable differences in the costs to produce one kilo of fish with the diets tested (Table 11). The costs varied from 1.40 to 3.80 mk/kg. Lohi-Sampo and Vaasan Höyrymyllyn Koerehu 2 were the most economic (1.40 mk/kg) and the floating Ewos Rauturehu, River Pride and F-Kalanrehu the most expensive (3.80 and 2.40 mk/kg) in this respect.

It must be pointed out that the cost of producing one kilo of fish would actually have been higher than those presented, since such items as purchasing costs of fish, nets and other devices and salaries have not been included in the calculations. On the other hand, when diets are bought wholesale, prices and hence feeding costs are reduced.

E. Mortality and state of health

As a consequence of the sudden change in the pH of the water, it was unfortunately not possible to gain a clear idea of the mortality among the fish fed on the different diets. Table 12 shows the number of fish at the beginning and end of the experiment as well as on July 21 (by which time deaths caused by the liming had practically ceased). As the above-mentioned change in pH was possibly the reason for some mortality observed later in the experiment, no conclusions about the mortality of fish fed with different diets will be made.

The temporary rise in the temperature of the surface water to +24°C (July 20—July 25 determined in the afternoon) was not found to increase the mortality of the fish. Evidently this was due to the large mesh of the nets, which prevented sliming. According to DEUZER (1952), the lethal temperature of water for fingerling rainbow trout is +24,5°C. For older rainbow trout ALABASTER (1962) mentions a lethal temperature of +28°C. Lethal and optimal temperatures of fish are greatly dependent on the acclimatization temperature as well as on the dissolved oxygen content of the water, and the race, age, size and nutrition of the fish (BRETT 1956, FRY 1957, 1958, 1964, PROSSER and BROWN 1962, MIHURSKY and KENNEDY 1967).

According to BROWN (1951), the growth of fish fed on a nutritionally inadeguate diet may be normal for several weeks and only after prolonged feeding do deficiency symptoms eventually appear. PHILLIPS and BALZER (1957) found that in water of +15°C a feeding experiment lasting 16—20 weeks is, under normal conditions, sufficient for comparing different diets. In this experiment the state of health of the test trout was good, except for the mortality due to the rise of pH. No deficiency symptoms were observed, even at the end of the 20-week feeding period.

F. Condition factor

In Table 13 are listed the mean, highest and lowest values for condition obtained for individual fish.

For steelhead trout (*Salmo gairdneri*) a condition factor of 0.80—0.90 represents a normal condition (REIMERS 1963). When the condition factor to 0.60—0.70 the trout is at the limits of survival.

Accordingly, all but a few individuals were in good condition at the end of the present experiment. The great differences observed within each group of fish may be caused by inherited factors and by competition for food, and probable also by the social hierarchy between the fish (BROWN 1957).

MANN (1966) presented the following relationship between feeding and the condition factor for second-summer rainbow trout cultivated in ponds:

Values of K	0.80—0.82	nutrition	poor
»	0.98—1.17	»	normal
»	1.12—1.25	»	good
»	1.54—1.72	»	excellent

Accordingly, the mean condition factors (1.19—1.29) in this experiment proved that the fish were in a good state of nutrition.

The differences between fish groups taken from different nets were so slight that on this basis it was not possible to draw conclusions about differences in condition. Such differences may also be a source of error, as mentioned by BROWN (1957) and TUUNAINEN (1966).

Diet *Rehu* Foderpreparat	Mean *Keskimääräinen* Medel	Highest *Suurin* Högsta	Lowest *Pienin* Lägsta
Lohi-Sampo	1.24	1.43	1.16
Ewos Rauturehu	1.19	1.34	0.95
River Pride	1.27	1.32	0.86
Klarkki	1.27	1.40	1.07
Kirjo	1.25	1.34	0.79
F-Kalanrehu	1.27	1.39	1.02
Raision Koerehu	1.25	1.36	0.93
F-Koerehu	1.25	1.29	1.01
Vaasan Höyrym. Koerehu 1	1.29	1.55	1.12
Vaasan Höyrym. Koerehu 2	1.26	1.28	1.06

Table 13. Mean condition factors (K) and lowest and highest K-value of individual rainbow trout at the end of the experiment.

Taulukko 13. Kirjolohien keskimääräiset kuntokertoimet (K) sekä suurimmat ja pienimmät yksityisillä kirjolohilla tavatut K:n arvot kokeen päättyessä.

Tabell 13. Konditionskoefficienternas medelvärden (K) hos regnbågslaxen samt de högsta och lägsta värdena på K hos enskilda regnbågs individ sedan försöket avslutats.

Diet *Rehu* Foderpreparat	Colour of the flesh *Lihan väri* Köttfärg
Lohi-Sampo	(+)++
Ewos Rauturehu	++
River Pride	+
Klarkki	++++
Kirjo	+++
F-Kalanrehu	+
Raision Koerehu	++++
F-Koerehu	+
Vaasan Höyrymyllyn Koerehu 1	+++
Vaasan Höyrymyllyn Koerehu 2	+++

\+ lightly reddish — *hiukan punertava* — lätt rödskiftande
++ reddish — *punertava* — rödaktig
+++ deep reddish — *hyvin punertava* — mycket rödaktig
++++ red — *punainen* — röd

Table 14. Colour of trout flesh estimated by eye.

Taulukko 14. Kirjolohen lihan väri silmämääräisesti arvioituna.

Tabell 14. Köttets färgrättning hos regnbågslaxen enligt okulär uppskattning.

G. Flesh colouration

Four different grades in the mean colouration of the fish flesh were observed (Table 14). Fish fed on Raision Koerehu and Klarkki had the brighest red colour. The flesh of trout fed on Kirjo and Vaasan Höyrymyllyn Koerehu 1 and 2 was also well coloured. The differences in colouration of fish classified as red or light reddish was quite considerable.

Flesh colouration is of great economic importance in trout cultivation in Finland, as only red specimens can be marketed with full profit. The typical bright colouration of wild trout is due to dietary fat-soluble carotenoids, principally astaxanthin. Trout obtain these pigments from the crustaceans they eat (STEVEN 1947, FOX 1957,

Bouthillier 1961, Jacquot 1961, Peterson et al. 1966).

Artifical diets for salmonids often embody ingredients containing carotenoids to make the fish »salmon-coloured». Tunison et al. (1943, 1945) reported that astaxanthin and astacin from crustaceans and capsanthin from paprika were the most potent pigments for colouring trout. According to Besse (1951), an extract of lobster shells added to the feed coloured trout. Grangaud et al. (1952) used astaxanthin, Bouthillier (1961) used shrimp meal and Deufel (1965) used canthaxanthin in the diet for trout. Peterson et al. (1966) found that when dull-coloured trout were fed on pellets including crayfish extract, the colouration became brighter in as little as 5—14 days. The colouration disappeared little by little when no crayfish extract was given any more. The extract influenced the colouration in a much shorter time than crayfish meal or paprika, which were also tried. As the carotenoid pigments decompose easily, they should be stored in a dry, cool, dark place (Peterson et al. 1966).

When colouration is compared, the size and maturity of the fish has to be considered. Wild rainbow trout below 20 cm in length rarely have bright-coloured flesh (Tuunainen 1965). At

Diet *Rehu* Foderpreparat	Wet basis *Tuorepainosta* Av färskvikten				Dry basis *Kuivapainosta* Av torrvikten		
	Water *Vesi* Vatten %	Fat *Rasva* Fett %	Protein *Valkuainen* Protein %	Ash *Tuhka* Aska %	Fat *Rasva* Fett %	Protein *Valkuainen* Protein %	Ash *Tuhka* Aska %
Lohi-Sampo	69.4	9.0	18.5	2.2	29.4	60.5	7.2
»	69.1	8.5	18.3	2.5	27.5	59.9	8.1
Average — *Keskimäärin* — Medeltal	69.3	8.8	18.4	2.4	28.5	59.9	7.7
Evos Rauturehu	71.4	5.8	18.9	2.9	20.3	66.1	10.1
» »	71.7	6.2	18.8	2.6	21.9	66.4	9.2
Average — *Keskimäärin* — Medeltal	71.6	6.0	18.9	2.8	21.1	66.3	9.7
River Pride	69.8	7.3	20.8	2.4	23.9	68.2	7.9
» »	69.3	6.9	20.0	2.5	22.5	65.1	8.1
Average — *Keskimäärin* — Medeltal	69.6	7.1	20.4	2.5	23.2	66.7	8.0
Klarkki	67.5	9.4	18.4	3.2	28.9	56.6	9.8
»	67.5	9.6	18.9	2.8	29.5	58.2	8.6
Average — *Keskimäärin* — Medeltal	67.5	9.5	18.7	3.0	29.2	57.4	9.2
Kirjo	70.8	7.1	19.7	2.8	24.0	66.6	9.5
»	71.1	6.6	19.1	2.6	22.8	66.1	9.0
Average — *Keskimäärin* — Medeltal	71.0	6.9	19.4	2.7	23.4	66.4	9.3
F-Kalanrehu	70.9	7.4	19.4	2.5	25.3	66.2	8.5
»	70.9	7.3	19.3	2.6	25.0	66.1	8.9
Average — *Keskimäärin* — Medeltal	70.9	7.4	19.4	2.6	25.2	66.2	8.7
Raision Koerehu	69.4	9.8	17.9	2.1	32.0	58.5	6.9
» »	69.1	9.7	18.4	2.5	31.4	59.5	8.1
Average — *Keskimäärin* — Medeltal	69.3	9.8	18.2	2.3	31.7	59.0	7.5
F-Koerehu	70.0	7.8	19.4	2.4	26.0	64.7	8.0
»	69.8	8.1	19.1	2.1	26.8	63.2	7.0
Average — *Keskimäärin* — Medeltal	69.9	8.0	19.3	2.3	26.4	64.0	7.5
Vaasan Höyrymyllyn Koerehu 1	68.5	9.0	19.9	2.1	28.6	63.2	6.7
» » »	68.7	9.3	19.5	2.3	29.7	62.3	7.3
Average — *Keskimäärin* — Medeltal	68.6	9.2	19.7	2.2	29.2	62.8	7.0
Vaasan Höyrymyllyn Koerehu 2	69.2	9.3	18.7	2.3	30.2	60.7	7.5
» » »	68.7	9.8	18.7	2.3	31.3	60.0	7.3
Average — *Keskimäärin* — Medeltal	69.0	9.6	18.7	2.3	30.8	60.4	7.4

Table 15. The chemical composition of whole rainbow trout.
Taulukko 15. Kokonaisen kirjolohen kemiallinen koostumus.
Tabell 15. Den kemiska sammansättningen hos hel regnbågslax.

spawning time the female fish, at least, are less brilliant in flesh colour than usual (Fox 1957, TUUNAINEN, personal note). This is because the pigments are transported from the flesh to the developing eggs (STEVEN 1949, Fox 1957).

The diets which produced the most marked pigmentation in the present experiment contained 11—15 per cent crustacean (shrimp) meal, except for Vaasan Höyrymyllyn Koerehu 1. Ewos Rauturehu, which contained only a small amount of artificial colouring matter (0.2 per cent), did not have any noteworth effect on the colouration of the trout flesh.

The differences in pigmentation between the different fish groups may be explained by these facts. It is possible that the contents of carotenoid pigments were insufficient or that the preparation methods or storage were unsuitable and thus made the pigments in the diets inefficient.

H. Chemical composition of the fish

1. Composition of whole and gutted fish

In Tables 15 and 16 are presented the results of the chemical analysis of the trout made at the end of the experiment. The results have been calculated on a wet and on a dry weight basis.

Diet *Rehu* Foderpreparat	Wet basis *Tuorepainosta* Av färskvikten				Dry basis *Kuivapainosta* Av torrvikten		
	Water *Vesi* Vatten %	Fat *Rasva* Fett %	Protein *Valkuainen* Protein %	Ash *Tuhka* Aska %	Fat *Rasva* Fett %	Protein *Valkuainen* Protein %	Ash *Tuhka* Aska %
Lohi-Sampo	68.7	9.2	19.4	1.7	29.4	62.0	5.4
»	68.3	9.6	19.8	1.7	30.3	62.5	5.4
Average — *Keskimäärin* — Medeltal	68.5	9.4	19.6	1.7	29.9	62.3	5.4
Ewos Rauturehu	71.8	5.0	19.9	2.9	17.7	70.6	10.3
» »	72.3	5.1	19.5	2.5	18.4	70.4	9.0
Average — *Keskimäärin* — Medeltal	72.1	5.1	19.7	2.7	18.1	70.5	9.7
River Pride	69.2	8.4	20.3	2.4	27.0	65.3	7.7
» »	69.3	8.7	19.7	2.0	28.3	64.2	6.5
Average — *Keskimäärin* — Medeltal	69.3	8.6	20.0	2.2	27.7	64.8	7.1
Klarkki	67.7	9.7	19.0	2.4	30.0	58.8	7.4
»	67.8	10.2	19.0	2.8	31.7	59.0	8.7
Average — *Keskimäärin* — Medeltal	67.8	10.0	19.0	2.6	30.9	58.9	8.1
Kirjo	69.8	7.8	19.5	2.6	25.8	64.6	8.6
»	69.7	8.2	19.6	2.7	26.9	64.3	8.9
Average — *Keskimäärin* — Medeltal	69.8	8.0	19.6	2.7	26.4	64.5	8.8
F-Kalanrehu	70.8	7.0	19.3	1.2	24.0	66.1	4.1
»	71.0	7.4	19.2	1.2	25.5	66.2	4.1
Average — *Keskimäärin* — Medeltal	70.9	7.2	19.3	1.2	24.8	66.2	4.1
Raision Koerehu	70.5	6.5	20.3	2.4	22.0	68.8	8.1
» »	70.6	6.3	20.2	2.2	21.4	68.7	7.5
Average — *Keskimäärin* — Medeltal	70.6	6.4	20.3	2.3	21.7	68.8	7.8
F-Koerehu	71.6	7.2	19.3	1.7	25.4	68.0	6.0
»	71.9	7.0	19.6	1.5	24.9	70.0	5.3
Average — *Keskimäärin* — Medeltal	71.8	7.1	19.5	1.6	25.2	69.0	5.7
Vaasan Höyrymyllyn Koerehu 1	70.2	7.4	20.0	1.7	24.8	67.1	5.7
» » »	70.1	7.6	20.3	1.6	25.4	67.9	5.4
Average — *Keskimäärin* — Medeltal	70.2	7.5	20.2	1.7	25.1	67.5	5.6
Vaasan Höyrymyllyn Koerehu 2	70.3	7.0	20.2	1.7	23.6	68.0	5.7
» » »	70.0	7.0	20.2	2.1	23.3	67.3	7.0
Average — *Keskimäärin* — Medeltal	70.2	7.0	20.2	1.9	23.5	67.7	6.4

Table 16. The chemical composition of gutted rainbow trout.
Taulukko 16. Peratun kirjolohen kemiallinen koostumus.
Tabell 16. Den kemiska sammansättningen hos rensad regnbågslax.

Diet *Rehu* Foderpreparat	Average weight *Keskipaino* Medelvikt g	Water *Vesi* Vatten g	Fat *Rasva* Fett g	Protein *Valkuainen* Protein g	Ash *Tuhka* Aska g
Lohi-Sampo	207.6	143.9	18.3	38.2	5.0
Ewos Rauturehu	124.5	89.1	7.5	23.5	3.5
River Pride	173.8	121.0	12.3	35.5	4.3
Klarkki	213.3	144.0	20.3	39.9	6.4
Kirjo	138.4	98.4	9.5	26.8	3.7
F-Kalanrehu	173.1	122.7	12.8	33.6	4.5
Raision Koerehu	180.4	125.0	17.7	32.8	4.1
F-Koerehu	175.2	122.5	14.0	33.8	4.0
Vaasan Höyrymyllyn Koerehu 1	214.4	147.1	19.7	42.2	4.7
Vaasan Höyrymyllyn Koerehu 2	205.8	142.0	19.8	38.5	4.7

Table 17. The chemical composition of average individual rainbow trout fed on the different diets.
Taulukko 17. Eri kuivarehuilla ruokittujen kirjolohien keskimääräinen yksilöllinen kemiallinen koostumus.
Tabell 17. Den kemiska sammasättningen hos enskilda medelstora, på olika torrfoderpreparat uppfödda fiskindivid.

The percentage chemical composition of whole fish shown in Table 15 is expressed in Table 17 as grams per individual fish.

The water content of the whole fish varied by 4.1 per cent (67.5—71.6) and that of the gutted fish (i.e. gills and intestines removed) by 4.3 per cent (67.8—72.1).

Water content was inversely correlated with body fat. Concequently, the amount of water plus fat in the fish groups was rather constant. It varied in whole fish from 76.7 to 79.1 per cent and in gutted fish from 77.0 to 78.9 per cent.

Great differences in fat contents were observed between the fish groups. On a wet weight basis the percentage of fat varied in the whole fish by 3.8 per cent (6.0—9.8) and in the gutted fish by 4.9 per cent (5.10—10.0).

The fat content in the whole fish was correlated on the whole with the fat and calorie contents of the diet. Fish groups which had the highest percentage of fat were fed on diets which had the highest content of fat, i.e. Klarkki, Vaasan Höyrymyllyn Koerehu 1 and 2 and Raision Koerehu. The three first-mentioned diets also had high calorie and protein contents. The trout which had the lowest percentage of fat had been fed on diets of low fat and calorie contents, i.e. Ewos Rauturehu and Kirjo, respectively. The percentage of protein was also low in Ewos Rauturehu but high in Kirjo (Table 2).

In the fish groups with the highest percentage of fat in the whole fish, the fat content of the gutted fish was not high (except the group fed on Klarkki), but on the contrary rather low, especially in those fed on Raision Koerehu and Vaasan Höyrymyllyn Koerehu 2 (Tables 15 and 16).

The protein content of the gutted fish is important from the point of view of the utilization of the fish. It was very high in all the groups tested, on a wet weight basis from 19.0 to 20.3 per cent. The percentage of protein in the gutted fish was equal to or slightly greater than that of the whole fish, except in fish fed on F-Koerehu.

On a dry weight basis there were differences in protein content between whole and gutted trout fed on the different diets. These differences were correlated with changes in the fat content of the fish. Of special interest is the low percentage of protein in whole fish of the groups fed on Klarkki, Raision Koerehu, Lohi-Sampo and Vaasan Höyrymyllyn Koerehu 2, all of which had a high fat content and except Raision Koerehu also a high calorie content. The reduction in protein of these fish was correlated with the incrase in their fat contents. It should be pointed out, however, that trout fed on the above-mentioned diets, except Raision Koerehu, had

the best increase in total body protein (Table 17). PHILLIPS et al. (1966) also found that when brook trout (*Savelinus fontinalis* Mitchill) were fed on diets which contained supplemental corn oil there was a reduction in protein content, on a dry weight basis, in the bodies of these fish.

Differences in the ash content of whole and gutted fish were rather high and depended upon the quality and quantity of food in the intestines in proportion to the amount of fins and bones.

2. Discussion of the chemical composition of the fish

The chemical composition of rainbow trout has been found to vary according to the size, age, sex and sexual phase of the fish, as well as to season, environment and nutrition.

MANN and ENGELHARDT (1964) with one-summer-old rainbow trout and LAINE et al. (1967 a) with trout a year older observed an increase of 0.9—2.4 per cent in fat content and a decrease of 3.1—5.3 per cent in water content towards the autumn. Later, LAINE et al. (1967 b) stated that the chemical composition of trout varies according to season and the locality of the cultivation place. According to GRAS et al. (1967 a, b), the chemical composition of rainbow trout varies primarily according to the reproductive cycle.

In rainbow trout, it has been found that the water content is higher in the gutted fish than in the whole fish, because from the gutted fish parts with a relatively low water content have been removed. The fat content of the whole fish is usually higher than that of gutted fish, because the bulk of the fat is accumulated in the liver and intestines (JACQUOT 1961). In this experiment the water content of whole fish was slightly higher in the groups fed on Lohi-Sampo, River Pride and Kirjo and in these, same goups as well as the group fed on Klarkki the fat content was lower in whole fish than in gutted fish. In other words, in the above-mentioned trout groups the situation differed from that usually found.

The fat content of gutted fish is important for the utilization of the fish. In general, a fish with a low fat content has a higher culinary value and its keepability is also better. The salmonids are, however, an exception in this respect, because despite their rather high fat content their culinary value is considered high (GEIGER and BORGSTROM 1961). In this experiment the fat content of gutted fish was rather high in all test groups.

A correlation has often been observed between the fat content of the food and the fish. MANN (1959), for example, found that when rainbow trout were fed on fish with a high fat content (4.2 per cent), the fat content of the fillets rose to as much as 11 per cent on a wet weight basis. When the trout were fed with lean fish (0.16 per cent fat), the fillets had a fat content of only 4.8 per cent. In experiments by MANN and ENGELHARDT (1964), the values for the fat content of whole fish and fillets were rather low (Table 18) but this was to be excepted, as the rainbow trout were fed on low-fat diets (Forelli 1.6, Ewos rot 0.35 and Ewos rosa 0.63 per cent fat). The opposite result was obtained with a food mixture with a high dietary level of fat (5.2 per cent) but the fat content of the fish was lower than in the test groups fed on the above mentioned dry diets.

In this experiment the fat and calorie contents of the diets were correlated, on the whole, with the fat content of the whole fish. On a dry weight basis, the increase in fat content was correlated with a reduction in protein content of the whole fish. It is possible that a surplus of calories was fed, or that the fat or protein was not very suitable for trout and/or that there was an unsuitable ratio of protein in the diet. Fish fed on diets with high fat and calorie content (Klarkki, Vaasan Höyrymyllyn Koerehu 1 and 2, Lohi-Sampo) had a low protein content in whole fish on a dry weight basis but they also had the best gains in weight and the best increase in total body protein (Table 17). This might be due to the fact that some dietary protein was spared by the dietary fat for true growth (protein

	Duration of the experiment *Kokeen kestoaika* Försökets längd (days päiviä dagar)	Sampling day *Näytteen otto* Provtagningsdag	Food *Ravinto* Näring
MANN & ENGELHARDT 1964	103	24.9	Forelli
1-summer old rainbow trouts — *1-kesäisiä kirjolohia* — 1-somriga regnbågslax			
	»	»	Ewos rot
	»	»	Ewos rosa
	»	»	Wet food — *Tuore ravinto* — Färsk föda
LAINE et al. 1967a	86	15.9	Dry diet I — *Kuivarehu I*—Torrfoder I
2-summer old rainbow trouts — *2-kesäisiä kirjolohia* — 2-somriga regnbågslax			
	»	»	Dry diet II — *Kuivarehu II* — Torrfoder II
	»	»	Dry diet III — *Kuivarehu III* — Torrfoder III
LAINE et al. 1967b	103	26.9	Dry diet I—*Kuivarehu I* — Torrfoder I
3-summer old rainbow trouts — *3-kesäisiä kirjolohia* — 3-somriga regnbågslax			
	»	»	Dry diet II — *Kuivarehu II* — Torrfoder II
	»	»	Dry diet III — *Kuivarehu III* — Torrfoder III
	»	»	Natural food — *Luonnon ravinto* — Naturlig näring

Table 18. The chemical composition of rainbow trout obtained in some feeding experiments.
Taulukko 18. Kokonaisen ja peratun kirjolohen kemiallinen koostumus eräissä kasvatuskokeissa.
Tabell 18. Den kemiska sammansättningen hos hel resp. rensad regnbågslax från vissa uppfödningsförsök.

synthesis). The increase in fat content indicates that a surplus of energy calories was available.

Similarly, PHILLIPS et al. (1966) reported that in brook trout *(Savelinus fontinalis* Mitchill) diets with higher calorie contents resulted in deposition of significantly more grams of body fat than lower calorie diets. Trout fed on oil-supplemented diets significantly increased their body fat.

The percentage of protein in fish depends not only on nutrition but also upon water and fat contents and the proportion of fish fillets (GEIGER and BORGSTROM 1961). According to MANN (1966), the amount of fish fillets in rainbow trout two summers old varies from 59.0 to 66.4 per cent. LAINE et al. (1967 b) reported that the amount of gutted fish in trout three summers old varied from 80.5 to 93.0 per cent. Variation depends on the size and sexual phase of the fish and also on the season and conditions.

Fish sample *Kalanäyte* Fiskprov	Water *Vesi* Vatten %	Fat *Rasva* Fett %	Protein *Valkuainen* Protein %	Ash *Tuhka* Aska %
Whole fish — *Koko kala* — Hel fisk	76.7	4.5	—	—
Fillet — *Filee* — Filé	77.1	3.5	—	—
Whole fish — *Koko kala* — Hel fisk	78.4	3.6	—	—
Fillet — *Filee* — Filé	77.7	3.2	—	—
Whole fish — *Koko kala* — Hel fisk	77.0	4.6	—	—
Fillet — *Filee* — Filé	76.5	3.9	—	—
Whole fish — *Koko kala* — Hel fisk	77.2	4.8	—	—
Fillet — *Filee* — Filé	77.3	2.9	—	—
Whole fish — *Koko kala* — Hel fisk	73.1	7.4	16.3	1.9
Gutted fisk — *Perattu kala* — Rensad fisk	73.9	4.1	16.9	3.1
Whole fish — *Koko kala* — Hel fisk	70.4	7.2	16.7	3.7
Gutted fish — *Perattu kala* — Rensad fisk	75.1	3.4	16.8	3.3
Whole fish — *Koko kala* — Hel fisk	73.2	6.3	16.8	2.6
Gutted fish — *Perattu kala* — Rensad fisk	76.1	4.5	15.8	2.5
Whole fish — *Koko kala* — Hel fisk	69.7	10.8	17.1	2.1
Gutted fish — *Perattu kala* — Rensad fisk	73.4	6.5	18.1	2.7
Whole fish — *Koko kala* — Hel fisk	67.0	12.5	17.4	2.1
Gutted fish — *Perattu kala* — Rensad fisk	68.2	8.9	18.7	2.8
Whole fish — *Koko kala* — Hel fisk	71.9	8.8	17.5	2.4
Gutted fish — *Perattu kala* — Rensad fisk	69.3	7.4	18.2	2.2
Whole fish — *Koko kala* — Hel fisk	68.8	11.9	17.4	3.3
Gutted fish — *Perattu kala* — Rensad fisk	69.0	8.4	18.5	2.7

The chemical composition of rainbow trout reported by MANN and ENGELHARD (1964) and LAINE et al. (1967 a, b) are presented in Table 18. To facilitate comparison with the results of the present study only analyses made in the autumn have been taken into account. Trout produced in this feeding trial have a higher percentage of protein in both whole and gutted fish as compared to the values presented in Tables 15 and 16. The body fat content was also high in fish fed on the test diets. In general, the nutritive value of the rainbow trout (especially the gutted fish) produced in this experiment may be considered rather good.

3. Composition of the liver

Table 19 shows the composition of the livers on a wet and a dry weight basis.

The water content of the livers varied by 3.4

Diet *Rehu* Foderpreparat	Wet basis *Tuorepainosta* Av färskvikten				Dry basis *Kuivapainosta* Av torrvikten		
	Water *Vesi* Vatten %	Fat *Rasva* Fett %	Protein *Valkuainen* Protein %	Ash *Tuhka* Aska %	Fat *Rasva* Fett %	Protein *Valkuainen* Protein %	Ash *Tuhka* Aska %
Lohi-Sampo	73.3	3.7	17.8	1.2	13.7	65.9	4.4
»	73.3	3.8	18.0	1.4	14.1	66.7	5.2
Average — *Keskimäärin* — Medeltal	73.3	3.8	17.9	1.3	13.9	66.3	4.8
Ewos Rauturehu	75.1	3.4	15.8	1.4	13.7	63.5	5.6
» »	74.8	3.4	16.0	1.5	13.5	63.5	6.0
Average — *Keskimäärin* — Medeltal	75.0	3.4	15.9	1.5	13.6	63.5	5.8
River Pride	72.4	5.6	16.1	1.5	20.3	58.3	5.4
» »	72.1	6.0	16.2	1.2	21.5	58.1	4.3
Average — *Keskimäärin* — Medeltal	72.3	5.8	16.2	1.4	20.9	58.2	4.9
Klarkki	73.3	5.5	16.6	1.4	20.6	62.2	5.2
»	73.7	5.8	16.8	1.6	22.1	63.9	6.1
Average — *Keskimäärin* — Medeltal	73.5	5.7	16.7	1.5	21.4	63.1	5.7
Kirjo	72.0	6.0	15.1	1.4	21.4	53.9	5.0
»	71.9	6.3	15.4	1.4	22.4	54.8	5.0
Average — *Keskimäärin* — Medeltal	72.0	6.2	15.3	1.4	21.9	54.4	5.0
F-Kalanrehu	71.6	6.4	15.8	1.6	22.5	55.6	5.6
»	71.5	6.5	15.6	1.5	22.8	54.7	5.3
Average — *Keskimäärin* — Medeltal	71.6	6.5	15.7	1.6	22.7	55.2	5.5
Raision Koerehu	72.9	5.0	17.0	1.5	18.5	62.7	5.5
» »	72.9	5.3	16.9	1.4	19.6	62.4	5.2
Average — *Keskimäärin* — Medeltal	72.9	5.2	17.0	1.5	19.1	62.6	5.4
F-Koerehu	74.0	4.4	16.8	1.6	16.9	64.9	6.2
»	74.1	4.6	16.5	1.4	17.8	63.7	5.4
Average — *Keskimäärin* — Medeltal	74.1	4.5	16.7	1.5	17.4	64.2	5.8
Vaasan Höyrymyllyn Koerehu 1	73.2	6.5	16.1	1.4	24.3	60.0	5.2
» » »	73.0	6.4	16.5	1.5	23.7	61.1	5.6
Average — *Keskimäärin* — Medeltal	73.1	6.5	16.3	1.5	24.0	60.6	5.4
Vaasan Höyrymyllyn Koerehu 2	73.1	5.5	16.7	1.3	20.4	62.1	4.8
» » »	73.2	5.7	16.9	1.4	21.3	63.1	5.2
Average — *Keskimäärin* — Medeltal	73.2	5.6	16.8	1.4	20.9	62.6	5.0

Table 19. The chemical composition of the livers of the rainbow trout tested.
Taulukko 19. Kirjolohien maksojen kemiallinen koostumus.
Tabell 19. Den kemiska sammansättningen av levern hos regnbågslax.

per cent (71.6—75.0) the fat content by 3.1 per cent (3.4—6.5) the protein content by 2.6 per cent (15.3—17.9) and the ash content by only 0,3 per cent (1.3—1.6). The calculated residue (=nonprotein extracts) in the liver was approximately 4 per cent.

As ALBRECHT (1967) has pointed out, defects due to overfeeding or improper feeding will be observable earlier from the chemical composition of the liver than from the corresponding values for the flesh on blood, or the condition of the fish.

The fat content of the liver is of great importance for the health of the fish. Several feeding trials have revealed that too high a percentage of fat in the food and/or overfeeding cause fattening of the liver as well as of the kidneys. As a result, the mortality may be high (HEWITT 1937 a, b, WOOD and YASUTAKE 1956, TACK 1961, FOWLER and WOOD 1966). High concentrations of carbohydrates in the food may also cause accumulation of fat and glycogen in the liver (PHILLIPS and BROCKWAY 1956) as well as high percentages of protein in the food (PHILLIPS and PODOLIAK 1957, OTTE 1966).

MANN and ENGELHARDT (1964) fed rainbow trout on a lean dry diet (fat content 0.35—2.5 per cent) and the fat content of the liver re-

mained low in all fish groups, 0.8—1.4 per cent. MANN (1966) found that in wild two-summer-old rainbow trout the fat content of the liver (0.56—0,70 per cent) was considerably lower than in propagated trout (1.50—4.50 per cent). According to DEUFEL (1963), the fat content of dry diets should not exceed 8 per cent to avoid fattening of the liver. PHILLIPS and PODOLIAK (1957) consider 3—5 per cent dietary fat safe in general. TACK (1961) and MANN (1961) observed signs of liver degeneration when the fat content of the liver exceeded 5 per cent. The safe percentage of dietary fat depends upon several factors, such as the composition of the fat and the contents of vitamin E and choline in the diet (PHILLIPS and BROCKWAY 1948). For instance, 20 mg of vitamin E per kilo of food prevents fatty degeneration of the liver (RUHDEL 1964).

The fat content of the dry diets were high in this experiment, in Klarkki as high as 8.5 per cent. The percentage of fat in the livers exceeded the »dangerous» 5 per cent level (see above) in most of the experimental fish groups. The high fat content did not cause any apparent damagae to health or growth, but it is possible that some harmful effects might have appeared had the experiment been prolonged over the winter (CHRISTENSEN 1966).

I. General discussion

The most important criteria generally employed in assessing the value of diets by means of feeding experiments have been discussed separately above. Although each one of them is of interest, the most important thing is to gain an idea of each diet as a whole. For instance, efficient conversion of food into fish is of little significance if the growth of the fish is simultaneously slow or the mortality high.

In the discussion of the results, attention was drawn to the fact that none of the diets used was superior to the others in every respect. It depends upon circumstances and personal interests which of the above-mentioned criteria is considered the most important and what significance is attributed to the differences. According to the criteria by which evident differences could be observed between the diets (growth and colour of fish, conversion of food into fish, food costs to produce one kilo of fish) Lohi-Sampo, and Vaasan Höyrymyllyn Koerehu 1 and 2 were in our opinion equal to Klarkki. Food costs per kilo of fish with Lohi-Sampo and Vaasan Höyrymyllyn Koerehu 2 were more favourable but the colour of the fish flesh was somewhat paler than with Klarkki. The growth of fish fed with Vaasan Höyrymyllyn Koerehu 1 was as good as with Klarkki, the flesh was somewhat duller, the conversion of food into flesh a little inferior but the cost of producing one kilo of fish was somewhat lower than that of the comparison diet.

Of the other diets, only a couple were equal to Klarkki according to some of the criteria mentioned earlier. With Kirjo the cost per kilo of fish was as favourable as with Klarkki, and the flesh colour of fish fed with Raision Koerehu was equal to that of Klarkki. Raision Koerehu and Lohi-Sampo proved to be clearly more efficient than Klarkki in producing rainbow trout according to calories and protein required per kilo of fish produced.

As mentioned earlier, it cannot be stated with certainty to what extent drifting of floating Ewos Rauturehu, River-Pride and F-Kalanrehu from the nets influenced the growth of the trout and the conversion ratios. In our opinion the only possible conclusion to be drawn from this experiment is that the floating dry diets are less suitable than non-floating diets for propagation of trout in floating nets.

It is to be pointed out that the growth of fish fed on Kirjo and F-Koerehu and their conversion to fish would obviously have been superior to the values now obtained had the accustoming feeding period in the beginning of the experiments been longer.

As regards the comparability of the results, it should be noted that the equal growth and conversion ratios obtained with River Pride and F-Kalanrehu indicate that the conditions in the different nets during the experiment were similar.

V. SUMMARY

1. In the present study six Finnish and three foreign commercial dry diets for rainbow trout were studied and compared in a feeding experiment in floating nets. Comparisons were made in regard to growth, mortality, condition factor, flesh colour, conversion of food into fish and food costs to produce one kilo of fish. Furthermore, the raw materials of the diets were ascertained, and their chemical composition analysed and compared with that of the propagated trout and their livers.

2. There was not much to choose between the diets as regards composition. Ewos Rauturehu differed most from the others. Fat, protein and ash contents in Ewos Rauturehu were far lower and nonprotein extracts and fibre higher than in the other diets (Tables 2 and 5).

The protein and calorie contents of the diets were high. The protein content averaged 38 per cent and the calorie content exceeded 2 000 kcal/kg. In all diets, over 50 per cent of the calories were supplied as protein (Table 2).

A great number of raw materials were used in the diets. On an average, 13 different raw materials had been used in producing a diet. In all diets fishmeal or fish extract was the chief ingredient of animal origin. Various cereals were the chief ingredients of plant origin (Table 3).

A vitamin concentrate made up 0.5 to 10 per cent of the diets. Special attention was paid to lack of some vitamins considered essential for rainbow trout in some vitamin extracts added to the diets (Tables 6 and 7). The amounts of added vitamins in the diets were about the same, except in Ewos Rauturehu, in which the amounts were two to four fold compared with the other diets.

3. At the end of the experiment the weights and lengths of fish fed on Lohi-Sampo and Vaasan Höyrymyllyn Koerehu 1 and 2 did not differ significantly from fish fed on the control diet Klarkki (Table 8). There were significant differences in weights and lengths between fish fed on other diets and on Klarkki ($P < 0.001$).

There were differences in the frequency distribution of the weights of the fish groups at the end of the experiment (Fig. 2). The trout grew best at the end of the summer (period III, August 12—September 16) except the groups fed on River Pride and F-Kalanrehu (Table 10). This might be due to changes in the temperature and pH of the water during the experiment (Table 4, Fig. 3).

Lohi-Sampo, Vaasan Höyrymyllyn Koerehu 1 and 2 and Klarkki, which gave the best growth results, had as a common factor a higher calorie content than the other diets (Table 2). They also had about the same percentage of calories as protein (58.3—60.0). Their fat contents (5.0—8.0 per cent) were higher and ash contents (10.0—13.5 per cent) lower than in most other diets. The protein contents were also relatively high (35.0—40.0 per cent).

4. The best conversions of food into fish were obtained with Vaasan Höyrymyllyn Koerehu 2 (1.67), Lohi-Sampo and Klarkki (both 1.68) (Table 11). According to PHILLIPS and BROCKWAY (1959), the conversion ratio decreases when the calorie content of the diet increases. This was also the case in the present experiment, as the calorie contents were highest in the above-mentioned diets (as well as Vaasan Höyrymyllyn Koerehu 1).

The conversion ratios obtained were in reasonable agreement with the values reported from other feeding experiments.

The floating diets, i.e. Ewos Rauturehu, River Pride and F-Kalanrehu, were found to drift out of the nets to some extent owing to the winds and especially to the movements of the fish. This may partly account for the high conversion ratios obtained with these diets. This indicates that floating dry diets are not so suitable as non-floating diets for propagation of rainbow trout in small nets.

The growth of fish fed on Kirjo and F-Koerehu and their conversions to fish would evidently have been superior to the values obtained, had the accustoming period in the beginning of the experiment been longer. This is due to their different appearance compared with Klarkki.

5. The number of calories required to produce one kilo of fish were lowest with Raision Koerehu (3 811 kcal/kg) and Lohi-Sampo (3 933 kcal/kg) and clearly highest with Ewos Rauturehu (5 836 kcal/kg) (Table 11).

Proteins required to produce one kilo of fish were lowest with Raision Koerehu (528 g) and Lohi-Sampo (588 g) and highest with Kirjo (860 g) and Ewos Rauturehu (822 g) (Table 11).

Calories and proteins required to produce one kilo of fish corresponded to the values obtained in other feeding experiments.

6. There were considerable differences in the costs to produce one kilo of fish with the diets tested (Table 11). Lohi-Sampo and Vaasan Höyrymyllyn Koerehu 2 were the most economic (1.40 mk/kg) and the floating Ewos Rauturehu, River Pride and F-Kalanrehu the most expensive (3.80 and 2.40 mk/kg).

7. As a consequence of the sudden change in the pH of the water, it was unfortunately not possible to gain a clear idea of the mortality of trout fed on the different diets (Table 12). No deficiency symptoms were observed, even at the end of the 20-week feeding period.

8. According to the calculated condition factors (Table 13), all but a few of the fish were in good condition at the end of the experiment. Differences between fish groups taken from different nets were so slight that it was not possible to draw any conclusions about differences in condition.

9. Fish fed on Raision Koerehu and Klarkki had the brightest red colour. Flesh of trout fed on Kirjo and Vaasan Höyrymyllyn Koerehu 1 and 2 was also well coloured (Table 14). The diets which produced the most marked pigmentation in this experiment contained from 5 to 11 per cent crustacean (shrimp) meal, except Vaasan Höyrymyllyn Koerehu 1 (Table 3).

10. Different percentages of water were found in fish fed on the diets tested (Tables 15, 16 and 17). These differences were correlated with changes in body fat.

Great differences in fat content were observed between the fish groups. On a wet weight basis the fat content varied in the whole fish by 3.8 per cent (6.0—9.8) and in the gutted fish by 4.9 per cent (5.1—10.0).

The fish groups with the highest fat content of the whole fish had not a high fat content in the gutted fish (except those fed on Klarkki) but, on the contrary, a rather low fat content. The protein content of the gutted fish was very high in all test groups, on a wet weight basis, from 19.0 to 20.3 per cent.

On a dry weight basis, there were differences in the percentage of protein in whole and gutted trout fed on the different diets. These differences were correlated with changes in the fat content of the fish. In this experiment the fat and calorie contents of the diets were correlated on a whole with the fat content of the whole fish. On a dry weight basis, increase in fat content was correlated with a reduction in protein content in the whole fish. Fish fed on diets with a high fat content and calorific value (Klarkki, Vaasan Höyrymyllyn Koerehu 1 and 2, Lohi-Sampo) had a low protein content in the whole fish on a dry weight basis but they also had the best gains in weight and the best increase in total body protein (Table 17). This may have been because

some dietary protein was spared by the dietary fat for protein synthesis. An increase in fat content indicates that a surplus of energy calories was available.

Differences in ash content between whole and gutted fish were rather high and depended upon the quality and quantity of food in the intestines and the proportions of fins and bones.

11. Trout produced in this experiment had a higher percentage of protein in both whole and gutted fish as compared to values obtained in some other feeding experiments (Table 18). In general, the nutritive value of rainbow trout, and especially of gutted fish, produced with the diets tested may be considered rather good.

12. The fat content of the liver is of great importance for the health of the fish. TACK (1961) and MANN (1961) observed signs of liver degeneration when the fat content of the liver exceeded 5 per cent. The percentage fat in the livers analysed exceeded the »dangerous» 5 per cent in most fish groups (Table 19). The high fat content did not cause any district damage to health or growth, but it is to be pointed out that some harmful effects might have appeared, had the experiment been prolonged over the winter.

13. None of the diets tested was superior to the others in every respect. According to the qualities in which evident differences were observed between the diets (growth and colour of fish, conversion of food into fish flesh, food costs per kilo of fish) Lohi-Sampo and Vaasan Höyrymyllyn Koerehu 1 and 2 were equal to Klarkki.

VI. YHTEENVETO: KUIVAREHUILLA VERKKOALTAISSA SUORITETTU KIRJOLOHEN (SALMO GAIRDNERI RICHARDSON) VERTAILEVA KASTATUSKOKEILU

1. Tässä käsiteltävänä olevassa kokeessa tutkittiin kuutta kotimaista ja kolmea ulkolaista kuivarehuvalmistetta kirjolohilla verkkoaltaissa suoritetussa kasvatuskokeessa. Tutkimuksessa vertailtiin eri rehuvalmisteilla ja vertailurehuna käytetyllä Klarkilla ruokittujen kirjolohien kasvua, rehujen ravintokertoimia ja tuotetun kalakilon hintoja sekä kalojen kuolleisuutta, kuntoa ja lihan väritystä. Lisäksi tutkittiin eri kuivarehujen kemiallista koostumusta ja sen vaikutusta kirjolohen kemialliseen koostumukseen ja maksan koostumukseen.

2. Rehujen kemialliset koostumukset eivät yleisesti ottaen poikenneet kovin paljoa toisistaan. Poikkeuksena oli Ewos Rauturehu, jonka rasva-, valkuais- ja tuhkapitoisuudet olivat huomattavasti muiden rehuvalmisteiden vastaavia arvoja alhaisemmat ja uuteaineiden ja kuidun määrät vastaavasti korkeammat (Taulukot 2 ja 5).

Rehujen valkuaispitoisuudet samaten kuin kaloripitoisuudet olivat varsin korkeat. Valkuaista oli keskimäärin 38 % ja kaloreita yli 2 000 kcal/kg rehua. Kaikissa rehuissa oli yli 50 % kaloreista valkuaisessa (Taulukko 2).

Rehujen raaka-ainekoostumukset olivat monipuoliset. Keskimäärin 13 erilaista raaka-ainetta oli käytetty rehujen valmistuksessa. Kaikissa rehuvalmisteissa muodosti kalajauho tai kalauute määrällisesti suurimman eläinperäisen raaka-aineen ja kasvisperäisistä olivat eniten käytettyjä erilaiset viljatuotteet (Taulukko 3).

Rehuihin oli lisätty vitamiinirikastetta 0,5—10 %. Erityistä huomiota kiinnitti eräiden kirjolohelle välttämättöminä pidettyjen vitamiinien puuttuminen muutamista rikasteista (Taulukot 6 ja 7). Rehuihin lisättyjen vitamiinien määrät olivat samaa suuruusluokkaa Ewos Rauturehua lukuunottamatta, jossa ne olivat useiden vitamiinien kohdalla kaksin—nelinkertaiset muihin rehuihin verrattuna.

3. Kasvatuskokeen päättyessä otettujen kalanäytteiden perusteella olivat Lohi-Sampolla sekä Vaasan Höyrymyllyn Koerehu 1:llä ja 2:lla ruokitut kirjolohet kasvaneet yhtä hyvin kuin Klarkilla ruokitut. Muita rehuvalmisteita saaneet kalat olivat selvästi pienempikokoisia, sillä kalanäytteiden pituus- ja painoerot olivat tilastollisesti erittäin merkitseviä ($P < 0{,}001$) (Taulukko 8). Eri rehulaaduilla ruokittujen koekalojen painojen jakautumissa oli kokeen päättyessä suuria eroja (Kuva 2).

Kalojen kasvu oli nopeinta vasta loppukesällä, kolmantena ruokintajaksona (12.8—16.9), lukuunottamatta River Pridea ja F-Kalanrehulla ruokittuja kaloja (Taulukko 10). Tämä johtui todennäköisesti veden lämpötilan ja pH:n muutoksista kokeen aikana (Taulukko 4, Kuva 3).

Lohi-Sampolla, Vaasan Höyrymyllyn Koerehuilla sekä Klarkilla, joilla saatiin parhaat kasvutulokset, olivat kaloripitoisuudet korkeammat kuin muilla rehuilla (Taulukko 2). Niillä oli myöskin lähes sama prosentuaalinen osa kaloreista valkuaisessa (58,3—60,0 %). Niiden rasvapitoisuus (5,0—8,0 %) oli korkeampi ja tuhkapitoisuus (10,0—13,5 %) alhaisempi kuin useimmilla muilla rehuilla. Niiden valkuaispitoisuus oli myös suhteellisen korkea (35,0—40,0 %).

4. Edullisimmat ravintokertoimet saatiin Vaasan Höyrymyllyn Koerehu 2:lla (1,67) sekä Lohi-Sampolla ja Klarkilla (molemmilla 1,68),

(Taulukko 11). PHILLIPSin ja BROCKWAYN (1959) mukaan ravintokerroin alenee ravinnon kalorimäärän kasvaessa. Tämä osoittautui varsin hyvin paikkansa pitäväksi myös tässä tutkimuksessa, sillä edellämainituissa kolmessa rehussa oli Vaasan Höyrymyllyn Koerehu 1 ohella eniten kaloreita.

Tässä kasvatuskokeessa saadut ravintokertoimet olivat useimpien rehuvalmisteiden osalta täysin tyydyttävät verrattuna muissa kirjolohella suoritetuissa kokeissa saatuihin.

Kokeessa mukana olleiden kelluvien rehujen Ewos Rauturehun, River Priden ja F-Kalanrehun havaittiin jossain määrin ajautuvan pois verkkoaltaista kalojen liikkeiden ja tuulen vaikutuksesta, mikä mahdollisesti oli syynä niillä saatujen ravintokertoimien epäedullisuuteen. Tämän vuoksi kelluvien rehujen katsottiin soveltuvan uppoavia rehuja heikommin pienikokoisissa verkkoaltaissa suoritettuun kirjolohien kasvatukseen.

Mikäli totutusruokinta ennen koetta olisi ollut pidempiaikainen, olisi Kirjolla ja F-Koerehulla ruokittujen kalojen kasvu ja ravintokertoimet olleet ilmeisestikin paremmat kuin nyt todetut.

5. Kaloreiden kulutuksen mukaan mitattuna osoittautuivat Raision Koerehu (3 811 kcal/kg) ja Lohi-Sampo (3 933 kcal/kg) tehokkaimmiksi ja Ewos Rauturehu selvästi heikoimmaksi (5 836 kcal/kg) (Taulukko 11)

Valkuaista tarvittiin kalakilon kasvattamiseen vähiten Raision Koerehulla (528 g) ja Lohi-Sampolla (588 g) ja eniten Kirjolla (860 g) ja Ewos Rauturehulla (822 g) (Taulukko 11).

Kaloreiden ja valkuaisen kulutus kalakilon kasvattamiseksi oli samaa suuruusluokkaa kuin eräissä muissa kasvatuskokeissa saadut.

6. Kokeessa saatujen ravintokertoimien ja rehujen vähittäismyyntihintojen perusteella lasketuissa kalan kasvatuskustannuksissa oli suuria eroja eri rehuvalmisteiden välillä. Kalakilon kasvattaminen tuli edullisimmaksi Lohi—Sampolla ja Vaasan Höyrymyllyn Koerehu 2:lla (1,40 mk/kg) ja kalleimmaksi kelluvilla rehuilla Ewos Rauturehulla, River Pridella ja F-Kalanrehulla (3,80 ja 2,40 mk/kg) (Taulukko 11).

7. Eri rehuvalmisteilla ruokittujen kalojen kuolleisuudesta ei voitu valitettavasti saada selvää kuvaa pH:n korotuksesta johtuen (Taulukko 12). Minkäänlaisia puutostautien oireita ei havaittu missään kalaryhmässä, ei edes 20 viikkoa kestäneen kokeen loppupuolella.

8. Koekalojen keskimääräiset kuntokertoimien arvot (Taulukko 13) olivat hyvät. Erot eri altaista otettujen kalanäytteiden välillä olivat niin vähäiset, että niiden perusteella ei voitu tehdä johtopäätöksiä kalojen erilaisesta kunnosta.

9. Punalihaisemmat kirjolohet saatiin Klarkilla ja Raision Koerehulla. Kirjolla sekä Vaasan Höyrymyllyn molemmilla koerehuilla ruokitut kalat olivat myös hyvin punertavalihaisia (Taulukko 14). Vaasan Höyrymyllyn Koerehu 1 lukuunottamatta oli punalihaisimpia kaloja kasvattaneisiin rehuihin lisätty 5—11 % äyriäis-(katkarapu)jauhoja (Taulukko 3).

10. Koko kalan ja peratun kalan vesipitoisuuksissa oli eri kalaryhmien välillä vähäisiä eroavaisuuksia (Taulukot 15, 16 ja 17). Vesi- ja rasvapitoisuuden välillä vallitsi käänteinen suhde. Rasvapitoisuuksissa oli huomattavia eroja havaittavissa eri kalaryhmien välillä. Koko kalan rasvapitoisuuden vaihtelu oli 3,8 % (6,9—9,8) ja peratun kalan 4,9 % (5,1—10,0) tuorepainosta laskettuna.

Kalaryhmillä, joilla koko kalan suhteellinen rasvapitoisuus oli korkein, oli peratussa kalassa suhteellisen alhainen rasvapitoisuus lukuunottamatta Klarkilla ruokittuja kaloja.

Kalan hyväksikäytön kannalta on peratun kalan valkuaispitoisuus tärkeä. Se oli kaikissa kalaryhmissä huomattavan korkea, 19,0—20,3 % tuorepainosta.

Eri rehuvalmisteilla ruokittujen kalojen kokokalan ja peratun kalan suhteellisissa valkuaispitoisuuksissa oli eroavaisuuksia kuivapainosta laskettuna. Kalojen valkuaispitoisuudet korreloivat rasvapitoisuuksien kanssa.

Rehujen rasva- ja kaloripitoisuudet korreloivat kalojen rasvapitoisuuksien kanssa. Kun koko

kalan suhteellinen rasvapitoisuus oli korkea, suhteellinen valkuaispitoisuus oli alhainen (kuivapainosta laskettuna). Kaloilla, joita oli ruokittu runsaasti rasvaa ja kaloreita sisältävillä rehuilla (Klarkki, Vaasan Höyrymyllyn molemmat koerehut, Lohi-Sampo), oli koko kalan suhteellinen valkuaispitoisuus alhainen (kuivapainosta), mutta samoilla kalaryhmillä oli toisaalta kasvu nopeinta ja kokonaisvaluaispitoisuus korkein (Taulukko 17). Tämä saattaa johtua siitä, että ko. rehujen runsaat rasvakalorit olivat säästäneet ravinnon valkuaista ja siten parantaneet kalojen kasvua. Kalojen suhteellisen rasvapitoisuuden kohoaminen viittaa siihen, että mainituissa rehuissa oli kaloreita enemmän kuin mitä energian tuottamiseen tarvittiin.

Koko kalan ja peratun kalan tuhkamäärät vaihtelivat paljon. Vaihtelu riippui suolessa olevan rehun määrästä ja laadusta sekä luiden, ruotojen ja evien suhteellisestä määrästä.

11. Tässä tutkimuksessa saadut kirjolohen koko kalan ja peratun kalan koostumukset eroavat eräissä muissa tutkimuksissa saaduista vastaavista tuloksista korkeamman valkuaispitoisuuden suhteen (Taulukko 18). Kokonaisuutena katsoen voidaan saatuja tuloksia ja etenkin peratun kalan koostumusta pitää varsin hyvänä kalojen hyväksikäyttöä ajatellen.

12. Maksan rasvapitoisuudella on keskeinen merkitys kalojen hyvinvoinnin kannalta. Maksan rasvapitoisuus kohosi useimmilla kalaryhmillä yli TACKin (1961) ja MANNin (1961) vaarallisena pitämän 5 % rajan (Taulukko 19). Mitään selvästi näkyvää haittaa kalojen terveydentilalle tai kasvulle ei tästä havaittu olevan, mutta on mahdollista, että haittavaikutuksia olisi tullut näkyviin, mikäli kasvatusta olisi jatkettu talven yli.

13. Mikään rehuvalmiste ei ollut joka suhteessa muita parempi. Ne arviontiperusteet huomioiden, joissa rehujen välillä havaittiin selviä eroja (kalojen kasvu ja lihan väritys, rehujen ravintokerroin ja tuotetun kalakilon hinta) olivat Lohi-Sampo ja Vaasan Höyrymyllyn molemmat koerehut suunnilleen samanarvoiset Klarkin kanssa.

VII. SAMMANDRAG: JÄMFÖRANDE TORRFODERFÖRSÖK MED REGNBÅGSLAX (SALMO GAIRDNERI RICHARDSON) I FLYTANDE NÄTKASSAR

1. Vid det försök som här redovisas, undersöktes sex inhemska och tre utländska torrfoderpreparat genom uppfödningsförsök med regnbågslax i nätkassar. Vid undersökningen jämfördes tillväxten hos regnbågarna vid utfordring med olika foderpreparat och kontrollfoder av märket klarkki, likaså klarlades foderkoefficienterna för foderpreparaten och priset på producerad fisk per kg samt fiskens dödlighet, kondition och köttets färg. Ytterligare undersöktes de olika torrfoderpreparatens kemiska sammansättning, dennas inverkan på regnbågens kemiska uppnyggnad och leverns sammansättning.

2. Den kemiska sammansättningen på foder av olika märken uppvisade ej större differenser. Ett undantag utgjorde Ewos Forellfoder, som i fråga om halt av fett, äggvita och aska hade betydligt lägre värden än övriga foderpreparat, medan extraktiva ämnen och fiber uppvisade motsvarande högre värde (Tabellerna 2 och 5).

Foderpreparaten uppvisade rätt höga värden för äggvitehalt och kaloriinnehåll. Äggvita fanns i medeltal 38 % och kaloriinnehållet var i medeltal över 2 000 kcal/kg foder. I alla foder förekom över 50 % av kalorivärdet bundet i äggvitan (Tabell 2).

Foderpreparatens sammansättning var mångsidig i fråga om råämnen. I medeltal hade 13 olika råämnen använts vid fodertillverkningen. I alla foderpreparat ingick fiskmjöl eller fiskextrakt i större halt än andra ämnen av animaliskt ursprung och av material från växtriket hade främst olika sädesprodukter använts (Tabell 3).

I fodren hade tillsats skett av antikade vitaminpreparat till en halt av 0,5—10 %. Speciell uppmärksamhet väckte det faktum, att vissa vitaminer, som anses nödvändiga för regnbågen fattades i några av vitaminanrikningarna (Tabellerna 6 och 7). Halterna av tillförda vitaminer var av samma storleksordning i olika foderpreparat med undantag av Ewos Forellfoder, där flera vitaminer ingick i mängder som var två-fyrdubbla i jämförelse med halterna i andra foder.

3. Sedan uppfödningsförsöket slutförts visade analyserade fiskprov, att fisk som uppfötts på Lohi-Sampo och Vasa Ångkvarns Koerehu 1 och Koerehu 2 vuxit lika bra som fisk som utfodrats med Klarkki. De på övriga foderpreparat uppfödda fiskarna var klart mindre till storleken, ty differenserna i fråga on längd och vikt hos fiskproven var statistiskt taget ytterst signifikativa ($P < 0{,}001$) (Tabell 8).

Viktfördelningen hos de på olika foder uppfödda försöksfiskarna uppvisade efter slutfört försök stora differenser (Fig. 2).

Fiskarnas snabbaste tillväxt inföll först på sensommaren, under tredje utfodringsperioden (12.8—16.9), dock med undantag av fisk som uppfötts på River Pride och F-Kalanrehu (Tabell 10). Detta berodde sannolikt på att vattnets temperatur och pH förändrats under försöket (Tabell 4, Fig. 3).

De foder som gav bästa tillväxt (Lohi-Sampo, Vasa Ångkvarns Koe-rehu 1 och 2, Klarkki), hade högre kaloriinnehåll än övriga foder (Tabell 2). Dessa foder uppvisade även i det närmaste samma procentuella andel av i äggvitan bundna kalorier (58,3—60,0 %). Dessa foders fetthalt (5,0—8,0 %) var högre och askhalten (10,0—13,5 %) var lägre än hos de flesta övriga

foder. Äggvitehalten hos dessa foder var också relativt hög (35,0—40,0 %).

4. De mest förmånliga foderkoefficienterna uppnåddes med Vasa Ångkvarns Koerehu 2 (1,67) samt med Lohi-Sampo och Klarkki (vardera 1,68) (Tabell 11). Enligt PHILLIPS och BROCKWAYN (1959) sjunker foderkoefficienten då fodrets kaloriinnehåll ökar. Detta konstaterande visade sig väl slå in även vid dessa undersökningar, ty nyssnämnda tre foderpreparat hade vid sidan av Vasa Ångkvarns Koerehu 1 största kaloriinnehåll.

De vid detta uppfördningsförsök erhållna foderkoefficienterna var för de flesta foderpreparats vidkommande helt tillfredsställande i jämförelse med de värden man fått vid andra försök med regnbåge.

De undersökta flytande foderpreparaten Ewos Forellfoder, River Pride och F-Kalanrehu konstaterades i viss mån på grund av fiskens förelser och under vindens inverkan, driva bort ur nätsumparna, vilket möjligen var orsaken till att de för dessa preparat erhållna foderkoefficienterna var ogynnsamma. Slutsatsen blev, att flytande foder sämre än sjunkande preparat lämpar sig för uppfödning av regnsbåge i nätsumpar av små dimensioner.

Ifall fisken under en längre tid än nu var fallet fått vänja sig vid här doserade foderpreparat, skulle tillväxten hos fisken som uppföddes på Kirjo och F-Koerehu tydligen ha uppvisat gynnsammare värden och foderkoefficienterna skulle ha blivit förmånligare.

5. I fråga om kaloriförbrukning visade sig Raisio Koerehu (3 811 kcal/kg) och Lohi-Sampo (3 933 kcal/kg) vara mest effektiva medan Ewos Forellfoder lämnade klart svagaste resultat (5 836 kcal/kg) (Tabell 11).

För produktionen av ett kilogram fisk behövdes minsta mängder äggvita i fråga om Raisio Koerehu (528 g) och Lohi-Sampo (588 g) och största mängder för Kirjo (860 g) och Ewos Forellfoder (822 g) (Tabell 11). Förbrukningen av kalorier och äggvita för produktionen av ett kg fisk var av samma storleksordning som de vid andra uppfödningsförsök erhållna resultaten.

6. De foderkoefficienter som uträknades vid försöken och de omkostnader som på basen av foderpreparatens minutpris beräknades för producerad fiskvikt (kg) uppvisade stora differenser för olika foderpreparats vidkommande. Produktionen av ett kg fisk ställde sig förmånligast med Lohi-Sampo och Vasa Ångkvarns Koerehu 2 (1,40 mk/kg) och dyrast med flytande Ewos Forellfoder, River Pride och F-Kalanrehu (3,80 och 2,40 mk/kg) (Tabell 11).

7. Dödligheten för på olika foderpreparat uppfödd fisk kunde på grund av stigande pH tyvärr ej klart utredas (Tabell 12). Inga som helst bristsjukdomssymptom konstaterades i någon av fiskgrupperna, ej ens mot slutet av försöksperioden, som omfattade 20 veckor.

8. Konditionskoefficienterna hos försöksfiskarna uppvisade i medeltal gynnsamma värden (Tabell 13). Differenserna mellan fiskprov från olika nätsumpar var så ringa, att man på basen av dessa ej kunde dra några slutsatser om olika kondition på fisken.

9. Starkaste rödfärgning hos regnbågsforellen erhölls med Klarkki och Raision Koerehu. Fisk, som uppfötts på Kirjo och båda foderpreparaten från Vasa Ångkvarn uppvisade också mycket god färgsättning (Tabell 14). Med undantag av Vasa Ångkvarns Koerehu 1 hade de foderpreparat, som åstadkom bästa rödfärgning hos fisken, tillsatts 5—11 % kräftdjurs (räk)-mjöl (Tabell 3).

10. I fråga om vattenhalten hos hel fisk och rensad fisk förekom i olika fiskgrupper smärre differenser (Tabellerna 15, 16 och 17). Mellan vatten- och fetthalt förekom omvänd proportionalitet. I fetthalterna förekom betydande skillnader mellan olika fiskgrupper. Fetthalten i hel fisk varierade med 3,8 % (6,9—9,8) och i rensad fisk med 4,9 % (5,1—10,0) beräknad på färskvikt.

De fiskgrupper, hos vilka den relativa fetthalten i hel fisk var störst, hade i rensad fisk en relativt låg fetthalt, detta dock med undantag av fisk som uppfötts på Klarkki.

Med tanke på fiskens användning är äggvitehalten i rensad fisk viktig. Den uppvisade i alla fiskgrupper en avsevärt hög andel av färskvikten (19,0—20,3 %).

I fråga om fisk som uppfötts på olika foderpreparat förekom mellan å ena sidan hel fisk och å andra sidan rensad fisk differenser i de på torrvikt beräknade relativa halterna av äggvita. Korrelation konstaterades föreligga mellan äggvitehalterna och fiskens relativa fetthalt (av torrvikten).

Korrelation konstaterades även mellan å ena sidan foderpreparatens fett- och kaloriinnehåll och å andra sidan fiskens relativa fetthalt. Ifall den relativa fetthalten i hel fisk var hög, var den relativa äggvitehalten låg (beräknad på torrvikt). Fisk, som utfodrats med foderpreparat innehållande rikliga mängder fett och kalorier (Klarkki, Vasa Ångkvarns båda foderpreparat, Lohi-Sampo) var hela fiskens relativa äggvitehalt låg (beräknad på torrvikt) men resp. fiskgrupper uppvisade å andra sidan snabbaste tillväxt och högsta äggvitehalt (Tabell 17). Detta kan bero på, att den rikliga kaloriförekomsten i fettet hos ifrågavarande foder medfört en inbesparing av äggvitan i fodret och sålunda förbättrat fiskens tillväxt. Höjningen av fiskens relativa fetthalt tyder på, att i nämnda foder förekom ett större kaloriinnehåll än vad som är nödigt för frigörandet av energi.

Variationerna i askinnehållet i hel och rensad fisk var stora och betingade av den i matsmältningskanalen befintliga fodermängden och dennas kvalitet samt relativa mängd en av ben och fenor.

11. De siffervärden för sammansättningen på hel och rensad fisk som erhållits vid denna undersökning avviker från de resultat som erhållits vid vissa andra undersökningar samt i fråga om hel och rensad fisk för den högre äggvitehaltens vidkommande (Tabell 18). Som helhet tagna kan de erhållna resultaten och särskilt sammansättningen på rensad fisk anses rätt gynnsamma med tanke på användningen av fisken.

12. Fettinnehållet i levern spelar en viktig roll för fiskens välmåga. Leverns fettinnehåll översteg i de flesta fiskgrupperna den riskgräns om 5 % som TACK (1961) och MANN (1961) anfört (Tabell 19). Det kunde dock ej konstateras, att denna klart skulle ha medfört olägenhet för fiskens hälsotillstånd eller tillväxt. Möjligt är, att negativa konsekvenser skulle ha uppträtt ifall uppfödningen fortsatt över vintern.

13. Inget av de använda foderprepraten var i alla avseenden bättre än övriga preparat. Utgående ifrån de kriterier, för vilkas vidkommande tydliga differenser konstaterades mellan olika foder (fiskens tillväxt, köttets färg, foderkoefficient och priset på producerad fisk per kg) var Lohi-Sampo och Vasa Ångkvarns båda foderpreparat i stort sett jämbördiga med Klarkki.

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