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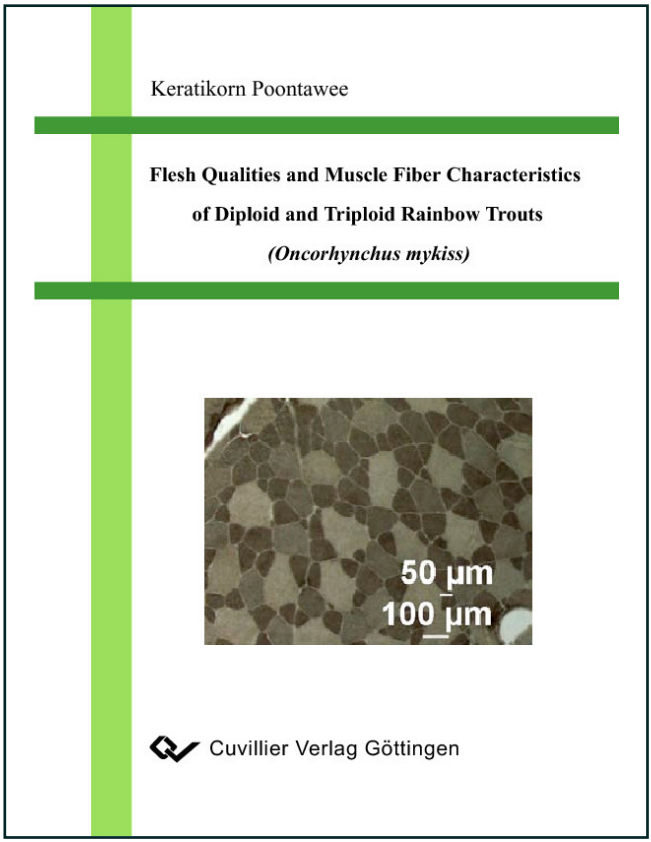
Flesh Qualities and Muscle Fiber Characteristics of Diploid and Triploid Rainbow Trouts (Oncorhynchus mykiss)



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1 INTRODUCTION

The rainbow trout has been known as a great sport fish. But in recent time, it has also gained recognition as a tasty, nutritious dinner.

For the fish farmer, sexual development in his stock can avoid. Several problems, the major one being that a significant proportion of males will generally mature in their first year, before the stock can be marketed; the secondary sexual characteristics associated with maturity in males reduce disease resistance and cause a deterioration in appearance and flesh quality decreasing their sale value considerably. In female fish, the gonads are composed of two duct-shaped ovaries that extend along the body cavity. During the breeding season the energy from feed intake is used for reproductive organ development (especially the eggs) and the muscle growth is stopped in this time. In rainbow trouts the average weight of female spawners before stripping is between 1,100-1,300 g (Hörstgen - Schwark *et al*.,1986) and a female rainbow trout can produce up to 2,000 eggs / kg of body weight in spawning time (Morrissy and Cassells, 1985). The average egg weight per 100 eggs is 7.5-9 g (Hörstgen -Schwark *et al*., 1986). It means 15-18 % of body weight was the weight of eggs. The farmer can get more money if they produce sterile fishes or sell fishes before onset of maturation.

The most promising method of producing sterile fishes is by inducing polyploidy. In diploid fishes (normal fish) the reproductive system develops continuously but triploid fishes are completely sterile. Although triploidy is related to impaired gonad development in fish it has been shown that the degree of impairment differs between the sexes. In triploid male plaice (*Pleuronectes platessa*) and in the hybrid with the flounder (*Platichthys flesus*) (Lincoln, 1981), for example, there is little or no reduction in testis growth compared with diploid controls. Thorgaard and Gall (1979) found that in naturally-occurring rainbow trout triploids, the females showed virtually no gonad development, while the males were morphologically in distinguishable form to diploid males. The others advantages which can tip the commercial production is that the impact

of escaped farmed fishes on the natural environment will be obviously reduced if they are sterile.

Triploid fishes are functionally sterile. In rainbow trouts sexual maturity results in lower feed conversion ratios, reduced carcass quality and higher susceptibility to bacterial and fungi infections. Triploids can have an advantage, especially fishes with more than one kg (Lincoln and Bye, 1984). The cells in most organs and tissues of triploid fish are larger than diploid because the extra set of chromosomes dictates an increase in cell nucleus dimensions which in turn affects overall cell size (Benfey, 1999).

The objective of this study was to compare the influence of polyploidy induction on the flesh quality and muscle structure depending on age of the diploid and triploid rainbow trouts (*Oncorhynchus mykiss*).

2 LITERATURE

2.1 Rainbow trout

Salmonids (soft-finned fishes of cold and temperate water) are belonging to the trout and salmon fishes:

Phylum	*Chordata*
Class	*Osteichthyes*
Order	*Salmoniformes*
Family	*Salmonidae*

Rainbow trouts (*Oncorhynchus mykiss*) belong to the Family *Salmonidae* of the Order *Salmoniformes*. Other important members of this family are the salmons (*Salmo salar*).

Salmons are large food and game fishes of the northern water usually migrating from salt to fresh water to spawn. Trouts are game and food fishes of cool fresh water mostly smaller than typical salmons.

The rainbow trout is an olive-green color fish with heavy black spotting over the length of the body. The adult fish has a red colored stripe along the lateral line, from the gills to the tail. Rainbow trouts prefer clear, cool, high quality water. The natural habitat of the species is fresh water with about $12^{o}C$ in summer. They require moderate to fast flowing, well oxygenated water for breeding, but they also live in cold lakes. Wild rainbow trouts spawn in the spring, but fish culturists have developed fall spawning races. Theses races allow fish hatcheries to raise young fish over the winter so they can be released at a catch able size in the spring.

A. Development of the rainbow trout

The life cycle of the rainbow trout is summarized in Table 1.

Table 1: The life cycle of the rainbow trout (Baron, 2006).

Fish	Age	Length	Wt.	Name	Habitat	Life style
embryonic stage	0	4mm diameter	0.01g	egg	hatchery	Eggs and ovarian fluid from 3 females are stripped into a bowl (containing no water, so that the micropyles remain open for longer). Milt from a male fish is stripped into the bowl and thoroughly mixed with the eggs.
	1-2 sec	4mm diameter	0.01g	green egg	hatchery	The head of the sperm makes its entry through the micropyle (a minute aperture in the ovum membrane) the tail which has propelled it, being left outside. The nuclei of egg and sperm fuse and this single cell immediately divides into two.
	14 days	4mm diameter	0.01g	eyed egg	hatchery	The embryo has developed sufficiently for the eyes to be seen as two black dots. Fungus is the biggest cause of mortality to incubating eggs. This can be treated with Malachite Green fungicide.
hatching stage	30-100 days	5mm diameter	0.01g	hatching egg	hatchery	The time of hatching depends on the water temperature. An enzyme is secreted which softens the eggshell and allows the alevin to break through.
larval stage	30-100 days	16mm	-	alevin	hatchery	When hatched the alevin retains its yolk sac and this may be referred to as the SWIM-UP stage.

larval stage	further 1 month	26mm	-	alevin	hatchery	Yolk has been absorbed and the alevin is fed on a high protein diet.
juvenile rainbow trout	further 1 month	-	-	fry	hatchery	Gradually acquire characteristic body markings of bluish or purple color on the back and 7-11 oval spots of the same color (parr marks) along the middle of each side.
	3-4 months	>10cm	-	fingerlings	hatchery	May - September are active feeding months. The fish are fed on high protein pellets.
Fattening rainbow trout	20 months	30cm	250g	portion size	freshwater	Supermarket fish
	24 months	25-45cm	1Kg	mature male	freshwater	Put-and-take fishery trout are usually infertile.
	36 months	25-45cm	1Kg	mature female	freshwater	
	5-6 years	45cm	3Kg	normal lifespan	freshwater	Mature trout released into the reservoirs at the 36 month stage will grow on to about 8lb.

B. Marketing of the rainbow trout

Rainbow trouts are produced in all continents. FAO statistics name about 70 countries in which this fish is farmed. However, in contrast to salmon, which is nearly always in the focus of interest, rainbow trouts receive much less attention. Wrongly so, however, for the production data for trout are in fact quite impressive. Total world production reached or even exceeded 500,000 tones for the first time in 2003. Although Chile is the biggest trout producer worldwide Europe is the centre of trout farming (Table 2). Two- thirds of the world production comes from Europe and over 30 European states produce this species (FAO, 2003).

Chile continues to hold its position as the biggest trout producer in the world. Trout production there accounts for 22% of the total fish production. 113,500 tones of trout were farmed in 2002, a rise of 11% (12,485 tones) to the previous year. More than three quarters of the production go into export. In 2002, exports amounted to 74,135 tones net, i.e. primary and processed trout products, with a total value of 192.74 million dollars. The main buyers were Japan, North America and Europe which together buy about 90% of the exports (FAO, 2003).

The traditional standard product is the white portion trout which is produced in sizes up to 400 grams. However, it is often placed on the market from 200 grams. Depending on the feed composition the flesh of trouts is mainly white or pale pink. Portion trout are reproduced and farmed in Europe in freshwater. This trout form is mainly farmed by small and middle-sized farms that are integrated in regional economic areas and market their fish locally, i.e. the fish are mainly sold fresh by the farmers themselves or via local hotel and restaurant outlets. This means that these farmers still make acceptable profits even in times of crisis. Due to this market proximity the production of portion trout is relatively stable and, viewed overall, this branch of the industry has only grown slowly over the decades. In times of short-term rises in demand this means that it is sometimes difficult or even impossible to satisfy demand. Particularly those producers who pulled out of local direct marketing and supply to wholesalers or retail chains have problems. They have recently been subject to immense price pressure which has greatly reduced the farms' profitability. Whereas in direct marketing, prices of 7 EUR/kg can be reached for portion trout, wholesalers were paying only 1.60 EUR/kg (FAO, 2003).

The larger trouts usually weight between 1.5 and 2 kg. Depending on the pigment content of the feed these trouts can either be white or pink. The red color fillets are particularly popular in Japan. The large trouts offer considerably more possibilities for processing than the smaller portions trouts. As in the case of salmons, numerous products are produced from these trouts, from large fillets, portion and steaks to cold and hot smoked products. In Chile, there is trend toward increased processing of the products. Currently about half of the exported trouts are already value-added in Chile compared to only a

tenth in 1993 and a third in 1997. The large-size trouts get higher price (2.90 – 3.0 EUR / kg in 2003) but are subject to stronger price fluctuation on the world market (FAO, 2003).

Table 2: Rainbow trout production (in tones) of the major European producer countries in 2002 (FAO, 2003)

Country	**Total production**	**Rainbow trout over 1 kg**	**White portion-size trout**	**Red portion-size trout**
Norway	83000	83000		
Italy	42500	600	17500	24400
France	42900	10400	2500	30000
Germany	25500	2500	22000	1000
Finland	14500	14500		

In Europe, Norway is the biggest rainbow trouts producer 83,000 tones. Germany is the biggest white portion size trouts producer 22,000 tones and France is the biggest red portion size trouts producer 30,000 tones (Table 2).

2.2 Chromosome manipulation

The manipulation of chromosome and chromosome sets are major components of aquatic animal genetics improvement. By manipulating chromosomes, we intend to create new genetic constructs that exhibit commercially useful traits. Chromosome manipulations can produce or modify the genome for better performance in the environment. Chromosome engineering not only involves addition of extra sets to the existing complement, resulting in triploid or tetraploid individuals, but also replacement of a duplicate set of chromosomes from the same individual, resulting in gynogenesis and androgenesis (Reddy, 1999).

Gynogenesis is the process of embryonic development with solely the maternal genome and without paternal genetic input. Other results from this method are homozygote and heterozygote gynogenetion. Androgensis results in progeny with only paternal inheritance. The process of inducing androgenesis involves the genetic inactivation of an egg and its fertilization with normal sperm of the corresponding species.

Diploid and Triploid Fishes

An increase in the level of ploidy of an individual by the addition of one or more sets of chromosomes refers to polyploidy resulting usually either in triploid or tetraploid animals (Figure 1).

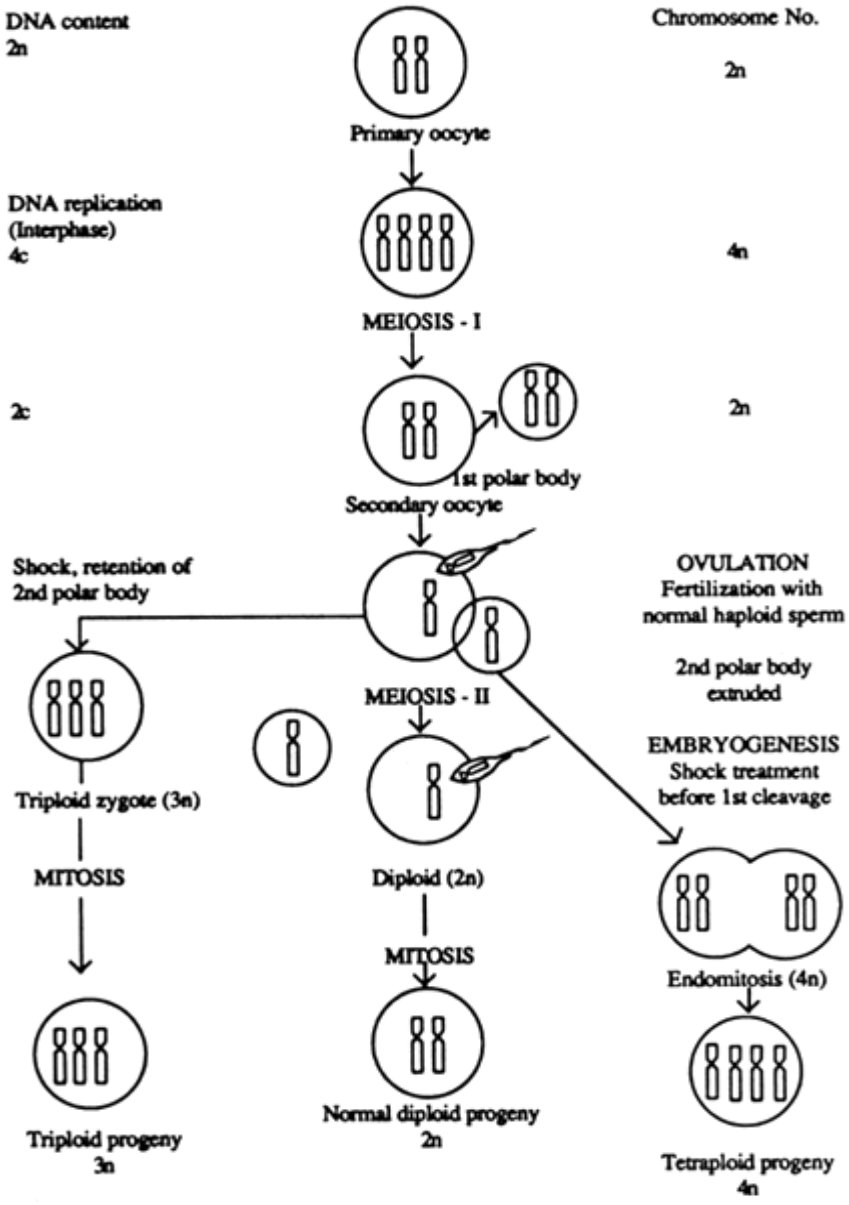

Figure 1: The meiosis of chromosome and the induction of polyploidy (triploid and tetraploid) (Reddy, 1999).

Triploid fishes after onset of maturation have several advantages over normal diploids, including sterility, faster growth, improved meat quality and increased disease resistance during the spawning season (Lincoln and Bye, 1984; Carter *et al*., 1994; Choubert *et al*., 1997; Sheehan *et al*., 1999).