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Feeding of bluefin tuna: Experiences in Japan and Spain

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SUMMARY – This paper summarizes the research on feeding the Pacific Bluefin Tuna (PBFT*), Thunnus thynnus orientalis*, carried out at Kinki University (Japan), together with the work in Spain from 1995 on the Atlantic Bluefin Tuna (ABFT), *Thunnus thynnus thynnus*, at the private company Tuna Farms of Mediterraneo S.L. (TFM). Results on growth and feeding parameters obtained by the utilisation of several raw fish and moist pellets as food for the on-growing of bluefin tuna are presented.

Key words: Feeding, Pacific bluefin tuna, Atlantic bluefin tuna, growth.

RESUME – *"Alimentation du thon rouge : Expériences au Japon et en Espagne". Cet article résume la recherche menée sur l'alimentation du thon rouge du Pacifique,* Thunnus thynnus orientalis*, à l'Université de Kinki (Japon), en même temps que le travail mené en Espagne depuis 1995 sur le thon rouge de l'Atlantique,* Thunnus thynnus thynnus*, dans une compagnie privée, Tuna Farms of the Mediterranean S.L. (TFM). Les résultats sur la croissance et les paramètres alimentaires obtenus en utilisant plusieurs types de poissons crus ainsi que des pellets humides comme aliment pour l'engraissement du thon sont présentés.*

Mots-clés : *Alimentation, thon rouge du Pacifique, thon rouge de l'Atlantique, croissance.*

Introduction

Research on feeding the Pacific Bluefin Tuna (PBFT) carried out at Kinki University (Japan) started in 1974. For sixteen years (1974-1990), several studies were accomplished in order to develop a suitable technology for the growing out of this species. Young PBFT (100-300 g body weight) were caught by trawling. In 1974 mortality rate at stocking was 85%. By removing the right-angled part of the hook used to catch the fish and handling it with care, PBFT injuries were diminished and mortality was reduced up to 15% in 1984. PBFT shown a good adaptability to the rearing conditions in cages, taking in food after 7-10 days after being transferred to the on growing cage. The food used consisted of mackerels (*Scomber japonicus*), horse mackerels (*Trachurus japonicus*), anchovies (*Engraulis japonica*) and cuttlefish (*Sepia esculenta*). In order to maintain suitable water conditions, nets were replaced eleven times along the growing period and new further offshore locations to place the cages were chosen, with good results.

Growth performance of 0-age class fishes (250 g mean body weight, MBW) was 2.6 kg in one year, 74 kg after five years, 145 kg at 15 years-old. The largest PBFT growth rate was 177 kg in weight and 229 cm in length at 16 years old. Spawning in captivity of PBFT occurred in fish over 5 years old.

In order to improve the growth and meat quality of PBFT, several kinds of raw fish were tested as food for the PBFT, most of them based on low cost commercial fish. A summary of the feeding experiments with PBFT carried out by Kinki University for sixteen years were presented in 1990 at the Congress of the Japanese Society of Fisheries Science (Harada *et al*., 1990). Previously, some of them were reported in Harada *et al*. (1983).

Further researches in Japan were focused on the comparison of moist pellet and raw fish on the growth and feeding performance of the PBFT. This information was employed and improved since 1995 for the Atlantic Bluefin Tuna (ABFT) at the commercial facilities of Tuna Farms of Mediterraneo S.L. (TFM) (Cartagena, SE Spain).

Material and methods

Experiments in Japan (Kinki University)

In 1981, some experiments were done by the utilization of moist pellet food (M-diet) for feeding PBFT. Four groups of 16 to 22 young PBFT (450 g MBW) were fed with sand eel (*Ammodytes personatus*), anchovy, mackerel and M-diet. The latter consisted of a mixture similar to the one used for yellowtail (*Seriola quinqueradiata*), composed of fishmeal and fish oil, minced mackerel and a vitamin mixture. Fish were stocked in 6 m square cages for 80 days. Temperatures during the experiment ranged between 16.8 and 24.8ºC. Table 1 shows the approximate composition of the four diets. Diet of anchovies and M-diet had the higher fat content, whilst the mackerel one had higher protein content.

Table 1. Approximate composition of experimental diets (%)

Group	Diet	Moisture	Crude lipid	Crude protein	Crude ash
1	Sand eel	77.9	3.0	15.4	2.6
2	Anchovy	73.0	5.4	17.5	4.0
3	Mackerel	72.0	3.0	23.5	1.5
4	M-diet	61.8	4.7	21.8	4.7

Experiments in Spain (TFM S.L.)

Since 1995, feeding knowledge acquired in Japan with the PBFT were put into practise with the ABFT in the grow out facilities from the company TFM, located in "El Gorgel" (Cartagena, Spain). There, polypropylene cages (90 m in diameter) are used over a sea concession of 30-50 m bottom depth. Sea temperatures range from 28ºC in August to 14ºC in February (Fig. 1). Annual production of TFM increased from 22 tonnes in 1995 to 1800 tonnes in 2000.

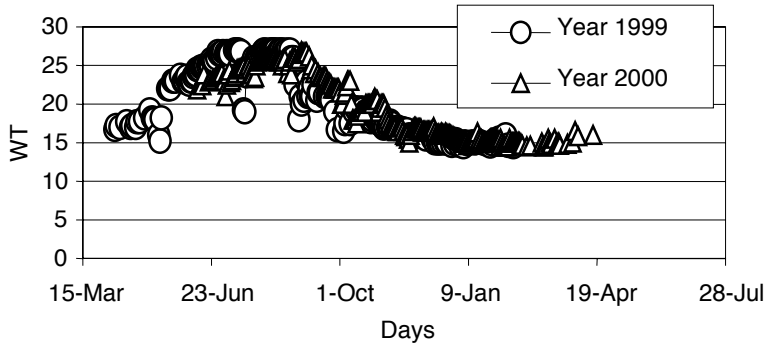

Fig. 1. Water temperature in the rearing facilities of TFM in SE Spain 1999-2000.

Regarding the feeding practise, at the beginning food was supplied by hand, but later automatic feeders were used. In order to facilitate the recovering of ABFT after spawning and towing for stocking in cages, and improve its meat quality, some nutritional supplements were included in the diet.

Results and discussion

Experiments in Japan

Results of the experiment made in Japan are shown in Table 2. Survival rate after the experiment

was 93.8% in the M-diet group, inferring that the vitamin supplements was the essential. Feeding efficiency in dry matter was 65.4% for the mackerel group.

Table 2. Results on feeding parameters obtained with the four different diets†

Group	Diet	SR†	CM	FE
1	Sand eel	81.3	160.5	54.9
2	Anchovy	66.7	63.4	34.3
3	Mackerel	81.8	165.0	64.5
4	M-diet	93.8	105.3	28.0

†SR = survival rate; CM = conversion magnificent; FE = feed efficiency.

Comparing the meat quality of experimental fish from all diets with the one in wild PBFT, an approximate composition analysis was made after the experiment (Table 3). The mackerel and M-diet group had the most similar composition to the wild PBFT ones. Especially, the liver composition of the mackerel group was very close to the wild fish. Although the anchovy feed was higher in crude lipids composition, fat content in this group was quite low. External appearance of PBFT fed with sand eel and mackerel was good, and meat colour of the latter was very similar to wild PBFT.

Table 3. Proximate composition of muscle and liver

Tissues	Group	Moisture	Crude lipid	Crude protein	Crude ash
Dorsal muscle	Sand eel	66.9	7.4	25.1	1.4
	Anchovy	76.4	1.9	20.7	1.5
	Mackerel	70.9	3.8	25.1	1.5
	M-diet	71.0	2.9	25.5	1.4
	Wild	71.3	2.5	25.5	1.7
Liver	Mackerel	67.0	12.1	16.9	1.4
	M-diet	62.2	17.9	14.6	1.3
	Wild	68.9	7.2	28.4	1.4

In conclusion, it was noticed that nutritional supplements can produce a positive influence on growth, survival rate and meat quality. PBFT fed with anchovies resulted in a lower growth and survival rates and inferior meat quality.

Experiments in Spain

Due to the technical improvement of growing ABFT, mortality at towing from the fishing ground to the rearing facilities decreased from 20.8% in 1995 to 3.9% in 2000.

After 8 months of rearing, ABFT showed a weight increase of 40-50% in smaller fish and 10-30% in the larger ones. Higher feeding rates (5.2%) of ABFT occurred in summer, 1.5 months after stocking. Thereafter it declines when seawater temperature falls in winter (Fig. 2). From 1995 to 2000, mortality rate of ABFT reared in TFM was reduced from 15.8 to 3.7%. Conversion magnificent (CM) and food efficiency (FE) also decreased from 24.1 to 15.8 and from 5.1 to 4.3 respectively (Table 4). FE differs when considering the ABFT size, being 5.0% for the larger and 13.8 for the smaller fish.

It is not possible to compare feed efficiency between ABFT and PBFT, because mass culture of large PBFT does not exist. Harada *et al* (1990) reported that FE decreases as the PBFT get older, showing 0.8% in the 14 years old ones. Large ABFT show a FE of 4.3%, which is very efficient.

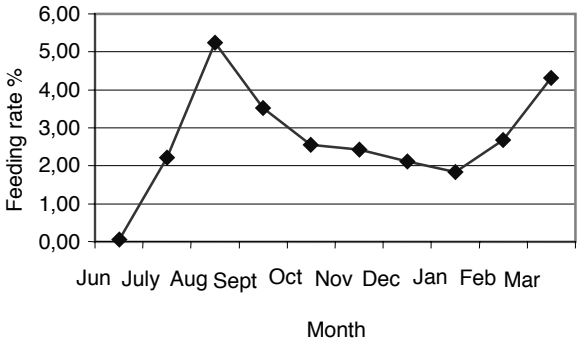

Fig. 2. Feeding rate during the rearing period.

Table 4. Yearly results of BFT of mortality and growth at TFM in the period 1995-2000

	1995	1997	1998	1999	2000
Mortality	15.8	38.1	6.1	6.9	3.7
CM†	24.1	8.2	24.7	15.1	15.8
FE††	5.1	2.5	6.2	4.4	4.3

†CM = conversion magnificent.
††FE = feed efficiency.

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