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SUMMARY- ACUINOVA is a company involved in marine aquaculture, owned by the PESCANOVA group; the later being one of the largest fishing companies in the world and very important in the food sector. ACUINOVA was established in 1986 and since then has been developing a "strategic plan" with the aim of controlling the production process involved in the culture of different marine species, the ultimate aim being to complement the supply of marine fisheries products that currently depend to a great extend on capture fisheries. When we talk about "production process control" we mean every part of the process, from those related to the design of facilities to such as cost control, quality control, culture technology, nutrition, pathology, genetic improvement, as well as the commercialization of the final products. The more control we establish in our culture method, the less it is influenced by external agents or, at least, those influences can be minimized. This lead, us to the possibility of developing an "intensive farming system". Consequently, since nutrition plays a major and critical role in intensive farming systems, the need for a "Nutrition subproject" arose. The aim of the subproject was to guarantee not only the adequate food supply for a certain set of conditions but also to develop simultaneously along with any progressive changes, that may be introduced into the system. This means that it must be able to produce a "tailored food ". The strategic plan of Acuinova de Galicia is currently focused on the production of sea bream (*Sparus aurata*) fry and the ongrowing of turbot (*Scophthalmus maximus*), whereas that of Acuinova de Andalucia is focused on integrated shrimp farming (*Penaeus japonicus*). The current paper summarizes Acuinova's evolution, progressive advances and achievements in this field including its medium-term strategies.

Key words: Nutrition, artificial diets, shrimp, turbot, sea bream, commercial fish farming.

RESUME *- "Projets de recherche et développement d'ACUINOVA concernant la nutrition de poissons et crevettes". ACUINOVA est une compagnie qui appartient au secteur de l'aquaculture, propriété du groupe PESCANOVA. Sans doute certains d'entre vous savent que PESCANOVA est une des plus grandes compagnies de pêche du monde, et très importante dans le secteur de l'alimentation. ACUINOVA s'est établie en 1986. A partir de là elle a développé un plan stratégique dans le but de contrôler tout le processus de production pour l'élevage de différentes espèces marines. Son principal objectif est de pouvoir fournir les produits qui de nos jours sont principalement dépendants de la pêche. Quand nous parlons de contrôler le processus de production, nous voulons dire toutes et chacune des parties qui sont liées aux usines de production ansi que les coûts, la qualité, la technologie, la nutrition, la pathologie, les améliorations génétiques... et même la commercialisation du produit fini. Plus le contrôle est établi sur notre méthode d'élevage, moins les agents externes peuvent nous influencer ou tout au moins ils seront minimisés. Cela nous permet de développer un " système intensif ". En raison de cette idée et de l'importance que la nutrition a sur ce genre de système, est apparu le besoin d'un "sous-projet Nutrition". Ce sous-projet doit nous garantir non seulement l'approvisionnement d'une nourriture adéquate sous certaines conditions mais aussi doit évoluer en parallèle avec les changements progressifs qui sont introduits dans le système. Cela veut dire, être capable de produire de la "nourriture faite sur mesure". Le plan stratégique d'ACUINOVA DE GALICIA est axé sur la production de larves de daurade (*Sparus aurata*) et l'élevage de turbot (*Scophthalmus maximus*), tandis que ACUINOVA DE ANDALUCIA est axé sur l'élevage intégral de crevettes (*Penaeus japonicus*). A travers cette présentation j'essayerai de*

résumer notre évolution, nos progrès graduels, nos succès dans ce secteur ainsi que nos stratégies à moyen terme.

***Mots-Clés** : Nutrition, aliment composé, crevettes, turbot, daurade.*

INTRODUCTION

Generally speaking, I do not think that today aquaculture feeding must be based on using 100% dry pellets; many farms over the world successfully using moist-pellets and/or frozen food with good results; however in my opinion, the nutrition of species that are going to be finally consumed by humans, must be based on diets that allows continuous changes to be made in its composition; the diet must be adjustable depending on the availability of raw materials and the recent advances in nutritional requirements and feed technology.

Day by day man is transforming and consuming food resources that yesterday were reserved only for animal feeding. From the beginning our company considered intensive culture as the best alternative on development and so feeding technologies based on the use of dry pelleted feeds turn out to be the most suitable.

In 1989 -1990, based on the experiences developed by Japan in this field, our first experiments were focused on trying out the culture system rather than making our own artificial diet. Consequently was imported commercial pelted feed for Hirame and Japanese shrimp from Japan and we adapted the culture technology of these species to our particular conditions.

Once we proved the suitability of the Japanese diets with our species and with our culture environment, we began comparative tests under experimental and production conditions, using concrete tanks in the case of turbot and earthen ponds in the case of shrimp, and began looking into the design of our own artificial diet for both species.

Within a two year period (1992-1993) we developed a diet for turbot and another diet for shrimp which achieved similar results to the imported Japanese diets. However, our diets needs to be further adjusted, and particularly in the case of our shrimp feed so as to improve its physical characteristics such as water stability and hardness...).

The fact that most nutritional studies are carried out under controlled indoor laboratory conditions and tested only in experimental scale, lead us to errors when we tried to define and produce a practical diet for use under farm production conditions.

Moreover, since most of the companies involved in commercial aquaculture feed manufacture, usually use their client's facilities to test their "improved diets", "new diets" or "cheaper diets", and it is the client who evaluates the results, we began to recognize that other secondary factors such as, size classifications, feed

management, seed quality and others related to farm management and facilities also influenced the success or not of the pelleted feeds.

It follows therefore that most of feed manufacturers are not sufficiently aware of the need of carrying out well planned research aimed at improving their feeds. Such a development involves researching into the following fields :

- **Introduction of new ingredients** as alternatives to conventional raw materials.

- **Feed adjustment to specific culture condition requirements** (i.e. 50 g. sea bream cultured at high stocking densities at low water temperatures).

- **Improvement of fish or shrimp quality** feed with diets containing different lipid or protein levels.

- **Development of diets for new species**.

Of course this research means a high investment in equipment and facilities, and therefore needs to be correctly evaluated. Most of the larger companies in the world have already considered this investment as being necessary and have subsequently attained successful results and profitability.

In our case, we are not trying to compare ourselves with aquafeed companies that commercialize their products in the national market, but rather consider that we have in our favor the close connection between animal food production and animal production itself.

We therefore carry out our own experiments in the laboratory as well as within the production tanks or ponds, and other factors that we consider as being very important are fish and shrimp quality, including colour and meat texture of the final product, since we must also commercialize our cultured products on the national and Japanese market.

We therefore have two major advantages :

1- **To know the formulation**, the quality of the raw materials used and the changes in other parameters introduced during the manufacture of every lot of feed.

2- ***Versatility in adjusting the formula depending on the culture conditions*** such as stocking density, environmental temperature, weakness etc. In short, being able to produce " made to measure food ".

On the other hand we have other negative factors, the most important being our small feed production and that we can not afford to have our own pelleting plant and therefore have to depend on an outside contractor for pellet manufacture.

This involves :

- **Higher price of raw materials** .

- **An increase of the manufacturing cost.**

- **Lack of control in the adjustment of manufacturing parameter conditions** (pressure, temperature, sieve size, times of retention, drying, etc.).

We are also aware of the fact that, since we do not commercialize our feed in the market we are not obliged to compete with other feed manufacturers in order to get a stable and competitive price. However, since we do not have a large production, we can not adjust our profit limits by lowering the price or by increasing the quantity of feed sold .

Before discussing in more depth turbot and shrimp feed development, I would like to stress another aspect which we consider as very important, but that at present we can not undertake, and that is concerning the nutrition of breeders, larvae and fry.

Apart from the ongrowing facilities ACUINOVA has two hatcheries that supply postlarvae and fry to our farms (Table 1); by this way we can control the entire production process including :

- Selection of our own broodstock for better growth and stronger health; introduction of genetic improvement programs with the aim of developing specific strain of broodstock

- The study of the relationship between the larval quality and improved juveniles/adults performance during growth out, with particular emphasis given to survival and growth enhancement; a better guaranteed and reliable seed supply; and adjusting seed production and supply to suite our own particular demand, with respect to time of delivery, average body weight and size distribution.

Table 1 ACUINOVA aquaculture production plants

PLANT NAME	LOCATION	FARMED PRODUCT
INSUIÑA	O Grove (Pontevedra)	Turbot
MOUGAS	Mougas Pontevedra)	Turbot and Sea Bream fry
LA CARABELA	S. Fernando (Cádiz)	Shrimp Postlarvae
SAN CARLOS	Sanlucar de B. (Cádiz)	Shrimp
EL DIQUE	Ayamonte (Huelva)	Shrimp

As mentioned previously, we are convinced of the importance of larval and broodstock nutrition, and therefore we use the highest quality feeds and enrichment products available for our complementary cultures and supplements for broodstock and larval diets. Although this approach is common to all hatcheries, at a commercial level we invariably have to confront economical and profitability criteria against nutritional value and quality.

TURBOT

During April 1991 we introduced at our INSUIÑA plant a dry pellet for feeding Turbot for the first time; the artificial diet was for Hirame and was imported from Japan. At that time all of the Turbot farms in Galicia used a raw fish and/or moist-pellet based feeding regimes.

The first difficulty we met was the need for changing the working mentality from a "handicraft" experience (but with successful results over a short-term period) which could not be supported on a long-term basis or in a large scale production. Once this hurdle was overcome then the other advances came subsequently.

In 1992 we tried our first pellet production with our own formula, and in 1993 we compared the growth of turbot fed with Japanese and Acuinova diets within duplicate tanks. The results are shown in Tables 2 and 3 and it can be seen that the Acuinova diet gave better results in terms of growth performance and food conversion ratio with Acuinova diet. However, the fact that the Japanese diet was originally formulated for a different fish species should also be taken into account.

Table 2. Experiment test number 1-93

DIET	Initial Nº fish	Initial weight (g)	Nº day	Weight gain (g)	FCR	Growth rate / month (%)
JAPANESE	1040	200.5	45	61.9	0.88	20.6
ACUINOVA	1041	202.1	45	95.4	0.56	31.5

Table 3. Experiment test number 2-93

DIET	Initial Nº fish	Initial weight (g)	Nº day	Weight gain (g)	FCR	Growth rate / month (%)
JAPANESE	884	276.5	30	50	0.76	18.1
ACUINOVA	879	275.5	30	63.2	0.74	22.9

During 1993 we also carried out a comparative test with a national commercial pellet for Turbot , however the diet could not sustain any reasonable growth. On July 1993 we cut off our dependence upon the Japanese feed (which was also too expensive) and we fed our fish entirely with the Acuinova diet. Since then, and in accordance with our possibilities, we have been continually improving the quality and reducing the cost of our compound feed.

At the same time most of the pathological problems which had been previously been related with feeding raw fish were solved and total production costs were considerably lowered by reducing both the staff and feeding costs. Apart from this, it facilitate for an easier planning and pursuit to rely on a food supply of stable quality.

In 1994 and 1995 the larger aquafeed manufacture companies began commercializing a dry feed for turbot at a more competitive price than our own. We have tested most of these commercially available feeds and have compared them in terms of growth and feed conversion rate with our own feed. The results are shown in Table 4, and it can be seen that the differences between the diet are very small.

Table 4. Experiment test number 1-95

DIET	Initial Nº fish	Initial weight (g)	Nº day	Weight gain (g)	FCR	Growth rate / month (%)
ACUINOVA	1776	545	60	192	1.1	35.2
DIET A	1753	570	60	185	1.2	32.5
DIET B	1782	562	60	179	1.1	31.9

However it should be pointed out that the proximate composition of the two commercial feeds was quite different from our own, and in particularly regarding the lipid content.

Although most of us are aware of the use of fish oil in supplying the dietary energy requirements of fish, growth increase is usually accompanied by a deterioration in fish quality by the accumulation of additional fat. However, although this fact has been repeatedly confirmed by organoleptic tests undertaken by our sales department , the argument that the final consumer cannot appreciate or feel the difference, leads us once again to put short term profitability before the good quality. During 1995 we tried a half-way solution by making some adjustments in the formula, and then compared this improved formulation with other different commercial diets. The results are shown in Table 5.

Table 5. Experiment test number 2-95

DIET	Initial Nº fish	Initial weight (g)	Nº day	Weight gain (g)	FCR	Growth rate / month (%)
ACUINOVA	2351	803	35	168	0.7	20.9
DIET C	2334	797	35	126	1	15.8
DIET B	2331	850	35	147	0.9	17.3

Finally, our aim for the present year is to reduce the feed cost for turbot by using an even more efficient feed which permits the production of higher quality and faster growing turbot.

SHRIMP

Shrimp culture first developed in Spain during the 1980's and was mostly extensive in nature, using low stocking densities (3-10 PL/m2) with growth depending mainly on the natural productivity of "virgin" earthen ponds.

These first attempts yielded good results, but gradually production decreased as the pond bottoms became more reduced and the natural productivity fell dramatically. The idea of a "growth stoppage" at 8-10 g. was generally extended between farmers and it was probably due to the depletion of natural food within the ponds and the utilization of unsuitable artificial feeds that did not satisfy the nutritional requirements of shrimps.

When our company started shrimp culture in 1990 it was impossible then to find a commercially available shrimp feed which was "made in Europe" and good enough to sustain the growth of shrimp within a semi-intensive culture system. As a consequence at this time the shrimp farmers had given the idea of shrimp shaming and shifted to culturing sea bream .

As with turbot, we started by importing feed from Japan and developed a semi-intensive culture system (using a stocking density of 25-30 PL/m2) based on available Japanese technology.

Once we had proved that shrimp culture was possible when using a good quality artificial diet, in 1993 we begun our first attempts to produce our own shrimp diet . Since September of that year and during 1994 we used our own diet for ongrowing exclusively and in 1995 we also developed a nursery diet for the nursery period.

Although the nutritional requirements of *P. japonicus* have been well documented by Japanese authors (Deshimaru, Kanazawa, Shigeno etc.) I would like to highlight some special facts that make the achievement of a high quality feed for shrimp much more difficult than in the case of turbot; namely :

High dietary protein requirements of this specie compared with other penaeid shrimps cultivated in South-America and S.E.Asia; regarding this matter during the last few years Kanazawa et al. have pointed out the possibility of reducing dietary protein levels while still sustaining a similar growth; **difficulty of supplying raw materials,** since most of the major ingredients must be imported from the Far East and their supply is conditioned by fluctuations in the availability in quantity and time of delivery; **importance of the pellet stability** due to the nocturnal feeding behavior of *P. japonicus* to achieve the require stability, it is necessary on the one hand, to utilize expensive binders, and on the other hand to use specific manufacturing machinery with a skillful handling and knowledge of extrusion technology; and **commercialization as live shrimp.** In order to maintain good selling prices, our shrimp must be sold live. Lately we have increased our exports to Japan. However we must compete with countries such as Taiwan, China and Korea in selling our live shrimp in the Tokyo market. For this reason we need tasty, colourful, and most of all, strong and healthy animals that can support the stress of transportation, (i.e. transport takes more than fifty hours from our farm to the Tokyo

market). Consequently, it is therefore necessary to feed the shrimp on a specially enriched diet during the last phase of the culture cycle prior to transportation.

Regarding our companies strategy for the near future, there are to:

1) **Increase feed production volume** according the increase in shrimp production, and 2) **Research and development of a suitable diet** which meets the nutritional requirements of shrimp **under super-intensive culture conditions.**

Finally we are conscious that there is still a long way ahead until the successful accomplishment of our objectives but we are optimistic and encouraged by the results obtained to date and firmly believe that the progress in aquaculture cannot be sustained without a progress in nutrition.