TAGUCHI'S LOSS FUNCTION APPLIED IN THE BREEDING OF TILAPIA, *Oreochromis niloticus* FED WITH DIFFERENT LEVELS OF PROTEINS OF YEAST IN TANK-NETS

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MEDRI[1],V.; MEDRI[2], W.; CAETANO-FILHO[3], M.; DALMAS[1], J.C. Taguchi's loss function applied in the breeding of tilapia, *Oreochromis niloticus* fed with different levels of proteins of yeast in tank-nets. *Arq. ciên. vet. zool.* UNIPAR, 7(2): p. 115-121, 2004.

ABSTRACT: The experiment was based on observations of 120 juveniles of tilapias of Nile, *Oreochromis niloticus,* sexually reverted, with an initial medium weight of 116.65 ± 0.85 g, distributed in a completely randomized design for 168 days. The objective of this work was to evaluate the effect of introducing tank-nets on the function Taguchi's loss fed with 0% (control), 20%, 40% and 60% (tests) of yeast distillery protein in substitution of traditional source of protein. The test of Tukey was accomplished showing that there were not statistical differences ($p > 0.05$) among the efficiency, the length and the weight of the fish. With relationship to the survival, it was observed that the treatments (T2, T3, T4) were statistically superior ($p < 0.01$) to the treatment T1. Taguchi's loss for the cost of production and for the dead fishes in tank-nets in the treatment T_2 = 20%, T_3 = 40% and T_4 = 60% (tests) were lower the group control (T_1 = 0%). This result confirm the direction of yeast distillery protein in substitution of traditional source of protein.
KEY WORDS: yeast, ration, Taguchi, *Oreochromis niloticus*

FUNÇÃO PERDA DE TAGUCHI APLICADA NA CRIAÇÃO DE TILÁPIA, *Oreochromis niloticus* ALIMENTADAS COM DIFERENTES NÍVEIS DE PROTEÍNAS DE LEVEDURA EM TANQUES-REDE

MEDRI,V.; MEDRI, W.; CAETANO-FILHO, M.; DALMAS, J.C. Função perda de Taguchi aplicada na criação de tilápia, *Oreochromis niloticus* alimentadas com diferentes níveis de proteínas de levedura em tanques-rede. *Arq. ciên. vet. zool.* UNIPAR, 7(2): p. 115-121, 2004.

RESUMO: Foram utilizados 120 juvenis de tilápia do Nilo, *Oreochromis niloticus*, sexualmente revertidos, com peso médio inicial de 116,65 ± 0,85 g, distribuídos num delineamento inteiramente casualizado, durante 168 dias. O objetivo foi avaliar o efeito da introdução de tanques-rede com cultivo de peixes alimentados com 0% (grupo padrão), 20%, 40% e 60% (grupos testes) de proteína oriunda de levedura de destilaria em substituição à proteína de fontes tradicionais sobre a função perda de Taguchi. O teste de Tukey foi realizado mostrando que não houve diferenças estatísticas ($p > 0,05$) entre a eficiência, o comprimento e o peso dos peixes. Com relação à sobrevivência, foi observado que os tratamentos (T_2, T_3, T_4) foram estatisticamente superiores ($p < 0,01$) ao tratamento T_1. As perdas de Taguchi para o custo de produção e para os peixes mortos nos tanques para os tratamentos T_2 = 20%, T_3 = 40% e T_4 = 60% , foram inferiores ao grupo controle (T_1 = 0%). Este resultado confirma o direcionamento da proteína oriunda de levedura de destilaria em substituição à proteína de fontes tradicionais.
PALAVRAS-CHAVE: levedura, ração, Taguchi, *Oreochromis niloticus*

FUNCIÓN PÉRDIDA DE TAGUCHI APLICADA EN LA CREACIÓN DE TILAPIA, *Oreochromis niloticus* ALIMENTADAS CON DIFERENTES NIVELES DE PROTEÍNAS DE LEVADURA EN ESTANQUES-RED

MEDRI,V.; MEDRI, W.; CAETANO-FILHO, M.; DALMAS, J.C. Función pérdida de taguchi aplicada en la creación de tilapia, *Oreochromis niloticus* alimentadas con diferentes niveles de proteínas de levadura en estanques-red. *Arq. ciên. vet. zool.* UNIPAR, 7(2): p. 115-121, 2004.

RESUMEN: Fueron utilizados 120 joveniles de tilapia del Nilo (*Oreochromis niloticus*), sexualmente revertidas con peso mediano inicial de 116,65 ± 0,85g distribuido en un diseño totalmente seleccionado al azar por 168 días. El objetivo de este trabajo fue evaluar el efecto de la sustitución de 0% (control), 20%, 40% y 60% (grupo teste) de proteína oriunda de levadura

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de destilería en sustitución a la proteína de fuentes tradicionales sobre la función pérdida de Taguchi. La prueba de Tukey era demostración lograda que no había diferencias estadísticas (p > 0,05) entre la eficacia, la longitud y el peso de los pescados. Con relación a la supervivencia, fue observado que los tratamientos (T2, T3, T4) eran estatisticamente superior (p < 0,01) al T1 del tratamiento. Las pérdidas de Taguchi para el coste de producción y para los peces muertos en los estanques-red para los tratamientos T2 = 20%, T3 = 40% y T4 = 60%, fueron inferiores al grupo control (T1 = 0%). Este resultado confirma el direccionamiento de la proteína oriunda de la levadura de destilería en sustitución a la proteína de fuentes tradicionales.
PALABRAS-CHAVE: levadura, ração, Taguchi, *Oreochromis niloticus*

Introduction

The system of growing fishes in tank-nets is classified as an intensive system of continuous renovation of water that removes the metabolites and provides oxigen to the fishes (COLT & MONT-GOMERY, 1991). This system is one of the more used ways for the intensive growth of fishes and has turned to the popular due to the easy management and fast return of the investiment (CHRISTENSEN, 1989).

The technology to tilapia cultivation in cages is well known and Brazil is the major producer of tilapia in cages of Latin America (BOZANO & ROMERO, 2001).

The necessary investiment for production of one ton of fishes in tank-nets corresponds 30 to 40% of the necessary for conventional hatchery fishery (MULLER, 1990).

When growing in tank-nets the Nile tilapia shows very good index of production. According SILVA & SIQUEIRA, 1997, tank-nets has been recognized as a system having advantages in relation to the traditional systems of fish exploration.

World-wide, tilapia aquaculture is impressive growth from 1990 to 2000, and there are indications that the industry will expand significantly in the future (ALCESTE & JORY, 2002).

Rations of good quality minimize the pollution (CYRINO *et al*., 1998). However, in regions where are no ration industries, the cost is very high to the producer, being onerous and inviable. So searching alternative products or even formulations that decrease the cost of fish production while maintaining the water quality and adequate levels for the fish growth, seems a good alternative for exploring with sustentation the hydric resources for this purpose Yeast is a worth product, adequately balanced, withdrawn from the process of alcoholic fermentation, and is an important alternative of protein on formulation of animal ration, so that high levels of protein, carbohydrates, lipids, etereo extract, vitamins and minerals are obtained (MATTOS, 1984).

Tilapias are able to utilize the remains of agroindustry such as yeast, besides the possibility to assimilate carbohydrates contained in the vegetable ration ingredients. These agroindustry remains can be utilized as supplement in animal rations, reducing the production costs and the pollution of the ambient (LITCHFIELD, 1983; ALCOPAR,1992).

Young tilapia eat mainly zooplancton and phitoplankton; while the adults, accept a variety of artificial food, vegetables, larvae and insects (WU *et al*., 1995).

Loss Function: The Taguchi's loss function or the quality function is defined as the value of the monetary loss expected caused by the characteristic deviation of performance, relating to the wished value or a specific value. This concept of loss shows a new thought of investments in quality improvement, because in a competitive economy, the continuos improvement of the quality and the reduction of costs are necessary to keep the product in market (KACKAR, 1986; BARKER, 1986). The loss considered here are calculated in monetary values and are associated to quantifiable characteristics of the product (TAGUCHI, 1993).

TAGUCHI *et al*. (1990), has as hypothesis, generally accepted, that the probabilistic distribution of the values obtained from a large scale production is normal and not uniform, so it follows the reduced function of Gauss.

TAGUCHI *et al*. (1990), consider as loss for the society the difference between the nominal values m and the obtained values x, in a simplified case where the quality depends on only one dimension. In general cases where the quality depends on many dimensions, the loss function is applied to each dimension and the value of one loss is summed to the others individual losses. In other words, each unity causes a loss, which is not kept to the owner, but is distributed to all the society (STANGE, 1996, MEDRI *et al.* 2000b).

It was developed the concept of Taguchi's loss function that relates the value of the monetary loss caused by the quality decrease to the removal of the nominal value (m) of the specification. It was shown to be a quadratic function. The maximum value is obtained when the deviation exceeds the specification limits (TAGUCHI *et al*., 1990; GUEDES, 1996).

When the loss function grows symmetrically with the deviation of the functional characteristics round the normal value, "the nominal is the best one" although, PHADKE (1989) *apud* GUEDES (1996), extended this concept to other two special cases of functional characteristics of quality: "The smaller is the best one" and "the biggest is the best one".

The aim of this work is to evaluate the Taguchi's loss function of Nile tilapia fed with 0% (control), 20%, 40% and 60% (tests) of yeast distillery protein in substitution of traditional source of protein.

Materials and Methods

Experimental conditions: One hundred and twenty juveniles of Nile tilapia (*Oreochromis niloticus*), ceded by the Fish Breeding Station of the Animal and Vegetal Department of Biology Science Center of the Universidade Estadual de Londrina. The initial average weight and length of the juveniles were respectively 116.65 ± 0.85g and 17.96 ± 0.13cm. The fishes were reverted by the supply of rations with 60mg/Kg of diet of the male hormone 17α – metiltestosterone, during a period of 30 days.

A computational program of Dr. José A. A. Resende was used to elaborate the ration with the needs of the mentioned species. Four isoproteic and isocaloric balanced rations with 0% (control group), 20%, 40% and 60% (test group) of yeast from alcoholic distillery were used (Table 1). The control ration was the commercial ration usually used by the fishery station to feed the fishes.

A rectangular fishpond of soil (12.5 m x 8 m), with an area of 100 m^2 approximately, was used. Inicially, the fishpond was drained and treated with quicklime (50 g/m^2). Later on it was exposed to the sun's rays for a period of seven days, and then it was quickly filled with water and stocked with 12 groups of 20 subjects distributed at random.

Each group was kept in tanks-net of 1 m x 1 m x 1 m length, width and depth respectively, in a mesh of 2 mm, tied by fixed poles to the fishpond of soil, 0.3 m of width apart from each other, where the water runs continuously through all the tanks connected to the sistem.

Table 1 - Composition of the experimental rations for the Nile tilapia

Ingredients (%)	Standar (T_1)	Test (T_2)	Test (T_3)	Test (T_4)
Yeast	0.00	20.00	40.00	60.00
Fish flour	10.00	10.00	10.00	5.00
Wheat flour	5.00	5.00	5.00	5.00
Crushed maize	44.35	35.36	25.14	11.76
Soybean flour	38.65	26.64	14.86	10.00
Bicalcic flour	0.00	0.00	0.00	1.24
Vegetable oil	0.00	1.00	3.00	5.00
Mineral supplement	1.00	1.00	1.00	1.00
Vitamine supplement	1.00	1.00	1.00	1.00
Total	100.00	100.00	100.00	100.00
Ration nutrients (%)				
Dry matter	88.54	89.07	89.72	90.37
DE	313630.63	309458.24	311293.31	306553.27
Fat	2.81	3.38	4.91	6.07
Crude fibre	3.96	3.01	2.04	1.45
Mineral matter	5.44	6.40	7.35	8.86
Total fhosfhorus (P)	0.67	0.60	0.52	0.54
Crude protein	28.00	28.00	28.00	28.00
Calcium (Ca)	0.77	0.74	0.71	0.70

Each of the ration treatments (T) was given to three groups of fishes (triplicate). The fingerlings were fed twice a day, at eight and seventeen o´clock.

Before the alevins of tilapia were put in, limnological analyses were conducted for the water quality control. The cleaning of the tanks-net was done monthly after each biometry. The experimental period was of 168 days (from 18/04 to 09/10/02).

Using a paquimeter and a balance of precision, the total weight (Wt), in grams, and the total length of the fishes (Lt), in centimeters, were monthly measured.

The water temperature was determined by a thermistor coupled to an oxygenmeter. Dissolved oxygen was measured by an oxygenmeter model Y55, pH by a electronic pHmeter model FI002. Conductivity was determined by a electronic conductmeter. Total alkalinity was measured by titulation with sulphuric acid (CARMOUSE, 1994; PARANHOS, 1996), ammonia by photometry through indophenol method as described by PARANHOS (1996). Nitrite was determined using the classic spectrophometric method based on the Griess reaction (CARMOUSE, 1994). Orthophosphate determination was based in the reaction between this and molibdic acid, given phosphomolibdic acid. After ascorbic acid reduction, it resulting blue compound was quantified by spectrophotometry.

All the limnological variables determined were on the limits recommended for he fish growth on the type of tilapia *(Oreochromis niloticus)*.

The finality of this control was to determinate the quality and quantity of water, which is essential on the interpretation of the results of this research.

Quantitative analysis: The development of the tilapias related to the different treatments was analyzed through the quantitative analysis of the relation total weight/ total length (SANTOS, 1978), feed conversion, efficiency index and survival (IVLEV, 1966), graphical expression of growth in total length (BERTALANFFY, 1938; Santos, 1978).

Taguchi's loss function in Nile tilapia breeding: It was used the functional characteristic of quality: "the biggest one is the best". In this case, the best value is not defined, the bigger is the characteristic value (fish weight) the better it is. The loss caused by a fish that has passed the inferior limit of tolerance is represented by A, and its corresponding deviation is ΔA. The function is expressed by:

$$L(Y) = K\,[1/Y^2] \text{ or } L(Y) = A\,\Delta^2\,v^2 \text{ (PHADKE, 1989).}$$

Calculus of cost of each fish (Pi)

P1 =	ration	+	yeast	+	fingerling	+	Food supplied
P2 =	ration	+	yeast	+	fingerling	+	Food supplied
... =	...	+	...	+	...	+	…
Pk =	ration	+	yeast	+	fingerling	+	Food supplied

....

$$\sum_{1}^{k} P_i = \sum_{1}^{k} (\text{ ration + yeast + fingerling + Food supplied})$$

A calculus :

$$A = \sum_{1}^{k} P_i / k \quad \text{com} \quad i = 1, 2, \ldots, k$$

Where **k** is the number of fishes.
A is the loss caused by fishes that passed the inferior limit of tolerance.

Δ calculus:

The fish production that presents high dispersion will have a higher cost on account to the rejects and consequently bigger quality loss. In this case, it is better to divide the fishes in lots to calculate the tolerance and the reduction of losses.

In general, the procedure to calculate the tolerance (Δ) is:

$$\Delta = m - s$$

where, **m** is the average and **s** is the stander desviation.

v^2 calculus:

$v^2 = 1 / n\ (1 / y_1^2 + 1 / y_2^2 + ... + 1 / y_n^2)$, where, $\mathbf{v^2}$ is the quadratic average deviation and $\mathbf{y_i}$ is the value of the studied characteristic (weigh).

Results and Discussion

Tilapias growth: The results for the average total length and weight of the standard group (T_1) and the tested groups (T_2, T_3 and T_4) of tilapias are presented on Table 2.

Table 2 - Length and average weigh of fishes on treatments T_1, T_2, T_3 and T_4

.	Length (cm)				Weight (g)			
Days	T_1=0%	T_2=20%	T_3=40%	T_4=60%	T_1=0%	T_2=20%	T_3=40%	T_4=60%
0	18.04	18.02	17.84	18.02	116.72	116.40	117.18	116.28.
28	19.44	19.70	19.28	19.48	141.93	144.28	137.12	137.15
56	20.32	20.64	20.42	20.48	164.72	165.24	164.16	161.09
84	21.04	21.42	21.34	21.15	188.68	193.08	198.85	184.61
112	22.08	22.12	22.43	21.97	206.54	203.53	224.50	198.92
140	22.55	23.28	23.26	22.49	231.85	242.06	248.60	218.74
168	23.35	24.88	24.23	23.73	240.83	289.82	293.14	237.78

On Table 3, the high values for the determination coefficient (R^2) shows a perfect adjust of the studied variables to the mathematical model used. On the other side, the variation coefficient values (V.C.) lower or near the 10% characterize homogeneity of the results, representative average and optimum experiment. These results indicated the possibility of using up to 60% of yeast in place of traditional sources of protein without affecting the growth in length and weight (table 4) of the tilapias.

Table 3 - Quadratic regression between the weight (y) and the time (x) in months

% Yeast	Quadratic regression	R^2	C. V.
T_1 = 0	$y = 116.01 + 0.9636x - 0.00122x^2$	0.9985	0.0168
T_2 = 20	$y = 121.76 + 0.5729x - 0.00235x^2$	0.9924	0.0459
T_3 = 40	$y = 116.11 + 0.8045x + 0.00137x^2$	0.9979	0.0253
T_4 = 60	$y = 115.76 + 0.8449x - 0.00073x^2$	0.9992	0.0122

R^2 = determination coefficient; **C.V.** = variation coefficient values.

Table 4 - Individual final weight of the fishes in the Tank-nets

	BLOCK 1				BLOCK 2				BLOCK 3			
Rep.	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
1	324.2	231.5	302.0	233.5	309.8	205.0	346.0	358.6	239.0	279.0	351.6	403.0
2	224.5	398.9	309.0	260.9	307.1	467.0	305.0	264.0	225.0	295.0	346.5	300.0
3	346.0	335.5	152.0	254.9	360.6	354.0	281.0	200.0	155.0	294.8	373.0	154.0
4	352.5	316.8	401.0	135.0	174.0	127.8	164.0	205.2	338.0	273.0	136.9	288.0
5	188.0	328.0	325.0	174.0	253.9	222.0	359.1	182.2		239.0	294.0	216.0
6		296.0	356.0	251.0	240.2	244.0	271.0	225.0		274.0	338.7	138.0
7		221.0	364.0	243.0	185.0	119.0	118.0	185.2		314.0		311.0
8		334.8	412.0	185.7	144.0	175.0	179.0			404.0		357.0
9		231.0	238.0			222.0	267.0			298.9		182.0
10			106.0							187.0		117.0

Contribution of the experimental rations in the studied parameters: The analysis of the final results of the experiment (Table 5) show that the total length, total weight, feed conversion coefficient and efficiency did not present significant statistic differences (P > 0.05) among the treatments.

Concerning the survival, it was observed that the treatments (T_2, T_3 and T_4) was statistically superior (P < 0.01) to the treatment T_1 (56,67%).

Table 5 - Tukey test for total length (Lt), total weight (Wt), feed conversion rate (Fcr), efficiency (Ea) and survival (Sb) of the experimental

% Lev.	Lt(cm)	Wt(g)	Fcr	Ea	Sb(%)
T_1=0	23,35A	240,83A	3,44A	0,29A	56,67a
T_2=20	24,88A	289,82A	3,87A	0,26A	93,3b
T_3=40	24,23A	293,14A	3,27A	0,31A	83,33b
T_4=60	23,73A	237,78A	4,38A	0,23A	83,33b

Averages followed by distinct capital letters differ from each other at 5% of probability level (P<0.05) and the ones followed by distinct small letters differ from each other at 1% of probability level (P < 0.01).

Some author cited in literature, who worked with distillery yeast in fish breeding, came to these conclusions:

RIBEIRO *et al.* (1996), who worked with Nile tilapia objecting to analyze the availability of the inclusion of increasing levels of sugarcane yeast (18, 36, 54, 72, 90%) included in the rations in a period of 45 days, did not were differ find statistics (P>0.05).

CASTAGNOLLI (1992), substituted gradually meat flour by dry yeast at levels of A=0%, B=33.3%, C=66.6% and D=100% and concluded that the treatments that received yeast were superior to the testimony and that the substitution of 33.3% of yeast was statistically the one that propitiated the best result.

For ALVES *et al.* (1988) the optimum level of substitution of soybean flour by yeast (*Saccharomyces cerevisiae*) for an increase of weight in Nile tilapias were 36.97%. The results obtained are according to COWEY (1974), when compared the nutritional worth of the yeast, and MATTY *et al.* (1978), who attributed to the yeast the digestibility the proteic matter closed to the observed with soybean flour and that rates higher than 40% of yeast decrease the development of trout.

PÁDUA (1996), tested five levels (0, 25, 50, 75 and 100%) of substitution of dry fish flour by distillery yeast as proteic supplement and observed that until levels of 75% of substitution did not show damage effect in the productive development and in the metabolism of young pacu.

The results from the substitution of 10%, 20% and 30% of the ration by yeast distillery *(Sacharomices Cerevisae)* in balanced experimental rations in development of Nile tilapia did not show harmful effect until the maximum level tested of 30%, indicating that the selected yeast level, in the ration, for this fishes depends on the availability and additional cost (MEDRI *et al*., 2000a).

After ROBERTS *et al.* (1988), deficient proteic supply determine a limited growth of the fishes, which can cause some symptoms such as erosion in the dorsal flipper, abnormalities in the vertebral column and darkening of the skin. WAAGBO (1994) commented the importance of nutrients in diet on general metabolism and on the animal immunity, suggesting that a good knowledge of preparation of the feed improve the conditions in the breeding, reducing the losses by death.

Application of the Taguchi's loss function

The Table 6 and the Figure 1 presents the Taguchi's loss in the treatments T_1, T_2, T_3 and T_4 for the cost of production.

Table 6 - Cost of production in the treatments T_1, T_2, T_3 and T_4

Specification	Quantity				Unitary cost (R$)	Total (R$)			
	T_1=0%	T_2=20%	T_3=40%	T_4=60%		T_1=0%	T_2=20%	T_3=40%	T_4=60%
Ration (kg)	11.83	12.09	8.21	5.90	0.70	8.28	8.46	5.75	4.13
Yeast(kg)	0.00	3.02	5.48	8.85	0.60	0.00	1.81	3.29	5.31
juveniles	30	30	30	30	0.05	1.50	1.50	1.50	1.50
Food supplied(h)	5.00	5.00	5.00	5.00	3.00	15.00	15.00	15.00	15.00
Total	…	…	...	…	...	24.78	26.77	25.54	25.94

a) T_1=0% of yeast distillery protein

A Calculus: $A = \sum_{1}^{k} P_i / k = 24.78/30 = 0.83$

Δ Calculus: $\Delta = m - s = 256.87 - 73.68 = 183.19$

V² Calculus: $v^2 = 1/17(0.0003337)$

Calculus of the Taguchi's loss function (L):

$L = A\,\Delta^2 v^2 = .831(183.19)^2 1/17(0.0003337)$

L= 0.5468, therefore, 30 x 0.5468 = R$ 16.40

b) T_2=20% of yeast distillery protein

A Calculus: $A = \sum_{1}^{k} P_i / k = 26.77/30 = 0.89$

Δ Calculus: $\Delta = m - s = 274.52 - 80.16 = 194.36$

V² Calculus: $v^2 = 1/28(0.00035)$

Calculus of the Taguchi's loss function (L):

$L = A\,\Delta^2 v^2 = 0.89(194.36)^2\ 1/28(0.00035)$

L = 0.4203, therefore, 30 x 0.4203 = R$ 12.61

c) T_3=40% of yeast distillery protein

A Calculus: $A = \sum_{1}^{k} P_i / k = 25.54/30 = 0.85$

Δ Calculus: $\Delta = m - s = 283.83 - 91.29 = 192.54$

V² Calculus: $v^2 = 1/25(0.00037)$

Calculus of the Taguchi's loss function (L):

$L = A\,\Delta^2 v^2 = 0.85(192.54)^2 1/25(0.00037)$

L = 0.4664, therefore, 30 x 0.4664 = R$ 13.99

d) T_4=60% of yeast distillery protein

A Calculus: $A = \sum_{1}^{k} P_i / k = 25.94/30 = 0.86$

Δ Calculus: $\Delta = m - s = 232.97 - 73.60 = 159.37$

V² Calculus: $v^2 = 1/25(0.00036)$

Calculus of the Taguchi's loss function (L):

$L = A\,\Delta^2 v^2 = 0.86(159.37)^2\ 1/25(0.00036)$

L = 0.3145, therefore, 30 x 0.3145 = R$ 9.44

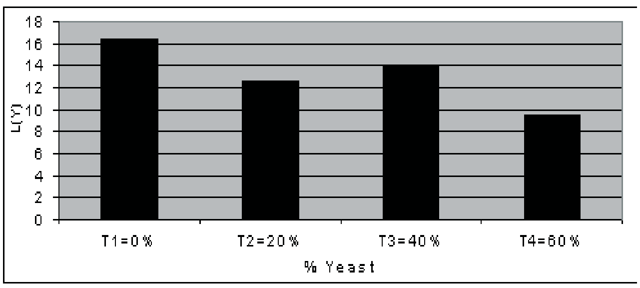

Figura 1 – Taguchi's loss function for the fishes production

Taguchi's Loss for the cost of production in tank-nets in the treatments T_2 = 20%, T_3 = 40% and T_4 = 60% (tests) were lower the group control (T_1 = 0%).

This result confirm the direction of yeast distillery protein in substitution of traditional source of protein.

The Table 7 and the Figure 2 presents the Taguchi's loss in the treatments T_1, T_2, T_3 and T_4 for the dead fishes.

Taguchi's Loss for the dead fishes in tank-nets in the treatments T_2 = 20%, T_3 = 40% and T_4 = 60% (tests) were lower the group control (T_1 = 0%). This result confirm

Table 7 - Dead fishes in the treatments T_1, T_2, T_3 and T_4

Specification	Quantity T_1=0%	T_2=20%	T_3=40%	T_4=60%	Unitary cost (R$)	Total (R$) T_1=0%	T_2=20%	T_3=40%	T_4=60%
Ration (kg)	2,95	0.17	0.47	0.59	0.70	2.07	0.20	0.33	0.41
Yeast(kg)	0.00	0.04	0.32	0.89	0.60	0.00	0.02	0.19	0.53
juveniles	13	2	5	5	0.05	0.65	0.10	0.25	0.25
Food supplied(h)	2.17	0.33	0.83	0.83	3.00	6.51	0.99	2.49	2.49
Total	…	…	...	…	...	9.23	1.31	3.26	3.68

a) T_1=0% of yeast distillery protein

A Calculus: $A = \sum_1^k P_i / k = 9.23/13 = 0.71$

Δ Calculus: $\Delta = m - s = 256.87 - 73.68 = 183.19$

V² Calculus: $v^2 = 1/17(0.0003337)$

Calculus of the Taguchi's loss function (L):

$L = A\,\Delta^2 v^2 = 0.71(183.19)^2 1/17(0.0003337)$

L = 0.4677, therefore, 13 x 0.4677= R$ 6.08.

b) T_2=20% of yeast distillery protein

A Calculus: $A = \sum_1^k P_i / k = 1.31/2 = 0.66$

Δ Calculus: $\Delta = m - s = 274.52 - 80.16 = 194.36$

V² Calculus: $v^2 = 1/28(0.00035)$

Calculus of the Taguchi's loss function (L):

$L = A\,\Delta^2 v^2 = 0.66(194.36)^2\ 1/28(0.00035)$

L = 0.3117 therefore, 2 x 0.3117 = R$ 0.62.

c) T_3=40% of yeast distillery protein

c) T_3=40% of yeast distillery protein

A Calculus: $A = \sum_1^k P_i / k = 3.26/5 = 0.65$

Δ Calculus: $\Delta = m - s = 283.83 - 91.29 = 192.54$

V² Calculus: $v^2 = 1/25(0.00037)$

Calculus of the Taguchi's loss function (L):

$L = A\,\Delta^2 v^2 = 0.65(192.54)^2 1/25(0.00037)$

L = 0.3566, therefore, 5 x 0.3566 = R$ 1.78.

d) T_4=60% of yeast distillery protein

A Calculus: $A = \sum_1^k P_i / k = 3.68/5 = 0.74$

Δ Calculus: $\Delta = m - s = 232.97 - 73.60 = 159.37$

V² Calculus: $v^2 = 1/25(0.00036)$

Calculus of the Taguchi's loss function (L):

$L = A\,\Delta^2 v^2 = 0.74(159.37)^2\ 1/25(0.00036)$

L = 0.2706, therefore, 5 x 0.2706 = R$ 1.35.

the direction of yeast distillery protein in substitution of traditional source of protein.

The Table 8 and the Figure 3 presents the Taguchi's loss in the treatments T_1, T_2, T_3 and T_4 for the discarded fishes.

Table 8 - Discarded fishes in the treatments T_1, T_2, T_3 and T_4

Specification	Quantity T_1=0%	T_2=20%	T_3=40%	T_4=60%	Unitary cost (R$)	Total (R$) T_1=0%	T_2=20%	T_3=40%	T_4=60%
Ration (kg)	2.09	1.73	1.64	0.94	0.70	1.46	1.21	1.15	0.66
Yeast(kg)	0.00	0.43	1.10	1.42	0.60	0.00	0.26	0.66	0.85
juveniles	3	4	6	4	0.05	0.15	0.20	0.15	0.20
Food supplied(h)	0.50	0.67	1.00	0.67	3.00	1.50	2.01	3.00	2.01
Total	…	…	...	…	...	3.11	3.68	4.96	3.72

a) T_1=0% of yeast distillery protein

A Calculus: $A = \sum_1^k P_i / k = 3.11/3 = 1.04$

Δ Calculus: $\Delta = m - s = 256.87 - 73.68 = 183.19$

V² Calculus: $v^2 = 1/17(0.0003337)$

Calculus of the Taguchi's loss function (L):

$L = A\,\Delta^2 v^2 = 1.04(183.19)^2 1/17(0.0003337)$

L = 0.6851, therefore, 3 x 0.6851= R$ 2.06.

b) T_2=20% of yeast distillery protein

A Calculus: $A = \sum_1^k P_i / k = 3.68/4 = 0.92$

Δ Calculus: $\Delta = m - s = 274.52 - 80.16 = 194.36$

V² Calculus: $v^2 = 1/28(0.00035)$

Calculus of the Taguchi's loss function (L):

$L = A\,\Delta^2 v^2 = 0.92(194.36)^2 1/28(0.00035)$

L =0.4344 therefore, x 0.4344 = R$ 0.86.

c) T_3=40% of yeast distillery protein

A Calculus: $A = \sum_1^k P_i / k = 4.96/6 = 0.83$

Δ Calculus: $\Delta = m - s = 283.83 - 91.29 = 192.54$

V² Calculus: $v^2 = 1/25(0.00037)$

Calculus of the Taguchi's loss function (L):

$L = A\,\Delta^2 v^2 = 0.83(192.54)^2 1/25(0.00037)$

L = 0.4554, therefore, 6 x 0.4554 = R$ 2.73.

d) T_4=60% of yeast distillery protein

A Calculus: $A = \sum_1^k P_i / k = 3.72/4 = 0.93$

Δ Calculus: $\Delta = m - s = 232.97 - 73.60 = 159.37$

V² Calculus: $v^2 = 1/25(0.00036)$

Calculus of the Taguchi's loss function (L):

$L = A\,\Delta^2 v^2 = 0.93(159.37)^2\ 1/25(0.00036)$

L = 0.3401, therefore, 4 x 0.3401 = R$ 1.36.

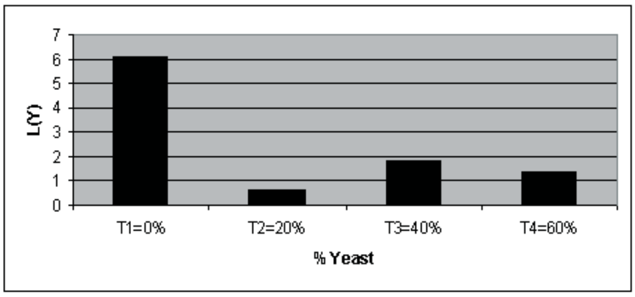

Figura 2 – Taguchi's loss for the dead fishes

In the graphic of Figure 3, the losses of the rejected fishes were R$2.06, 0.86, 2.73 and 1.36 for the respective treatments T_1=0%, T_2=20%, T_3=40% and T_4=60% yeast distillery protein in substitution of traditional source of protein. The losses of treatment T_3 were higher than the others treatments. The T_2 and T_4 treatments presented losses lower than the control group (T_1=0%).

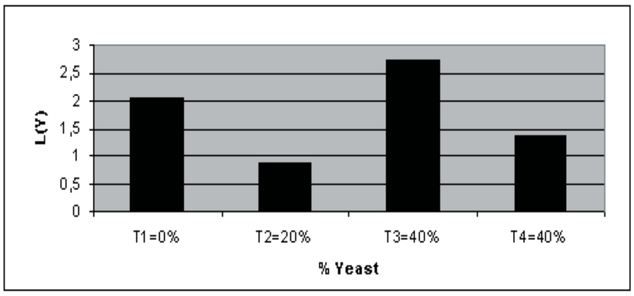

Figura 3 – Taguchi's loss for the discarded fishes

Conclusions

The test of Tukey was accomplished showing that there were not statistical differences ($p > 0.05$) among the efficiency, the length and the weight of the fish. With relationship to the survival, it was observed that the treatments (T2, T3, T4) was statistically superior ($p < 0.01$) to the treatment T1. Taguchi's Loss for the cost of production and for the dead fishes in tank-nets in the treatment T_2 = 20%, T_3 = 40% and T_4 = 60% (tests) were lower than the group control (T_1 = 0%). This result confirm the direction of yeast distillery protein in substitution of traditional source of protein.

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Recebido para publicação em 13/06/03.
Received for publication on 13 June 2003.
Recibido para publicación en 13/06/03.
Aceito para publicação em 30/09/03.
Acepted for publication on 30 September 2003.
Acepto para publicación en 30/09/03.