

Durability, Water Absorption and Water Stability of Two Commercial Fish Feed Pellets and Their Evaluation as Tilapia Feeds in Saudi Arabia

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ABSTRACT. Two fish feeds, one locally produced and the other imported, were investigated for pellet durability, water absorption and water stability and then evaluated as tilapia diets in intensive culture. Pellets of both feeds did not differ in durability, water absorption and water stability, though the loss of imported feed packed in wire netting bags and immersed in water was more than the local feed ($P < 0.05$). Large-size tilapia reared on large pelleted local feed showed better growth and feed conversion efficiency than tilapia reared on imported feed ($P < 0.05$). For medium size tilapia no difference was found in the growth rate and feed conversion efficiency reared on two types of feeds ($P > 0.05$), though the performance of tilapia reared on local feed was better. Small size tilapia reared on two types of feeds also did not show any significant difference in the growth rate and feed conversion efficiency ($P > 0.05$), but the imported feed gave better growth and feed conversion ratio. For all size-classes of tilapia no difference was found in the condition factor (K) ($P > 0.05$), except for medium-size tilapia where the condition factor of tilapia reared on local feed was higher than the tilapia reared on imported feed ($P < 0.05$). Survival rate in all the treatments was 100%. Based on a FCR of 2, the production cost of 1 kg tilapia will be SR. 2.80 (US \$ 0.75) with the local feed and SR. 6.00 (US \$ 1.6) with the imported feed excluding other costs.

Tilapias are the main species cultured in Saudi Arabia. The production system ranges from simple technology to more intensive aquaculture practices. Presently, tilapia production has almost reached to the level of 2000 tons per year, although Siddiqui and Al-Najada (1992) reported a production of 800 tons from 19 operational farms surveyed in 1990-91 and FAO (1992) reported a production of 1617 tons in 1990. The annual fish feed demand is about 5000-6000 tons and there are four feed mills which

meet this requirement. The feeds are steam pelleted and are available as pellets, crumbles and powders. Limited quantities of fry feed are imported with higher crude protein contents than that available from the locally produced ones to enhance the growth of fry. Similarly, some farmers feel that better tilapia growth and production may be obtained from imported feeds. The imported feeds are available on a much higher price and their use on a large scale may increase the production cost and may affect the success of tilapia culture.

For a successful aquaculture, particularly in semi and intensive culture systems, nutritionally adequate and cost effective diets is a major pre-requisite. Therefore, before a decision is made to import and market fish feed on a large scale an evaluation of the feed in comparison to locally available feeds is essential.

The present study was undertaken to determine durability, water absorption and stability of two fish feed pellets, one locally produced and the other imported from Germany, and to evaluate these feeds as diets of tilapia, and to find out which feed is most cost effective.

Materials and Methods

Fish feeds

Two tilapia feeds, one locally manufactured by Grain Silos and Flour Mills Organization, Riyadh, and the other imported from Germany (Alma-Futter Friedrich Botzenhardt and supplied by Alnaseria Trading Establishment, Riyadh) were evaluated for their durability, water absorption, water stability and their relative suitability as tilapia feeds in Saudi Arabia. Imported feeds were of three types, tilapia feed 35, pellet 3.3 mm, tilapia feed 35, pellet 2.3 mm and tilapia feed crumbles 1.5 - 2.3 mm. These feeds had different chemical composition (Table 1). Similarly, local feeds of similar particle sizes were selected, pellet 5.0 mm, crumbles 2.0 - 2.5 mm and small crumbles 1.5 - 2.0 mm. All the three feeds had the same chemical composition (Table 2). Durability, water absorption and feed loss by water leaching were tested only for large size pelleted feeds (5.0 mm and 3.3 mm). Relative suitability of the two types of feeds of three different particle sizes was determined for three size-classes (5 g, 50 g and 100 g) of tilapia.

Table 1. Proximate composition of imported tilapia feed^{1,2}.

Composition	Feed Type	
	Tilapia 35 (3.3 mm)	Tilapia Auschlussfutter
Protein (%)	35.0	36.0
Lysin (%)	2.0	2.2
Fat (%)	14.0	10.0
Fiber (%)	3.5	3.0
Ash (%)	7.0	6.5
Vitamin A (IU/kg)	30,000.0	30,000.0
Vitamin D ₃ (IU/kg)	2,500.0	2,500.0
Vitamin E (IU/kg)	200.0	200.0
Vitamin C (IU/kg)	100.0	150.0
ME (MJ/kg)	13.7	13.2

1. Proximate composition was provided by the manufacturer, Alma - Futter Friedrich Botzenhardt KG, D-8960 Kempten, Germany.
2. Proximate composition of tilapia 35 of 3.3 mm and 2.3 mm pellet size was the same.

Table 2. Proximate composition of locally manufactured tilapia feed^{1,2}

Composition	Feed Type
Protein (%)	34.0
Fat (%)	4.0
Fiber (%)	3.0
Ash (%)	11.0
Calcium (%)	1.2
Salt (%)	0.3
Phosphorus(%)	1.0
Vitamin A (IU/g)	20.0
Vitamin D (IU/g)	6.0
Vitamin E (IU/kg)	25.0
ME (MJ/kg)	12.5

1. Proximate composition was provided by the manufacturer of the feed, Grain Silos and Flour Mills Organization, Riyadh.
2. Proximate composition of the feed of three particle sizes (5.0 mm, 2.0 – 2.5 mm and 1.5 – 2.0 mm) was the same.

Pellet durability

Feeds were screened on sieve No. 8 (mesh size 2.38 mm) to remove crumbles and fines. Fifty gram of pre-screened feed was placed on a No. 8 sieve which was stacked on Nos. 16, 30, 50 and 200 with 1.18, 0.6, 0.3 and 0.075 mm mesh sizes, respectively and shaken for 20 minutes (80 cycles/min.) on a Endecotts sieve shaker Model. EVS 1. Five fractions of feed on each of five sieves were carefully removed and weighed and recorded as a percentage of the total feed used. Dust collected on the sieve wire and wall was brushed off and weighed with fraction of sieve No. 200.

Pellet water absorption

Ten grams of pre-screened (5.0 mm local feed; 3.3 mm imported feed) pellets were placed on a sieve No. 8 and immersed in a 50 liter fish tank containing water at 25°C for periods of 10, 60 and 180 s. The pellets were allowed to drain for 1 min after each time period and then weighed. For each time period the procedure was replicated three times.

Pellet water stability

The water stability of the pellets was determined by two methods. In method one, 10 g of pre-screened pellets were taken in 9 numbered 100 ml beakers, each of known weight. The beakers were immersed in 150 l fish tank containing 50 l water at 25°C, for periods of 1, 3 and 7 h. During this period the water was flowing through the tank at a rate of 1.3 l per min. Three beakers were removed carefully after the set time interval, water was drained carefully and the residue was oven-dried at 105°C for 24 h. Beakers were cooled in a desiccator and then weighed. The difference in feed weight before immersion and after drying was used to calculate the percentage of dry matter loss and was considered as water stability of the pellets. Both feeds were tested at the same time in the same tank.

In method two, 10 grams of the pre-screened pellets were taken in 12 numbered and weighed bags (10 x 10 cm) made from wire netting of 2 mm mesh size. The bags were closed (by stapling) and immersed in 150 l fish tank containing 100 l water at 25°C for periods of 1, 5, 15 and 30 min. The tank had a water flow through system (1 l/min), and 20 tilapia averaging 50 g each. The tank was aerated. Three bags were removed after the set time interval, water was drained and then oven-dried at 105°C for 24 h. Bags were cooled in a desiccator and weighed. The difference in feed weight before immersion and after drying gave the amount of feed loss for different time intervals. For both feeds same procedures were followed.

Growth and feed conversion

Locally produced hybrid tilapia *Oreochromis niloticus* x *O. aureus* (small 5 g, medium 50 g, large 100 g) were selected, starved for 48 h and used for the present

study (Table 7). Before stocking all fish were individually weighed. For large and medium size tilapia 900 l fiberglass tanks containing 400 l water and for small size tilapia 120 l fiberglass tanks containing 60 l water were used. Stocking rates were 10, 20, and 40 per tank for large, medium and small-size tilapias, respectively. The tanks were aerated and fresh ground water was continuously flowing through the tanks to give a complete exchange of water about every 6 h. Every two weeks all fish from each tank were caught and group weight was taken to adjust the feeding rate. Large-size tilapia were fed pelleted (5.0 mm and 3.3) feed at the rate of 3% (4 weeks), 2.5% (2 weeks) and 2.0% (2 weeks) of fish biomass in each tank; medium-size tilapia were fed pellets and crumbles (2.3 mm and 2.0 - 2.5 mm) at the rate of 3% (6 weeks) and 2.5% (2 weeks) of fish biomass in each tank; small-size tilapia were fed crumbles (1.5 - 2.3 mm) at the rate of 5% of body weight for 8 weeks. For each feed, the treatment was replicated twice.

After 56 days feeding trial all the fish from each tank were caught, individually weighed and sexed. The data were used to determine mean final body weight, daily growth rate, specific growth rate (SGR), feed conversion ratio (FCR) and condition factor (K) of the fish as follows:

Mean final body weight = Mean weight of all fish in 2 tanks.

$$\text{Daily growth rate} = \frac{\text{Final weight} - \text{initial weight}}{\text{Number of days}}$$

$$\text{SGR} = \frac{\ln W_2 - \ln W_1}{\text{Number of days}} \times 100$$

Where W_1 = initial weight and W_2 = final weight

$$\text{FCR} = \text{g dry feed} / \text{g live weight gain}$$

$$K = (W/L^3) \times 100$$

where W = weight of fish and L = total length of fish.

Water quality and temperature

In two tanks (900 l and 120 l) maximum and minimum water temperatures were recorded daily. Dissolved oxygen (DO), pH and $\text{NH}_3\text{-N}$ were determined in three

tanks (2 900 l tanks containing large and medium size tilapia, and one 120 l containing small-size tilapia) at weekly intervals. Total alkalinity, total water hardness and salinity were determined two times in the first and last week of the experimental period. Temperature was recorded with maximum - minimum thermometers, salinity was determined with a refractometer and other water quality parameters were determined using a HACH DR/2000 water analysis kit.

Statistical analyses

Statistical analyses on growth (mean final body weight), daily growth rate, SGR, FCR and K were made using one way analysis of variance and LSD range test was used to determine differences at 5% level of significance between the two types of fish feeds.

Results

Pellet durability

The amount of feed remaining on sieve No. 8, 16 and 30 were not different for the two feeds tested for durability (Table 3), but the percentage on sieve No. 50 and 200 was higher for the local feed than the imported feed.

Table 3. Pellet durability expressed as % of total feed remaining on different sieves of two tilapia fish feeds. Means of three samples \pm standard deviation.

Sieves	Feed Type	
	Local	Imported
No. 8 + 16 + 30	98.66 \pm 0.2 ^a	99.60 \pm 0.05 ^a
No. 50 + 200	1.34 \pm 0.2 ^a	0.39 \pm 0.05 ^b

Means in rows with different letter differ significantly (P = 0.05).

Pellet water absorption

Water absorption for both the feeds was almost the same (Table 4), and water intake did not increase significantly with immersion time. In both feeds after 1 min immersion outer covering was soft but intact and the central core was dry. After 3 min the pellets were quite swollen and the central core was almost wet. Local feed pellets looked coarse and lumpy after 3 min immersion.

Table 4. Effect of immersion time on water absorption (g) of two types of tilapia fish feeds.

Immersion Time (s)	Feed Type	
	Local	Imported
10	8.2 ± 0.3 ^a	7.2 ± 0.5 ^a
60	8.3 ± 0.3 ^a	7.6 ± 0.7 ^a
180	10.0 ± 0.7 ^a	11.7 ± 0.7 ^a

Water absorption = Weight gain of 10 g of feed, means of three samples ± standard deviation. Means in rows followed by the same letter do not differ significantly ($P = 0.05$).

Pellet water stability

Water stability of the two types of feed pellets tested in beakers was not significant between the two feeds for three different time intervals (Table 5), but the rate of leaching of pellets for both feeds increased with time. In the wire netting bags differences in the loss of feed from the bags were different between the two types of feeds for all time intervals (Table 6) and the loss of feed increased with time.

Table 5. Effect of leaching on dry matter residue (% of original weight) of two tilapia fish feeds tested in beakers.

Diet	Period of immersion (h)		
	1	3	7
Local	^x 87.9 ± 0.5 ^a	^x 84.7 ± 1.3 ^a	^x 83.8 ± 1.5 ^a
Imported	^x 86.4 ± 0.3 ^a	^x 86.3 ± 0.4 ^a	^x 84.9 ± 0.5 ^a

Means of three samples ± standard deviation.

Means in columns (a, b, c) and rows (x, y, z) followed by the same letter do not differ significantly ($P = 0.05$).

Table 6. Effect of immersion time on dry matter loss (%) of two tilapia fish feeds tested in wire netting bags (mesh size 2.0 mm)

Diet	Period of immersion (min.)			
	1	5	15	30
Local	^z 7.9 ± 0.4 ^a	^{yz} 13.0 ± 1.5 ^a	^{xy} 15.9 ± 0.5 ^a	^x 26.4 ± 4.4 ^a
Imported	^z 10.6 ± 0.1 ^b	^{yz} 22.5 ± 0.5 ^b	^{xy} 39.6 ± 5.1 ^b	^x 48.4 ± 18.9 ^a

Means of three samples ± standard deviation.

Means in columns (a, b, c) and rows (x, y, z) with different letters differ significantly ($P = 0.05$).

Growth and feed conversion

Large size tilapia reared on the local pelleted feed had higher final weight, daily growth rate, SGR and better feed conversion than the imported feed at 5% level of significance (Table 7). No difference was found in the condition factor. For medium-size tilapia no difference was found in growth and feed conversion ratio between the two types of feeds ($P > 0.05$), though the values were more favorable for

Table 7. Effect of two types of fish feeds on final body weight, daily growth rate, specific growth rate (SGR), feed conversion ratio (FCR) and condition factor (K) of hybrid tilapia.

Tilapia Size group	Feed Type	
	Local	Imported
Large-size tilapia	P (5.0 mm)	P (3.5 mm)
Initial weight (g)	104.0	104.0
Final weight (g)	208.7 a	182.6 b
Growth (g/d)	1.9 a	1.4 b
SGR (%/d)	1.2 a	1.0 b
FCR	1.7 a	2.2 b
Condition factor (K)	1.79 a	1.75 a
Survival rate (%)	100.0	100.0
Male (%)	100.0	100.0
Medium-size tilapia	C (2.0 – 2.5 mm)	P (2.3 mm)
Initial weight (g)	48.0	48.0
Final weight (g)	112.6 a	97.1 a
Growth (g/d)	1.2 a	0.9 a
SGR (%/d)	1.5 a	1.3 a
FCR	1.5 a	1.9 a
Condition factor (K)	1.71 a	1.59 b
Survival rate (%)	100.0	100.0
Male (%)	78.0	75.0
Small-size tilapia	C (1.5 – 2.0 mm)	C (1.5 – 2.3 mm)
Initial weight (g)	5.3	5.3
Final weight (g)	18.9 a	20.9 a
Growth (g/d)	0.24 a	0.27 a
SGR (%/d)	2.3 a	2.5 a
FCR	1.6 a	1.5 a
Condition factor (K)	1.78 a	1.87 a
Survival rate (%)	100.0	100.0

Means in rows followed by the same letter do not differ significantly ($P = 0.05$).

P means pelleted feed

C means crumbled feed

the local feed than the imported feed (Table 7). Small-size tilapia fed on imported feed showed better growth and feed conversion ratio than the local feed, but the difference in mean values was not significant ($P > 0.05$). Survival rate in all the treatments was 100%. Condition factor (K) also did not vary in all the treatments except in medium-size tilapia where condition factor K was higher for tilapia reared on the local feed.

Temperature and water quality

Temperature, DO, pH, $\text{NH}_3\text{-N}$, total alkalinity, total water hardness and salinity levels are given in Table 8. All these parameters were found to be within optimum ranges for tilapia culture.

Table 8. Maximum - minimum water temperatures and some of the water quality parameters recorded during experimentation.

Parameter	Mean \pm SD	Range
Max. Temp. ($^{\circ}\text{C}$)	28.0 \pm 1.0	26 - 29
Min. Temp. ($^{\circ}\text{C}$)	25.0 \pm 1.0	22 - 26
DO (mg L^{-1})	5.3 \pm 0.7	4.0 - 6.5
PH	8.1 \pm 0.1	7.8 - 8.2
$\text{NH}_3\text{-N}$ (mg L^{-1})	0.08 \pm 0.02	0.06 - 0.12
Total alkalinity (mg L^{-1})	160	—
Total hardness (mg L^{-1})	950	—
Salinity (o/‰)	1.5	—

Discussion

Both types of feed, local and imported, tested are steam pelleted and are of sinking type. Imported feed was more durable on sieve test than the local one. Pellets of both feeds showed similar water absorption capacity in 10 s to 180 s immersion and no difference was found in water stability in 1 to 7 h stability test. However, it was noted that prolonged immersion caused expansion of pellets. Imported feed had almost become pulplike after 1 h immersion in the beaker test while the local feed pellet looked coarse and lumpy as it lost the covering and pellet shape making coarse particles of the feed particularly corn particles visible, but still the pellet was intact. Similarly, in wire netting bags more loss was recorded for the imported feed than for the local feed indicating that the imported pellet broke down quicker and the fine particles escaped from the netting. The chemical composition provided by the manufacturers show that the fat contents of imported feed pellet (14%) is higher than the local pellet (4%). Lower stability of imported pellet may be due to incorrect

gelatinization because of the high fat contents of pellet and fat covering the surface of the carbohydrate particles as reported by Jayram and Shetty (1979, 1981). Stivers (1971) found that the degree of stability of feeds is almost directly related to the extent of gelatinization during steam processing. Slightly better stability of local feed may be due to large size of particles of feed ingredients in comparison to the finely ground ingredients of the imported feed, since finely ground material is likely to dissipate more rapidly once the pellet starts disintegrating (Stivers 1971, Jayram and Shetty 1981). Nevertheless, while feeding it was observed that pellets of both imported and local feeds were reasonably stable for 20-30 min in the rearing tanks, the period generally required for successful feeding of tilapia.

Large-size tilapia reared on the local pelleted feed showed significantly higher mean final weight, daily growth rate, specific growth rate and better feed conversion ratio than the tilapia reared on imported pelleted feed (Table 7). It was also noted that the local feed consumption was better than the imported feed. Crude protein contents of the two feeds were almost the same, meeting the general protein requirements of 30% crude protein for the best growth of this size-class of tilapia (Siddiqui *et al.* 1988). Higher fat content of imported feed might have affected the consumption and assimilation of the feed leading to poor feed conversion efficiency and growth of large-size tilapia.

Medium-size tilapia reared on two types of feed did not show any significant difference in growth and feed conversion efficiency, though tilapia reared on the local feed performed better than the tilapia reared on imported feed (Table 7). Almost a reverse situation was found for small-size tilapia which showed better performance when reared on imported feed than the tilapia reared on the local feed, but the differences in performance with respect to growth and feed conversion efficiency were not significant.

There is also a considerable price difference between the local feed and imported feed. The local feed is subsidized and available at SR. 1400 per ton, while the price of imported feed is quoted at SR. 3000 per ton. Therefore, based on a feed conversion ratio of 2, the production cost based on feed only will be SR. 2.80 /kg for the local feed and SR. 6.00 /kg for the imported feed. The use of imported feed for all growing stages of tilapia-fry, fingerlings, sub-adults and adults is not economical. Imported feed for tilapia fry may be used as suitable feed with optimum protein content and particle size is not manufactured locally. For other size-classes of tilapia locally manufactured feed should be used. Further, it is felt that the local manufacturers should be encouraged to produce fry feed using locally available ingredients which will be fresh and cost-effective.

In summary, the performance of tilapia reared on local feed was found quite satisfactory for three size-classes of tilapia, for large and medium-size tilapia better

than the imported feeds, and therefore, a great caution is required in deciding to import and market tilapia feed for medium and large-size tilapia.

Acknowledgements

We are thankful to Alnaseria Trading Establishment, Riyadh for providing the Alma-Futter Friedrich Botzenhardt tilapia feeds and for its encouragement to make this study. Thanks are also due to Mr. Musa Chin for his help during the study.

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(Received 15/01/1994;
in revised form 05/05/1994)

دراسة مقدار المتانة ، الامتصاصية للماء والثبات في الماء
لنوعين من حبيبات غذاء تجاري وتقييمهما
كغذاء لسماك البلطي
في المملكة العربية السعودية

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تم إجراء الدراسة على نوعين من غذاء الأسماك أحدهما منتج محلياً والآخر مستورد وتناولت الدراسة معرفة متانة حبيبات الغذاء، إمتصاصيتها للماء وفترة ثباتها في الماء ومن ثم تقييمهما كغذاء لسماك البلطي في الزراعة المكثفة. وقد وجد أن الحبيبات الغذائية في كل من النوعين لم تختلف في المتانة وفي إمتصاصيتها للماء، وثباتها فيه، لكن مقدار الفقد في الغذاء المستورد الموضوع في أكياس شبكية مصنوعة من السلك المعدني والمغمورة في الماء كان أكبر من الغذاء المحلي ($P < 0.05$).

وأعطت أسماك البلطي ذات الحجم الكبير والمرباة على حبيبات كبيرة من الغذاء المحلي نمواً وكفاءة تحويل غذائي أفضل من البلطي المرباة على الغذاء المستورد ($P < 0.05$). وبالنسبة للبلطي المتوسط الحجم والمربي أيضاً على كلا النوعين من الغذاء فلم يوجد أي اختلاف في النمو وكفاءة التحويل الغذائي ($P > 0.05$). برغم ذلك فإن أداء البلطي المربي على الغذاء المحلي كان الأفضل.

أما البلطي ذو الحجم الصغير والمرى على النوعين من الغذاء فلم يظهر أي اختلاف كبير في معدل النمو وكفاءة التحويل الغذائي ($P > 0.05$)، ولكن الغذاء المستورد أعطى معدل نمو وكفاءة تحول غذائي أفضل. لا يوجد أي اختلاف لمعامل الحالة (K) في الأسماك الكبيرة والصغيرة ($P > 0.05$) ما عدا في الأحجام المتوسطة حيث وجد أن معامل الحالة (K) للأسماك المرباة على الغذاء المحلي كان أفضل من الأسماك المرباة على الغذاء المستورد ($P < 0.05$).

كان معدل البقاء في جميع المعالجات ١٠٠٪. إستناداً على أن كفاءة تحول الغذاء بنوعيه المستخدمين في هذه الدراسة يساوي ٢، فقد وجد أن تكلفة الكيلوجرام الواحد من سمك البلطي المربى على الغذاء المحلي هو (٢,٨) ريال سعودي أي ما يقارب (٥,٧٥) دولار أمريكي والمرى على الغذاء المستورد بلغت تكلفة الكيلوجرام (٦) ريال سعودي أي ما يقارب (١,٦) دولار أمريكي غير شامل التكاليف الأخرى.