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Research Article

The Physicochemical Property of The Extruded Trout Feeds of The Leading Domestic Manufacturer ın Turkey

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Abstract

Physical properties (pellet dimension, sinking velocity, hardness, durability, friability, and water absorption) and proximate composition of two major domestic producer's trout feeds, the trademarks are BioAqua (Çamlı Feed by Pınar Campany) and Blueaq (Abalıoğlu), in Turkey were evaluated. The amount of uneaten feed is closely related to physical characteristics such as sinking velocity and durability of the pellet. In offshore cage culture, uneaten feed and nutrient losses resulting from poor pellet quality are the main problems for production cost and environment. This paper is the first attempt to evaluate the physical characteristics of the extruded trout feeds widely used in fresh water and sea cages. However, there are no definite values of physical properties for fish pellets in literature. There was a contrasting relationship between size and hardness of the pellets and as pellet size increased, pellet durability raised, too. The settling velocity of the pellets showed significant variations for same kind of feed between companies ($P<0.05$). Water absorption rates increased with temperature and immersion duration but decreased with salinity. Proximate composition of the feeds was almost close to the values declared by the manufacturers.

Keywords: Fish feed, settling velocity, hardness, absorption, friability.

Öz

Sektörde Öncü Türk Firmalarınca Üretilen Ticari Ektrüde Alabalık Yemlerinin Fizikokimyasal Özellikleri

Türkiye'de iki öncü üretici firma BioAqua (Çamlı yem, Yaşar Holding) ve Blueaq (Abalıoğlu Yem) tarafından üretilen alabalık yemlerinin fiziksel özellikleri (pelet boyutu, batma hızı, sertlik ve dayanım, tozlanma ve su absorbsiyonu) ve biyokimyasal kompozisyonu incelenmiştir. Balık tarafından alınamayan yemlerin miktarı peletin batma hızı ve dayanımı gibi fiziksel özellikleriyle yakından ilgilidir. Kafes kültüründe zayıf pelet kalitesinden kaynaklanan yenmeyen yem ve besin elementi kayıpları üretim maliyeti ve çevre açısından başlıca problemlerdir. Bu makale Karadeniz offshore kafeslerinde yoğun olarak kullanılan ektrüde alabalık peletlerinin fiziksel özelliklerini ortaya koyan ilk girişimdir. Bununla birlikte literatürde balık yemlerinin fiziksel özelliklerine yönelik kesin olarak tanımlanmış değerler mevcut değildir. Test edilen yemlerde, pelet ebadı küçüldükçe pelet sertliğinin artış gösterdiği genel bir eğilim vardır. Diğer taraftan, pelet ebadı artarken pelet dayanımı da artış göstermektedir. Her iki firmanın aynı tür yemlerinin batma hızları önemli varyasyonlar göstermektedir ($P<0.05$). Su absorbsiyon oranları su sıcaklığı ve immersiyon süresiyle artarken tuzlulukla birlikte düşmektedir. Yemlerdeki biyokimyasal içeriklerin firmalarca bildirilen değerlere oldukça yakın olduğu belirlenmiştir.

Anahtar Kelimeler: Balık yemi, batma hızı, sertlik, absorbsiyon, tozlanma.

Introduction

In aquaculture, feeding is based on commercial feeds and constitutes 50-70% of the production costs related to capacity and management. Although nutrient dispersal models take into accounts both food and feces, uneaten food is the greatest contributor to of solid waste loads (Beveridge et al., 1991). Pellet water stability is defined as the retention of its physical characteristics with minimal disintegration and nutrient leaching from immersion to when it is consumed (Palma et al., 2008). Lower pellet stability breaks up into small particles, leach nutrients to the environment and affect water quality, which leads to poor animal growth, high conversion rates, and low survival, thereafter. The higher the water stability of the feeds, the less waste will be produced and the bigger proportion of nutrients will be transmitted to the cultured species (Leonard et al., 2002). The degree of stability and the duration of immersion are shorter with diets containing suitable attractants that enhance feed consumption (Lim and Cuzon, 1994). The effect of ingredients on pellet quality has been regarded to changes in the ingredients when they are subjected to physical compression and shear during the pelleting process (Thomas and Van Der Poel, 1996).

The use of the least cost formulation for diets leads to a large number of feedstuffs incorporated at different inclusion levels which may lead to a variation in physical quality of the feeds after a pelleting process, although the calculated nutritional requirements seem to be met (Thomas and Van Der Poel, 1996). Besides, pelleting processes such as pressure in the die hole and porosity will change during the pelleting process. Moreover, the amount of energy required to overcome friction in the die hole can only be roughly estimated rather than exactly measured, and these parameters are strongly dependent on the physicochemical properties of the diet ingredients themselves (Thomas and Van Der Poel, 1996). For these reasons stated, even feed batches produced by the same company may have different physical and biochemical characteristics and eventually be of different quality.

Feed and feeding also have important effects on growth performance, feed utilization and fish meat quality (Storebakken and Austreng, 1987; Johansson et al., 1995). Environmental effects of aquaculture caused primarily by uneaten food and fecal excrete; have become a critical factor of attention in recent years.

Alvarado (1997) stated that intensive efforts have been carried out to eliminate the environmental damage of aquaculture and for this reason environmental-friendly feeds and improved new feeding strategies should be implemented. On the other hand, features of diet ingredients used in composed feeds may cause differences in feed quality (Thomas and Van Der Poel, 1996).

Waste dispersion models applied to the cage culture of Atlantic salmon (*Salmo salar* L.) have relied on scant data sets of feed settling value (Gowen and Bradbury, 1987). Chen et al. (1999) studied salmon feeds produced by Ewos and Trouw Company's related to settling velocity, hardness and friability and water absorption. Leonard et al. (2002) evaluated the physical stability of shrimp feeds by physically testing.

Some test procedures and devices such as DORIS and Holmen improved to measure physical quality of the pellets. DORIS test is a novel procedure in order to evaluate pellet degradation during pneumatic conveying (Askeland et al., 2002; Aas et al., 2011a). The Holmen pellet tester (NHP New Holmen Portable Pellet Tester, Norfolk, UK) was developed to determine physical feed quality by Holmen Feed Company and the device allows to measure abrasion and fragmentation in a simulated pneumatic transportation (Fahrenholz, 2012). The DORIS value, friability, hardness and durability of the extruded high energy salmonid feeds, with a diameter of 12 mm without giving brand names, was measured to observe them during pneumatic conveying by Aas et al. (2011a). Another study conducted on test feeds developed for Atlantic salmon to evaluate the relationship between physical feed quality and moisture content on nutritional response by Oehme et al. (2014).

There are relatively few studies on the physical quality of trout pellets and most published ones are mainly focused on the feeds of salmon and shrimp. The main basis of this kind of studies illustrates the nutrient losses resulting from poor feed quality. There are many trout cages along the Black Sea coast and all of the farms are using commercial trout feeds mainly supplied by BioAqua and Blueaq.

The present study attempted to evaluate physical (dimension, friability, hardness, sinking velocity, water absorption and durability in Black Sea water) and biochemical (dry matter, ash, organic matter, crude protein and crude lipid) properties of trout feeds of two major Turkish feed companies which are widely used for trout cage culture in the Black Sea. These producers are the oldest and rooted in the aquafeed sector and constitute majority proportion of total national fish feed production.

Materials and Methods

Two commercial extruded standard feed pellets were tested. Some feed samples were acquired directly from the producers but most we acquired from the local distributors. Total 0.5 kg sample from each feed type were stored in sealed plastic bags under normal room conditions. The tests applied on the feeds appear in Table 1.

Table 1. Pellet types and measurements

Comp.	Pellet type	Size	Settling velocity	Hardness	Friability	*Water abs.	Dry matter	Protein	Lipid	*Ash and OM
BioAqua	E9	+	+	+	+	+	+	+	+	+
	E6	+	+	+	+	+	+	+	+	+
	E5	+	+	+	+	+	+	+	+	+
	E4	+	+	+	+	+	+	+	+	+
	E3	+	+	+	+	+	+	+	+	+
	E2	+			+	+	+	+	+	+
Blueaq	E8	+	+	+	+	+	+	+	+	+
	E5	+	+	+	+	+	+	+	+	+
	E4	+	+	+	+	+	+	+	+	+
	E3	+	+	+	+	+	+	+	+	+
	E2	+			+	+	+	+	+	+

*Water abs. Water absorption, OM Organic matter

Physical Properties of the Pellets;

Size and weight; Sixty-five feed pellets were taken randomly from each feed sample. Their dimensions and weights were measured with a digital compass (±0.01mm) and a digital balance (±0.1mg), respectively.

Friability method; Approximately 50 gr from each pellet samples was placed in an attrition mill box (5cm diameter, 15cm length) for agitation. The box was revolved at 150 rpm for 10 min according to the method by Chen et al. (1999). Samples were then sieved and the proportion of the original sample weight that passed through a laboratory sieve (mesh size 2mm), after sieving samples were reweighed. One sample for each feed type was done.

Hardness and durability; To test hardness and durability, 30-35 pellets were placed individually in a pellet crusher (ELE comp.), and the pressure at which the pellet disintegrated was recorded.

Sinking velocity; A 2m length of 25cm diameter transparent calibrated plastic tube was used for preliminary assessment of pellet settling velocity in freshwater as well as in seawater and secured in a vertical position. Pellet was gently introduced just below the water surface, and the settling velocity was recorded by video camera within the range of 190cm, the first of which was 10cm below the water surface. The pellets which remained on the water surface without sinking or adhered to the tube's wall were eliminated.

Water absorption; Water absorption capacity of the pellets was tested by using stainless steel cages with 3cm in diameter and 6cm in length and the cages had 0,5mm mesh size defined by Tacon and Leonard (2001). Approximately 5g of feed sample from each type were placed in individual compartments containing seawater (17ppt) and freshwater. Pellets were left for 5 and 10 min at 10˚C and 20˚C, respectively. Then they were removed, and placed on an absorbent paper to remove excess water and re-weighed. The absorbed water was calculated as a percentage of the initial weight.

Proximate composition; Three replicate was done in determining proximate composition. The proximate components (Crude protein, crude lipid, dry matter and ash) of these pellets were analyzed according to AOAC (1990) standard methods; kjeldahl distillation method for protein, soxhlet extraction method for lipid, moisture extraction oven at 105 ^{0}C for 12h and a muffle furnace at 550 ^{0}C until it turned white and free of carbon.

Statistical analysis; All data sets were tested for homogeneity of variances and normality. Statistical significances within measured parameters were computed from one-way analysis of variance using Minitab^{TM}. In all cases, differences were considered as significant where $P<0.05$.

Results

Pellet size and weight; Similar type and sizes of pellets (diameter and length) and weights may show differences between companies and even among batches of the same company. Feed companies served their feeds on market by declaring pellet diameter. In the present study, measured pellet diameters were found bigger than declared values by the manufacturers. This difference was more obvious for E6 and E5 pellets of BioAqua, E5 of Blueaq. Diameters of some pellets were smaller than declared values (E9 of BioAqua). These values were shown at Table 2.

Table 2. Diameter, length, weight and length/diameter ratios of pellets (mean ±sd; n=65)

Comp.	Pellet type	Diameter (mm)	Length (mm)	L/D	Weight (g)
BioAqua	E9 (9 mm)	8.85±0.21	7.90±0.87	0.89	0.429±0.054
	E6 (6 mm)	7.67±0.21	7.14±0.60	0.93	0.286±0.023
	E5 (5 mm)	6.00±0.19	5.50±0.29	0.92	0.117±0.006
	E4 (4 mm)	4.83±0.22	5.16±0.42	1.07	0.077±0.012
	E3 (3 mm)	3.12±0.12	4.40±0.47	1.41	0.030±0.004
Blueaq	E8 (8 mm)	8.22±0.33	8.99±0.86	1.09	0.430±0.048
	E5 (5 mm)	6.07±0.21	5.52±0.51	0.91	0.149±0.015
	E4 (4 mm)	4.51±0.18	4.34±0.30	0.96	0.066±0.006
	E3 (3 mm)	3.55±0.14	4.47±0.38	1.26	0.039±0.005

Table 3. Friability rates

Comp.	Pellet type	Friability rate (%)
BioAqua	E9	0.104
	E6	0.146
	E5	0.122
	E4	0.096
	E3	0.199
	E2	0.018
Blueaq	E8	0.042
	E5	0.084
	E4	**0.384**
	E3	0.171
	E2	0.209

Pellet Friability; Friability ratios of the feed ranged between 0.018% and 0.384% (Table 3). Extruded pellets have lower friability ratios than those of normal steam pellets. There was no significant difference between companies except for Blueaq E4.

Pellet Hardness and durability; Extruded pellets had hardness between 1.14-2.26kg/cm^2; maximum durability was between 1.40-8.53kNt. Hardness of extruded pellets belonging to BioAqua and Blueaq didn't show significant differences (Table 4).

Proximate composition; With some exceptions such as BlueAqua E9 and Blueaq E8-E2, there were no significant differences between measured values and those of declared by the companies.Settling velocity;Today in trout feed production, especially with a goal of the feed's remaining a longer time on water column or surface; produced extruded feeds

Table 4. Hardness and durability (mean ±sd; n=33; 1kg=9.81 kNt)

Comp.	Pellet type	Hardness (kg/cm^2)	Max. Durability (kNt)
BioAqua	E9	1.32±0.33	8.29±1.68
	E6	1.14±0.19	5.22±0.83
	E5	1.25±0.14	3.45±0.31
	E4	1.28±0.18	2.37±0.32
	E3	2.21±0.23	1.60±0.19
Blueaq	E8	1.71±0.29	8.53±1.41
	E5	2.26±0.43	6.16±0.93
	E4	1.57±0.40	2.50±0.60
	E3	1.55±0.33	1.40±0.28

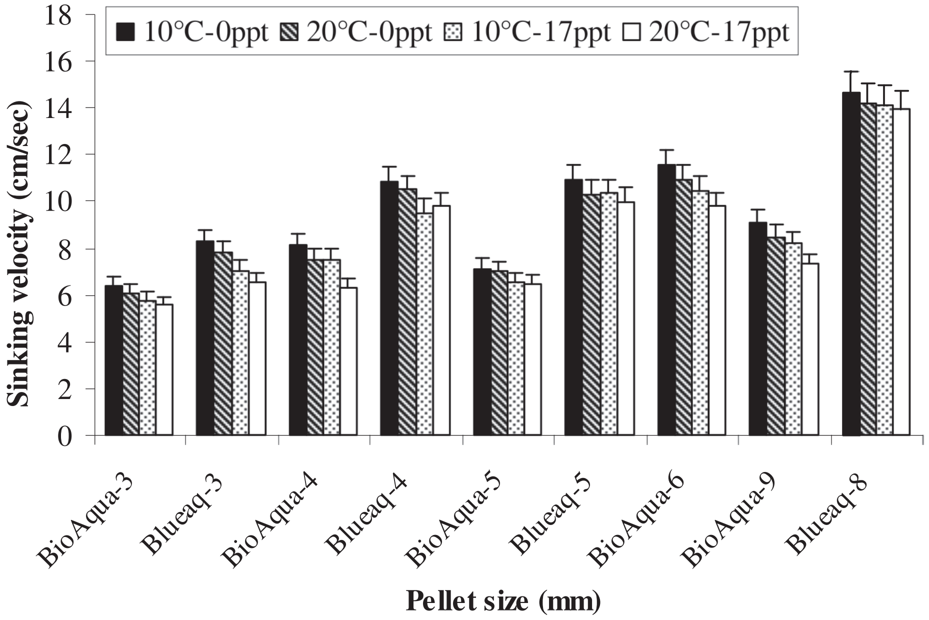

Figure 1. Settling velocity of the pellets.

have slower sinking velocity than normal pellets because of the higher lipid content and the applied production technology. It was determined that there is an important difference between BioAqua and Blueaq extruded pellets' sinking velocities ($P<0.05$) (Figure 1).

Except for E6 feed (mean velocity 10.66 cm/sec) of BioAqua, all pellets have slower sinking velocity (mean 5.96-8.27 cm/sec). When taking into consideration temperature and salinity, while pellets had slower sinking velocity in sea water (‰17±1), water temperature (10°C and 20°C) did not show any significant effect on sinking velocity (Table 5).

Table 5. Settling velocity at different temperature and salinity (mean ± sd; n=32)

Comp.	Pellet type	Settling velocity (cm/sec)				
		10°C–0ppt	20°C-0ppt	10°C-17ppt	20°C-17ppt	Mean
BioAqua	E9 ^{c,b}	9.11±1.47	8.48±1.17	8.17±1.01	7.31±1.04	8.27
	E6 ^{c}	11.53±0.82	10.92±0.89	10.44±0.76	9.76±0.80	10.66
	E5 ^{a,b}	7.12±1.05	7.02±1.29	6.50±1.14	6.45±1.57	6.77
	E4 ^{b}	8.09±1.01	7.52±1.26	7.48±0.79	6.32±1.14	7.35
	E3 ^{a}	6.41±1.23	6.06±0.94	5.76±0.73	5.59±0.93	5.96
Blueaq	E8 ^{d}	14.63±1.41	14.20±1.42	14.10±1.84	13.93±1.37	14.21
	E5 ^{c}	10.89±1.08	10.30±1.10	10.32±1.14	9.97±0.93	10.37
	E4 ^{c}	10.84±0.99	10.48±0.69	9.51±1.23	9.78±0.85	10.15
	E3 ^{b}	8.26±0.85	7.84±1.40	7.04±1.01	6.54±0.85	7.42

Table 6. Water absorption ratios (%) of the pellets at different temperature (10-20 °C) and salinity conditions according to immersion duration (5, 10 minutes)

Comp.	Pellet type	Freshwater				Sea water (17ppt)			
		10°C		20°C		10°C		20°C	
		5'	10'	5'	10'	5'	10'	5'	10'
BioAqua	E9	12.95	15.59	13.26	20.80	11.77	14.35	14.09	18.24
	E6	8.39	11.73	9.47	13.89	8.35	13.71	10.01	12.42
	E5	11.22	15.20	12,57	15.77	10.81	12.70	12.21	16.20
	E4	15.02	19.24	20.77	25.11	15.16	22.77	19.64	23.75
	E3	21.40	23.00	21.31	27.64	17.74	23.08	22.59	30.92
	E2	23.74	31.95	30.10	39.29	24.02	31.90	30.61	37.11
Blueaq	E8	8.44	10.71	8.97	11.47	8.00	9.61	10.33	12.36
	E5	9.76	12.66	11.41	14.20	7.76	11.00	10.77	13.50
	E4	12.17	15.89	13.84	18.86	10.87	15.30	12.36	17.30
	E3	13.46	19.43	23.52	26.06	12.28	17.84	18.30	27.38
	E2	18.46	26.67	24.82	34.01	18.74	26.32	25.33	32.83

Water absorption; Water absorption rates of the pellets increased significantly depending on immersion time (P<0.05). In contrast; as pellet size raised, water absorption rates decreased. In general, water absorption increased with the increase of temperature, and decreased with the increase of salinity. But it was determined that these differences were not statistically significant (Table 6).

Discussion

The present study's goal is to determine the physical and proximate biochemical characteristics of commercial trout feeds produced by two Turkish companies and compare between these companies and the global feed companies like Trouw and Ewos.

In sinking velocity and water absorption trials, the important physical parameters in aquaculture like temperature and salinity were taken into consideration. It was stated that rainbow trout could tolerate temperature changes on a "large scala" (Gall and Crandel, 1992). But, at temperatures lower than 12°C and higher than 20°C there is a negative effect on the effective growth of this species. Therefore, the temperature limits (10°C and 20°C ±1) used in this study was decided according to the optimal growth conditions of trout. The salinity limits (‰0 and ‰17 ±1) used in the study was selected according to aquaculture ambient in the Eastern Black Sea. Trout production at sea cages is more preferred in Black Sea Coast; therefore both production amount and the number of farms are rising fast at sea.

The desired (ideal) length/diameter (l/d) ratio must be 0.90-1.20 in extruded pellets. The l/d ratio affects the sinking velocity of pellets significantly. Except for BioAqua 3mm extruded pellets, this ratio was measured in normal limits for all pellets. Different disc holes are used according to desired pellet sizes in feed production. But, the pellet sizes produced can change depending on processing conditions used in the feed production process. Because of heat operation and steam addition, swelling or constriction may occur in some processes upon pellets outputting from disc holes. Consequently, pellet sizes may demonstrate differences. The pellets expressing homogeneity in size may have advantage on producer preference.

Friability is a physical process where microparticules separate from pellets, which causes loss in weight and nutrients, especially in pellets having lower lipid content and in relatively soft pellets. During packaging and transporting of feeds, friction among and between pellets and the packet membrane cause friability and friction is a major factor of friability. The common practice to decrease friability is the addition of oil to the pellet surface via spraying or immersion during cooling. Friability rates of pellets were measured 0.018-0.199% for BioAqua, 0.042-0.384% for Blueaq. There is no difference in friability rates between Turkish companies and International companies like Trouw and Ewos. Scientific publications on friability of trout pellets are quite limited, Chen et al. (1999) studied salmon extruded feeds of Ewos and Trouw and they measured friability rates of 0.58-5.69% on standard pellets, 0.20-1.67% on high energy pellets. These researchers did not find significant differences for friability between Ewos and Trouw.

Hardness of pellets is an important factor for protection of their integrity during storage and in the water environment. The hard pellets have relatively less loss and longer resistance. On the other hand, it is more difficult for fish to digest the hard pellets. Processing conditions, feedstuffs and storage conditions affect the hardness and resistance of feeds notably. As pellet size became smaller (BioAqua 3mm and 9mm 2.21-1.32 kg/cm^2 respectively, Blueaq 3mm and 8mm 1.55-1.71 kg/cm^2 respectively), hardness increased relatively. Robohm and Apelt 1985, 1986 (in Chen et al. 1999) conducted a study on hardness of salmon feeds and there was a contradiction between their findings and those of Thomas and Van Der Poel (1996). Chen et al. (1999) measured the hardness of some pellets produced by two companies and they determined Trouw pellets were harder than Ewos pellets. They measured the hardness of Ewos standard 6-10 pellets as 2.4-4.7 kg/cm^2, Ewos high energy 6-10 pellets as 2.6-3.9 kg/cm^2, Trouw standard 6 pellet as 6 kg/cm^2, Trouw high energy pellets 6 and 11 as 4-6.3 kg/cm^2 respectively.

The hardness given for the feeds, with a diameter of 12 mm by Aas et al. (2011a) is too much higher than our results because of feed size tested. According to the findings of Robohm and Apelt 1985, 1986 (in Chen et al., 1999), small pellets are more resistant and have a lower friability rate than big pellets. According to the findings of Chen et al. (1999), small pellets (2-3mm) tend to become broken compared to larger pellets (6mm). It appears that there is no relationship between hardness of pellets and the size of pellets linearly but it may relate to feedstuff and feed technology. Also, Chen et al. (1999) attributed the differences among studies to the differences of feed formulation and feed technology. Thomas and Van Der Poel (1996) stated the relationship between pellet hardness and friability are generally only found where the feed ingredients and pellet manufacturing processes are the same. In an experimental study on rainbow trout, harder pellets with high water stability were resulted in 23% lower feed intake comparing to the pellets with low water stability (Aas et al., 2011b).

According to Stokes' Law, settling velocity of a particle depends on its dimensions, shape, density and the viscosity of the medium. Viscosity, in turn, is dependent upon temperature, solute concentration and pressure. However, the pellet sizes are much larger than the limits of Stokes' Law. In order for Stokes' Law to apply, the Reynolds Number (Re) should be less than 0.5 and hence the maximum settling velocity should be <1 cm/sec (Smith, 1975). However pellet sizes are much larger than the particle sizes in Stokes' Law. Pellets' sinking very fast or very slowly is not desirable. Particularly in cage culture, pellets sinking slowly escape from the cage because of wind current. This situation in turn causes both feed loss and undesired environmental effects. As it is known, extruded pellets sink slower than normal pellets. There was no abnormal situation contradiction of this phenomenon in this study. Extruded pellets' sinking velocity was slower than normal pellets, BioAqua extruded pellets' sinking velocity was slower than those of Blueaq, the difference between two manufacturers was found statistically important ($P< 0.05$). This situation is closely related to feed density, production conditions (mostly pressure), feed technology and the particle size of feed ingredients.

The mean sinking velocity of small extruded pellets (3mm) was 5.96cm/sec in BioAqua, 7.42cm/sec in Blueaq. For bigger extruded pellets, BioAqua 9mm was 8.27 cm/sec, Blueaq 8mm pellets was 14.21 cm/sec. Although it was not showed in this paper, steam pellets of these companies were tested at the same time. In these steam pellets, BioAqua 3-9mm were 12.52-20.54cm/sec, Blueaq 3-6mm were 11.74-17.69cm/sec. Chen et al. (1999) stated that as pellet size increases sinking velocity will increase. There is an apparent exception in BioAqua 6mm pellets.

While settling velocity was 10.66cm/sec in BioAqua 6mm pellets, it was 8.27cm/sec in BioAqua 9mm pellets. Sinking velocities were measured 5.96 and 8.27cm/sec in BioAqua 3-9mm pellets, respectively. The density of sea water decreases by approximately 0.2% between 10 and 20°C (Kalle, 1971). So, it was expected that food pellets would sink more rapidly at 20°C than at 10°C. But according to the findings of Chen et al. (1999), feed pellets sank faster at 10°C than at 20°C for some pellet types and they attributed that to the influence of temperature on pellet density. In the current study, it was determined that majority of the pellets sink faster at 10°C than at 20°C as quoted by Chen et al. (1999).

It was determined that there was no statistical difference between sinking velocity and temperature differences (10°C and 20°C) and results were similar to those of Chen et al. (1999). But salinity differences (0ppt and 17ppt) changed the sinking velocity to a small degree. A few studies were conducted on the sinking velocity of feeds. But it has not been met any certain sinking velocity value in literature. Chen et al. (1999) reported that Gowen and Bradbury (1987) stated results from unpublished studies of 9 to 15cm/sec (no pellet sizes given). Findlay and Watling (1997) provide data on seven North American pellet types or sizes and recorded settling rates of 5.5 to 15.5cm/sec for 3mm and 10mm dry pellets. Elberizon and Kelly (1998) showed settling velocities of freshwater salmonid pellet diets ranged 5-12cm/sec for 2mm and 8mm pellet sizes, respectively. These results are similar to settling rates found here under marine conditions. According to the results of Chen et al. (1999), settling velocities were mean 5.6cm/sec for small extruded pellets (Ewos 2mm), 13.9cm/sec for Ewos standard 10mm extruded pellets and settling velocity increased as pellet size increased and the sinking velocity ranged 5.86-14.91cm/sec (Ewos 2, 6, 8, 10mm; Trouw 4mm high energy pellet and 6mm standard pellet). But they reported that there was no tendency in big size pellets (Trouw 14mm 10.9cm/sec) because of rising friction power in the water medium or differences of pellet density. Additionally, they determined there were no significant differences in settling velocity between dry pellets and immersed pellets.

Water absorption capacity of pellets is closely related to their sinking velocity, dispersing in water and in turn nutrient losses. In the present study the water absorption increased with an increase of temperature and immersion time and decreased with the increase of salinity. Regarding water absorption of feeds there were two studies made by Chen et al. (1999) on salmon pellets and Leonard et al. (2002) on shrimp feeds. These studies showed that the increase of temperature and immersion time increased the water absorption of feeds. On the contrary, the increase of salinity decreased the water absorption.

In the present study, the water absorption rates in fresh water at 10˚C and 5' immersion time were 8.39-23.74% for BioAqua pellets, 8.44-18.46% for Blueaq pellets. Chen et al. (1999) measured the water absorption rates 1.4-30% (10-20˚C, ‰33 salinity, immersion times 0.5-15 min.) on Salmon pellets (Ewos 2, 6, 8, 10 standard, Trouw 6 standard, 4 high energy). Leonard et al. (2002) measured the highest absorption rates in fresh water medium for shrimp feeds.

Proximate biochemical contents of the pellets used in the present study didn't illustrate extensive differences to the declared values of the manufacturers. It was determined BioAqua and Blueaq manufacturers produced the pellets on the standard values which they declared. It was comparable to the measured proximate biochemical values and the declared values by the manufacturers in Table 7. The lipid contents of Blueaq feeds were found higher than declared values.

There was no discrepancy found in the pellets studied; BioAqua and Blueaq pellets are very close to the international fish feed manufacturers such as Trouw and Ewos. Measured pellet sizes are different from values declared by the manufacturers. This situation may result from equipment used in production (disc holes etc.) and processing conditions

Table 7. Proximate biochemical values (%) measured and the declared by the companies

Comp.	Pellet type				Crude Protein (%)			Crude Lipid (%)		
		*DM	Ash	*OM	Measured	Declared	Difference	Measured	Declared	Difference
BioAqua	E9	90.82	10.05	80.77	40.45	43.00	-2.55	18.32	20.00	-1.68
	E6	90.90	10.27	80.63	42.87	43.00	-0.13	23.35	20.00	+3.35
	E5	90.86	10.59	80.27	43.05	43.00	+0.05	22.80	20.00	+2.80
	E4	90.56	11.09	79.47	43.48	43.00	+0.05	22.50	20.00	+2.50
	E3	90.65	10.95	79.70	45.32	45.00	+0.03	19.68	20.00	-0.32
	E2	90.60	10.34	80.26	46.50	47.00	+0.50	21.08	20.00	+1.08
Blueaq	E8	92.30	9.62	81.68	41.25	44.00	-2.75	18.90	20.00	-1.10
	E5	91.21	10.28	80.93	44.23	44.00	+0.23	18.00	20.00	-2.00
	E4	92.00	9.55	82.45	43.22	44.00	-0.78	20.40	20.00	+0.40
	E3	92.49	9.91	81.58	44.36	44.00	+0.36	19.52	20.00	-0.48
	E2	93.47	9.31	82.16	43.00	46.00	-3.00	23.90	20.00	+3.90

*DM, Dry matter; OM, Organic matter

(temperature, steam addition, pressure etc.). To prevent these types of problems, standardization of equipment used and the processes of production need to occur. Friability causes the loss of nutrient and matter. Oiling and the addition of pelleting via different methods (immersion and spray) in feed production decrease the friability rate of pellets. To ensure this attention should be paid to the selection of feedstuffs and the appropriate oiling and processing conditions need to be applied. Pellets which are too hard or too soft may cause some undesired situations. Particularly, with regard to the softer pellets which may cause too much dispersion and friability. On the other hand, pellets which are too hard negatively affect the digestion of the pellet by fish. It is possible to prevent these situations by standardizing the physical conditions applied in production. It is possible the produce pellets having ideal hardness. Therefore an effort should be made to control the physical conditions of production. Retention too many pellets on the water surface and pellets sinking too fast may cause some problems in fish farming. In floating cage systems, the retention of pellets on water surface may cause the pellets to be dragged out of the cage medium by water currents. Pellets sinking too fast may cause them to settle uneaten by fish, and in turn cause environmental problems. The water absorption capacity of pellets effects their sinking velocity and dispersing and it is in turn closely related to nutrient losses.

When extruded pellets are gently left on the water surface, a majority of them didn't sink for a while, but any physical action on water surface such as waves and handling forced the pellets sink. Twenty percent of BioAqua pellets didn't sink, although they were left below 10cm of the water surface, even after applied some actions were applied to the surface.

The apparent reason for this is that these particular pellets contain air bubbles because of production technology (extrusion). Therefore these particular pellets could sink when the air bubbles inside the pellets replaced by water diffusion.

Some extruded pellets have densities lower than the density of water. Consequently, physically these pellets should not sink. This may mean that pellet density measured with compass (diameter, length) may not be accurate approach. For this reason, a more accurate ways to measure pellet density must be used, because density measure via compass does not take into account air bubbles inside the pellet (Karabulut and Yandi 2011).

The physical conditions applied in feed production are the most important factors which affect the water absorption capacity of the pellets, therefore are a critical condition to which attention must be paid.

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