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EFFECTS OF STORAGE CONDITIONS ON QUALITY CHARACTERISTICS OF COMMERCIAL AQUAFEEDS AND GROWTH OF AFRICAN CATFISH *Clarias gariepinus*

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ABSTRACT

This study was conducted to determine the effect of storage conditions on the quality of feed and the aftermath effect of feeding fish with such feeds. Three commercial diets used for this study included Coppens®, Multifeed® and Vital feed®. Feed was stored either by opening the bag to the atmosphere (WO), the bag opened with neck tied using a rubber ring to prevent exposure to the atmosphere (OT) or sealed (SC) until the start of the feeding trials. The feed was stored under these conditions for six months. Nutrient analyses revealed significant changes in feeds held under the WO condition when compared with other storage conditions. Nutritive changes also varied with commercial feed type. Mould infestation of the feed was noticeable more in the WO condition of storage compared to the SC condition. After feeding *C. gariepinus* for fifty-six days, lesions were observed on fish fed mouldy feed held under the WO condition, which led to mass mortalities. Growth performance was higher in all fish fed SC stored feed, and for those fed Coppens® and Multifeed® under OT storage conditions. It is advised that storage of fish feeds up to six months should be undertaken with considerable care and attention.

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INTRODUCTION

To sustain fish under culture, supplementation diet must be provided to complement natural feeds supply (Karapan, 2002). Generally, nutrition of fish is an important aspect of any viable aquaculture enterprise accounting for at least 60% of the total cost of fish production (Jamu and Ayinla, 2003; Madu *et al.,* 2003). The nutrient composition of feed influences feed utilization and ultimately the growth of fish (Adaga, 2014).

The prevailing climatic conditions in the tropics experience an increase in temperature and relative humidity of over 25^{0}C and 70%, respectively (Adaga, 2014). Such conditions accelerate mould growth and lipid oxidation (Berger, 1989; Coppen, 1989; Van den Bergh, 1990). According to Bautista *et al.* (1992) and Ramezandeh *et al.* (1999), feed storage at high temperature results in an increase in both oxidative and hydrolytic rancidity with loss in feed quality. Studies by Van den Bergh *et al.* (1990) and Ruiz *et al.* (2000) indicate that fats are intrinsically unstable when subjected to high temperature above 30^{0}C. Under such conditions, fats are hydrolysed to release ketonic acids, which further undergo auto-oxidation with degeneration of free radical products (Hamilton, 1989). According to FAO (2001), these environmental factors also predispose fish feeds to microbial spoilage, hence causing feeds to decompose and fed fish to become diseased. Toxin producing fungi are dangerous,

most of them producing *aflatoxins, patulins* and *trichotecens* which are strongly carcinogenic and mutagenic (Ciceron *et al.,* 2008; Brown, 2001). Aflatoxins are chemicals produced by fungi such as *Aspergilus flavus* and *A. parasiticus* (mould) (Russo and Yanong, 2006). Mould infested fish feeds have been reported to impact negatively the growth of vundu *Heterobranchus bidorsalis* (Effiong and Alatise, 2009).

Manufactured feeds are stored under different storage conditions by commercial fish feed sellers and farmers without respect to the effect of these conditions on the nutrient profiles of the feeds (Adaga, 2014). Since the nutrient profile of a feed determines the growth performance of fish, this study was designed to investigate effect of storage conditions on feed nutrient quality and performance of African catfish *Clarias gariepinus*. African catfish was chosen for this study because of its availability, economic importance, fast growth rates, tolerance to crowded conditions, high feed conversion, high consumer acceptability, high quality of its flesh and high adaptation to poor environmental conditions (Olufeagaba, 1999; Ataguba *et al.*, 2010; Solomon *et al.,* 2013).

MATERIALS AND METHODS

The experiment was carried out in the postgraduate laboratory of the Department of Fisheries and Aquaculture, University of Agriculture, Makurdi. Twelve kilograms of each of Coppens®, Multifeed® and Vital feed® was purchased from a reputable feed store along a modern market road, Makurdi, Nigeria. For the purpose of this study, various experimental feeds were divided into three halves (4 kg) and stored under different storage conditions for a period of six months. The first set of feeds was widely open to the atmosphere (WO), the second set had the bag opened and the open edge tied using a rubber ring to prevent exposure to the atmosphere (OT), while the last set which served as the control remained sealed until the start of the feeding trials (SC). Samples were collected at the end of six months for different nutrient analyses. Proximate analysis of feeds and fish carcass was determined using the methods of AOAC (2002). Parameters measured included moisture, ash, crude fibre, ether extract and crude protein, while nitrogen-free extract (NFE) was determined by difference.

Peroxide value (POV) and free fatty acid (FFA) analysis was also done according to AOAC (2002). Oils with POV well below 10 mg/kg were considered fresh, while oils with POV between 20-40 mg/kg were termed rancid. Mould growth was identified according to the method described by APHA (1998). Seven hundred and twenty fingerlings were obtained from the University research farm and acclimatized under laboratory conditions for two weeks prior to the start of the feeding trial (with 10% mortality recorded during acclimation). Twenty fingerlings were randomly selected and stocked in triplicate plastic basins (50 L) and assigned to the different treatment according to the different commercial diet and the system of storage. The fingerlings were starved for a day (24 hrs) before commencement of feeding trials to allow the emptying of the gastro-intestinal tract in anticipation of the experimental diets. The fingerlings were hand-fed 5% of their body weight; this was divided and administered to the fish twice daily (8:00 am and 5:00 pm). Bulk weights of the fish were taken weekly and feeding rate was adjusted accordingly. The experimental tanks were aerated throughout the experimental period to ensure oxygen availability. Uneaten feed and faecal droppings were removed by siphoning using capillary tubes of 0.8 mm lateral diameter after three hours of administering food. Water quality parameters such as temperature, dissolve oxygen (DO), pH, conductivity and total dissolved solids were monitored to ensure that they were within recommended ranges throughout the experimental period (Temp, 32-35^{0}C; DO, 4-5 mgl^{-1}; pH, 6.5-7.0; Conductivity, 114-150 µmhos/cm; TDS, 50-95 mgl^{-1}). When water quality parameters were getting too critical, complete tank water exchange was undertaken. After feeding the fish for eight weeks, growth performance and nutrient utilization were assessed using the relations below:

(a) Mean Initial Weight (MIW) = $\frac{TotalInitialWeightofFingerlings}{TotalNumberofFingerlings}$

(b) Mean Weight Gain (MWG) = Mean final weight − Mean initial weight

(c) Growth Rate = $\frac{Meanfinalweight\text{-}MeanInitialWeightX\ 100}{DurationoftheExperiment}$

(d) Specific Growth Rate (%/day) = $\frac{log_e\,(wt_2)\text{-}log_e\,(wt_1)}{t_2\text{-}t_1}$

Where Wt_1= Initial weight gain

Wt_2= Final weight gain

T_2-T_1= Duration (in days) considered between Wt_2 and Wt_1

(e) Feed Fed (FF) = $\frac{SumofTotalfeedintakeperweek}{Numberoffish}$

(f) Feed conversion ratio (FCR) = $\frac{dryfeedintake}{wetweightgain}$

(g) Feed efficiency ratio (FER) = $\frac{wetweightgainx\ 100}{dryfeedintake}$

(h) Protein efficiency ratio = $\frac{wetweightgain}{proteinfed}$

Where Protein fed = $\frac{\%proteinindiet\times totaldietconsumed}{100}$

(i) % survival rate = $\frac{totalnumberoffish\text{-}mortality}{totalnumberoffish}$ x100

Summary statistics of different variables measured across the treatment were obtained using Minitab 14 for Windows. Results were then subjected to Analysis of variance, where significant differences occurred; means were separated using Fisher's least significant difference.

RESULTS AND DISCUSSION

The aim of feed storage is to reduce the rapidity at which feed deteriorates. Hence storage never enhances feed

quality but proper storage maintains the shelf life of feed. The different commercial fish feed stored in open conditions for the period of six months was observed to have reduced nutritional content, insect population and unpleasant smell indicating the presence of rancidity (Tables 1, 2 and 3). De Silva *et al.* (1995) has opined that loss of flavour and appearance of feed clumping leads to reduced palatability of stored feed. Mould growth in stored feeds has been implicated to reduce nutritional value owing to the loss of dietary lipids, amino acids (especially lysine and arginine) and vitamins by enzymatic digestion (Jones, 1987). The study observed that feed stored in open conditions had higher mould infestation compared to other storage methods (Table 3). This observation is in accordance with reports of Cockrell (1971), NRC (1981), New (1987), Effiong and Eyo (1997), and Eyo (2001). The OT stored feed had no such problem except for Vital feed®. Vital feed® became damp and musty but with reduced mould growth compared to the WO feeds. This could be explained by the influence of factors such as combination of the feed ingredients, chemical composition and interaction of the feed. Furthermore, the high relative humidity created within the OT stored Vital feed® increased the dampness of the feed which in turn led to mould proliferation; the inside of other feeds held under OT conditions was noticed to be dry throughout the storage period unlike the Vital feed®, highlighting the role the nature of packaging material played in feed preservation. This is in line with the observations of NRC (1981).

The percentage of crude protein (CP) content of Coppens® OT condition remains fairly constant during a storage period of six months, while that of Multifeed® and Vital feed® reduced significantly (Table 1). This could be a result of protein ageing as postulated by Shyong (1998); however, deviation from the trend of decreased protein observed in Coppens® may have been due to differences in feed ingredients and their susceptibility to protein ageing. Hossain *et al.* (2011) reported that changes in the chemical composition and nutritive value of feed may occur during storage. The protein content of all commercial feeds stored in the WO conditions were reduced at the end of six-month storage; hence nutrient deterioration may be said to be reduced with proper storage practices as reduction in protein levels were marginal with OT and SC storage conditions. This observation agrees with Jones (1987) and Lim *et al.* (2008) who reported that infestation of feed by spoilage microorganisms results in loss of dietary nutritional value owning to the loss of amino acids (especially lysine and arginine), dietary lipids and vitamins.

Lipid content of Coppens® was higher compared to those observed in Multifeed®, however, Vital feed® had the lowest lipid content both in WO and OT conditions of storage (Table 1). Ayuba and Iorkohol (2013) also reported differences in lipid content of Coppens®, Dizengoff®, Durante® and Adolf calyx® fish feeds. The feed ingredients used in the formulations, as well as feed nutritional specification as determined by the manufacturer, may have led to this variation. The lipid content of Coppens® and Vital feed® was reduced at the end of storage, although Multifeed® expressed less pronounced variation (Table 1). These trends could be attributed to lipid oxidation which would be dependent on feed ingredients and their susceptibility to deterioration. According to NRC (1981), feed stored for longer than 90 days (three months) at ambient temperature is subjected to the breakdown of oil and vitamins along with peroxidation of the lipid component. Rancidity resulting from lipid oxidation is the most outstanding deteriorative change in feed during storage. Feed ingredients containing lipids which are highly polyunsaturated such as fish meals are susceptible to oxidations (Pezzuto and Park, 2002; Sidhuraju and Backer, 2003). Chan (1987) reported that polyunsaturated fats can quickly autoxidize at ambient or sub-ambient temperatures.

Table 1. Proximate composition of feeds stored under different conditions

	Ash	Lipid	Fibre	Protein	NFE	Moisture
Coppens®(OT)	7.15±0.01^{b}	13.23±0.01^{a}	2.75±0.02^{c}	43.72±0.02^{e}	33.14±0.04^{c}	9.65±0.04^{c}
Coppens® (WO)	7.17±0.01^{a}	12.73±0.11^{b}	2.70±0.02^{d}	41.60±0.49^{f}	35.80±0.61^{a}	9.64±0.07^{d}
Coppens® (SC)	3.70±0.01^{g}	13.29±0.11^{a}	2.50±0.02^{e}	43.79±0.49^{e}	33.00±0.61^{c}	9.50±0.07^{e}
Multifeed®(OT)	5.99±0.01^{e}	12.71±0.02^{c}	2.59±0.01^{f}	46.17±0.20^{b}	32.54±0.21^{e}	9.47±0.04^{f}
Multifeed®(WO)	6.17±0.04^{d}	12.26±0.03^{d}	2.62±0.02^{e}	46.01±0.21^{c}	32.94±0.20^{d}	9.56±0.07^{e}
Multifeed®(SC)	6.08±0.04^{d}	12.00±0.03^{f}	2.50±0.02^{e}	47.11±0.21^{a}	33.94±0.20^{b}	9.31±0.07^{g}
Vital feed® (OT)	5.84±0.01^{f}	11.90±0.02^{e}	3.59±0.02^{b}	46.87±0.40^{a}	31.79±0.44^{f}	11.16±0.04^{b}
Vital feed® (WO)	6.23±0.09^{c}	11.44±0.09^{f}	3.72±0.05^{a}	44.03±1.25^{d}	34.57±1.23^{b}	11.50±0.10^{a}
Vital feed®(SC)	5.86±0.09^{f}	12.02±0.01^{f}	3.67±0.05^{a}	48.13±0.15^{d}	34.57±1.23^{b}	11.04±0.10^{b}
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
S.E.M.	0.004	0.005	0.004	0.005	0.007	0.003

Means in the same column followed by different superscripts differ significantly ($p<0.05$)
Keys: Widely open (WO), Seal Opened but tired (OT), Sealed (SC)

The AIN (1980), however, reported that diets containing fish oil are more susceptible to autoxidation than diets containing other polyunsaturated fats. It is an established fact that different variables are involved in oil shelf-life; processing, storage conditions, light exposure, type of packing material, availability of oxygen and addition of antioxidants all affect the quality and characteristics of fats and lipids containing products (Lawson, 1995; Polvillo *et al.*, 2004).

The magnitude of oxidative changes was monitored by periodical measurement of peroxide value (POV) and free fatty acid (Table 2). The peroxide value levels increased in all feeds after a period of six months, being the highest in Multifeed® and the lowest in Coppen® for all storage conditions. Esterbauer *et al*. (1986) reported that POV of fish oil diets constantly increased with time of exposure to air and under normal feeding conditions. Peroxide formation is likely to occur as susceptible polyunsaturated fatty acids are available in the oil. Increases in POV are catalyzed by free radicals, and Fritche and Johnson (1988) reported an extremely rapid autoxidation of diets with added fish oil as measured by peroxide value rapid oxidation (POV).

Table 2. Free Fatty Acid and peroxide value of feeds stored under different conditions

	FFA	PV
Coppens® (OT)	6.93±0.17^{f}	16.09±3.48^{f}
Coppens® (WO)	7.72±0.35^{d}	20.63±1.13^{d}
Coppens® (SC)	4.30±0.35^{i}	12.11±1.13^{h}
Multifeed® (OT)	7.49±0.18^{e}	18.73±0.81^{e}
Multifeed® (WO)	8.06±0.37^{c}	27.07±2.64^{b}
Multifeed® (SC)	5.02±0.37^{g}	15.02±2.64^{g}
Vital feed® (OT)	8.69±0.44^{b}	20.88±2.76^{c}
Vital feed® (WO)	9.12±0.74^{a}	28.13±3.98^{a}
Vital feed® (SC)	4.91±0.74^{h}	18.90±3.98^{e}
p-value	<0.001	<0.001
S.E.M.	0.0090	0.0132

Means in the same column followed by different superscripts differ significantly (p<0.05)
Keys: Widely open (WO), Seal Opened but tired (OT), Sealed (SC)

Table 3. Total mould count and mould identified in feed stored under different conditions

Samples	Mould count (cfu/g)	Mould Identified
Coppens® (OT)	4.7×10^{3} ± 0.011^{c}	*Aspergillus flavus*
Coppens® (WO)	5.1×10^{3} ± 0.120^{c}	*Aspergillus flavus*
Coppens® (SC)	1.1×10^{1} ± 0.21^{c}	*Aspergillus flavus*
Multifeed® (OT)	7.3×10^{4} ± 0.047^{b}	*Aspergillus flavus*
Multifeed® (WO)	9.5×10^{4} ± 0.214^{b}	*Aspergillus flavus*
Multifeed® (SC)	3.5×10^{2} ± 0.108^{b}	*Aspergillus flavus*
Vital feed® (OT)	1.2×10^{5} ± 0.412^{a}	*Aspergillus flavus, Aspergillus niger*
Vital feed® (WO)	2.2×10^{5} ± 0.049^{a}	*Aspergillus flavus, Aspergillus niger*
Vital feed® (SC)	0.2×10^{2} ± 0.114^{a}	*Aspergillus flavus, Aspergillus niger*
P-Value	0.013	

Means in the same column followed by different superscript differ significantly (P<0.05)
Keys: Widely open (WO), Seal Opened but tired (OT), Sealed (SC)

Table 4. The rainfall, temperature and relative humidity during the storage period

	MONTHS					
Parameters	Nov	Dec	Jan	Feb	Mar	April
Max (°C)	34.0	34.5	35.9	38.2	35.2	31.9
Min (°C)	19.4	14.5	18.3	22.7	23.5	22.8
Ext Reme (°C)	36	37	37	38	40	39
RH (%)	40	44.21	47.26	66.38	58.28	71.53
Rainfall (mm)	0.0	0.6	0.	0.5	0.0	143.2

Source: NIMET: TAC, MKD, AIR PORT

Aside from the fish fed with feeds held under SC conditions which had exceptional growth performance, *C. gariepinus* fingerlings fed Coppens® and Multifeed® under OT conditions were found to have better growth and survival rate compared to other diets (Table 5). This could be a result of varying crude protein levels in various diets which likely affected growth. The growth rates observed in this study compare well with the results of Amin *et al.* (2010) who recorded the best growth in *Clarias spp* fed diet containing 40% and 58% of crude protein (CP). It was also observed that most of the fingerlings lost movement and appetite and this resulted in starvation. This could be attributed to off-flavour and decreased palatability of the feed.

The study revealed that all the fish fed feed WO and Vital feed® had higher rate of mortality. Many of the mortalities, especially of fish fed WO stored feed, had lesions on their body (Fig. 1), while others had swollen bellies (Fig. 2).

The increased mortality observed in Vital feed® for all storage conditions may be an indication of poor feed acceptability as a result of feed ingredient used to produce the feed locally (Vital feed® is an indigenous Nigerian locally produced fish feed). Mould infested fish feeds have been reported to negatively impact growth of vundu fish (Effiong and Alatise, 2009) and this is in line with the findings of this study. Deaths of fingerlings were likely due to feeding feeds containing toxin-producing fungi which are known to be strongly carcinogenic and mutagenic in nature (Ciceron *et al.,* 2008). Anomalies associated with feeding mouldy feed to fish, as reported by Jantrarotai and Lovell (1990), include pale gills, impaired blood clothing, anemia, poor growth rates and loss of weight. Sergent *et al*. (2002) also

Table 5. Nutrients utilization by *Clarias gariepinus* fingerlings fed commercial feed stored under different storage conditions

Parameter	MIW(g)	MFW(g)	MWG(g)*	MWG(g)**	SGR(%.day-1)	FCR	PER	ANPU	Survival (%)
Coppens® (OT)	5.63±0.18	21.38±1.60^{c}	28.06±1.91^{b}	15.75±1.22^{b}	0.024±0.011^{c}	1.36±0.07^{b}	1.82±0.09^{b}	0.11±0.00^{b}	91.25±1.25^{b}
Coppens® (WO)	6.38±0.32	7.39±0.28^{e}	14.11±1.55^{c}	1.01±0.10^{d}	0.003±0.001^{d}	2.10±0.09^{a}	1.24±0.05^{bc}	0.08±0.01^{c}	15.00±7.50^{h}
Coppens® (SC)	6.02±0.30	36.18±1.00^{a}	27.06±0.01^{b}	25.01±1.22^{a}	0.101±0.001^{a}	1.02±0.01^{b}	2.31±0.01^{a}	0.52±0.00^{a}	98.59±0.11^{a}
Multifeed® (OT)	5.75±0.10	29.12±0.97^{b}	37.95±0.65^{a}	13.37±0.97^{b}	0.029±0.000^{c}	1.29±0.10^{b}	1.82±0.14^{b}	0.07±0.01^{c}	61.25±6.25^{e}
Multifeed® (WO)	6.00±0.30	4.93±0.71^{f}	7.88±1.09^{d}	-1.08±0.71^{e}	-0.004±0.003^{e}	2.41±0.18^{a}	0.98±0.07^{cd}	0.05±0.00^{c}	31.21±3.75^{f}
Multifeed® (SC)	6.15±0.10	32.32±0.71^{ab}	37.95±0.60^{a}	23.37±0.01^{a}	0.091±0.000^{a}	1.12±0.11^{b}	2.02±0.11^{ab}	0.31±0.11^{a}	88.23±1.23^{c}
Vital feed® (OT)	6.50±0.15	7.03±0.17^{e}	13.92±0.52^{c}	0.53±0.42^{d}	0.001±0.001^{d}	2.09±0.01^{a}	1.11±0.00^{c}	0.06±0.00^{c}	15.00±2.50^{h}
Vital feed® (WO)	6.25±0.25	5.79±0.61^{ef}	8.79±0.08^{d}	-0.46±0.36^{e}	0.001±0.001^{d}	2.24±0.07^{a}	1.11±0.04^{c}	0.07±0.02^{c}	26.25±1.25^{g}
Vital feed® (SC)	6.00±0.60	17.03±0.17^{d}	23.92±0.92^{c}	10.03±0.12^{c}	0.051±0.011^{b}	1.50±0.02^{b}	0.69±0.10^{d}	0.16±0.01^{b}	60.00±0.19^{d}
p-value	0.2602	0.001	0.014	0.0001	0.0013	0.002	0.0004	0.0048	0.0008

Means in the same column followed by different superscripts differ significantly ($p<0.05$)
KEY: MIW=mean initial weight, MFW=mean final weight, MWG* = mean weight gain includes weight of dead fish in order to give a true FCR, MWG**= mean Weight gain excluding mortality, FCR= Feed conversion ratio, PER= Protein efficiency ratio, ANPU= Apparent net protein utilization, SGR= Specific growth rate. Keys: Widely open (WO), Seal Opened but tired (OT), Sealed (SC)

Fig 1. Observed lesions on *C. gariepinus* fingerlings fed mould infested feed

Fig 2. *C. gariepinus* fingerlings fed infested feed showing swollen and reddish belly

reported the pathological consequences of feeding with highly oxidized lipid include reduced growth, poor survival, liver degradation, anaemia and depletion of vitamins E and C. Also work done by Arjmandi *et al.* (2002) reported that oxidized lipids suppress osteoblastic differentiation and may cause an increase in osteoclastic differentiation ultimately resulting in net bone loss. The difference in storage and responses of different fish species may explain different observations of these studies.

The proximate composition of *C. gariepinus* fed different commercial feeds stored under different conditions revealed considerable variation in carcass crude protein (Table 6). The high protein content from fish fed Coppens® in SC condition could be an indication that there are variations in the nutritional value of feed under SC, OT and WO conditions.

This is in line with the observation of Adewale and Omotosho (1997). The moisture content of fish in all conditions was within the acceptable range of 30-90% which is common for most fish species (FAO, 2001; Eyo, 2001). The variations in the mean proximate composition among the fish fed variously stored feeds might be attributed to the effect of holding condition and environmental factors on the feed which is then translated into observed growth (Gupta *et al.,* 2007).

CONCLUSION

The storage of feed is crucial to ensure better keeping quality of food, the importance of packaging material for preventing or making vulnerable fish feed to deterioration was also emphasized. The study also revealed that *C. gariepinus* fingerlings are very sensitive to mouldy feed despite being considered a hardy species. More research needs to be done in this line to improve storage of feed and ensure better growth for fish.

Sažetak

UČINCI UVJETA SKLADIŠTENJA NA ODLIKE KVALITETE KOMERCIJALNE RIBLJE HRANE I RASTA AFRIČKOG SOMA *Clarius gariepinus*

Istraživanje je provedeno kako bi se utvrdio utjecaj uvjeta skladištenja na kakvoću hrane i posljedica učinka hranjenja

Table 6. Proximate composition of carcass of *Clarias gariepinus* fingerlings fed commercial feed stored under different storage conditions

	Ash	Lipid	Protein	NFE	Moisture
Initial	11.39±0.02^{a}	12.59±0.03^{b}	75.31±0.03^{g}	0.71±0.05^{e}	0.73±0.02
Coppens® (OT)	7.40±0.01^{g}	11.58±0.02^{e}	79.99±0.09^{a}	1.03±0.07^{cd}	0.64±0.02
Coppens® (WO)	9.78±0.02^{d}	11.19±0.02^{g}	77.09±0.11^{d}	1.95±0.09^{a}	0.67±0.01
Coppens® (SC)	8.38±0.12^{d}	11.11±0.02^{g}	80.11±0.21^{d}	1.05±0.09^{a}	0.64±0.01
Multifeed® (OT)	7.57±0.01^{f}	11.68±0.01^{d}	79.31±0.04^{b}	1.44±0.02^{b}	0.69±0.01
Multifeed® (WO)	11.12±0.00^{b}	12.15±0.01^{c}	75.58±0.02^{f}	1.15±0.00^{c}	0.67±0.01
Multifeed® (SC)	8.11±0.00^{b}	12.05±0.01^{c}	78.41±0.52^{f}	1.35±0.00^{c}	0.67±0.01
Vital feed® (OT)	9.57±0.01^{e}	11.42±0.03^{f}	78.03±0.03^{c}	0.98±0.01^{d}	0.70±0.01
Vital feed® (WO)	10.54±0.02^{c}	12.66±0.03^{a}	75.79±0.00^{e}	1.00±0.00^{cd}	0.65±0.00
Vital feed® (SC)	8.59±0.01^{c}	12.00±0.03^{a}	79.12±0.00^{e}	0.90±0.00^{cd}	0.62±0.00
P-value	0.001	0.001	0.001	0.001	0.123

Means in the same column followed by different superscripts differ significantly ($p<0.05$) Keys: Widely open (WO), Seal Opened but tired (OT), Sealed (SC)

ribe s takvom hranom. Tri komercijalna hranjiva su korištena u ovom istraživanju su: Coppens®**,** Multifeed® **i** Vital feed ®. Hrana je uskladištena: otvaranjem vreća u atmosferu (WO), otvaranjem vreća vezanih gumenim prstenom kako bi se spriječilo izlaganje atmosferi (OT) ili hermetički zatvorene vreće (SC) do početka hranjenja. Hrana je pohranjena u tim uvjetima tijekom šest mjeseci. Analiza hranjiva pokazala je značajne promjene u hrani koja se održava u WO stanju u usporedbi s drugim uvjetima skladištenja. Nutritivne promjene također su varirale s vrstom komercijalne hrane. Pojava plijesni na hrani je bila primjetno viša u WO uvjetima čuvanja u odnosu na SC uvijete. Nakon hranjenja *C. gariepinus* tijekom pedeset i šest dana, uočene su lezije na ribi koja je hranjena pljesnivom hranom, koja se skladištila pod WO uvjetima, što je dovelo do masovnih uginuća. Karakteristike rasta su bile veće kod svih riba hranjenih u SC uvjetima pohranjene hrane, kao i za one hranjene Coppens® **i** Multifeed® **pod uvjetima COT skladištenja. Preporučljivo je da se skladištenju riblje hrane do šest mjeseci treba posvetiti znatnu brigu i pažnju.**

Ključne riječi: ozljede, neposredan sastav, FFA, POV

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