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Research Application Summary

# Lipid oxidation of dried silver cyprinid fishmeal as an impediment in the manufacture of aquafeeds

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## Abstract

Dietary lipid oxidation is a salient quality issue in aquafeeds that has been neglected. Oxidized lipids get into aquafeeds mainly through poorly processed fishmeal and oils and tend to build up during feed processing and storage. In this study, lipid oxidation levels and proximate composition were investigated in *Rastrineobola argentea* fishmeal dried by artisanal methods and in a separate experiment where it was salted and indirectly dried on air-ventilated raised racks. Samples were drawn in the dry and wet seasons at 30 day interval for 90 days. Free fatty acids (FFA), peroxide value (POV) and thiobarbituric acid-reactive substances (TBARS) were used to monitor lipid oxidation stability, while proximate composition was based on moisture, ash, crude protein (CP), crude fat (EE) and gross energy (GE). Lipid spoilage was higher in fishmeal dried directly on bare ground and in that on mesh laid on ground compared to the one dried on air ventilated raised racks. There was higher lipid hydrolysis in the wet season than in the dry season. Salting and indirect drying were associated with elevated lipid hydrolysis and oxidation. Crude lipid decreased as moisture increased with storage time, while crude protein and GE were not significantly affected by season, processing methods or storage time. Ash was highest in salted *R. argentea* and that dried on bare ground. Both lipid degradation and crude protein loss were minimal in *R. argentea* dried on air-ventilated raised racks. Accordingly, drying *R. argentea* on raised racks without salting is adequate. Further considerations should be made to treatment of *R. argentea* with antioxidants to combat lipid oxidation spoilage as soon it is harvested and during processing and storage.

Key words: Fishmeal, lipid oxidation, processing methods, proximate composition, *Rastreneobola argentea,* storage time

**Résumé**

L'oxydation des lipides alimentaires est un problème de qualité saillant dans les aliments aquacoles qui a été négligée. Les lipides oxydés entrent dans les aliments aquacoles principalement par le biais de la farine de poisson et les huiles mal traitées et ont une tendance à s'accumuler au cours du traitement et du stockage des aliments. Dans cette étude, les niveaux d'oxydation et la composition approximative des lipides ont été étudiés dans la farine de poisson séché du *Rastrineobola argentea* par des méthodes artisanales et dans une expérimentation séparée où il a été salé et séché indirectement à air ventilé sur des grilles soulevés. Les échantillons ont été collectés dans les saisons sèches et humides à 30 jours d'intervalle pendant 90 jours. Acides gras libres (FFA), la valeur de peroxyde (POV) et des substances réactives de l'acide thiobarbiturique (TBARS) ont été utilisés pour surveiller la stabilité de l'oxydation des lipides, alors que la composition approximative est basée sur l'humidité, les cendres, les protéines brutes (CP), les matières grasses brutes (EE) et l'énergie brute (GE). La détérioration des Lipides était plus élevée dans la farine de poisson séché directement sur sol nu que celle exposée sur des grillages à même le sol et par rapport à celui séché à l'air ventilé sur des grillages soulevés. L'hydrolyse des lipides a été plus observée dans la saison pluvieuse que pendant la saison sèche. Le salage et le séchage indirect donnaient lieu à des taux plus élevés d'hydrolyse et de l'oxydation des lipides. Les lipides bruts diminuaient à mesure que l'humidité augmente avec le temps de stockage, tandis que la protéine brute et l'énergie brute ne sont pas significativement affectées par la saison, les méthodes de traitement ou le temps de stockage. Le taux de cendre était le plus élevé pour le traitement de poison salé et séché sur sol nu. La dégradation des lipides et la perte en protéines brutes ont été minimes dans *R. argentea* séchés sur des grillages soulevés à air ventilé. Ainsi donc, le séchage de *R. argentea* sur des supports élevés sans salage est adéquat. D'autres considérations devraient être faites pour le traitement de *R. argentea* avec des antioxydants pour lutter contre la détérioration de l'oxydation des lipides qui survient aussitôt après récolte et pendant le traitement et le stockage.

Mots clés : Farine de poisson, oxydation lipidique, procédés de transformation, composition approximative, *Rastreneobola argentea*, temps de stockage

## Introduction

Access to high quality aquafeeds is among the key bottlenecks to sustainable aquaculture in Uganda (Isyagi *et al*., 2009; Nalwanga *et al*., 2009; Lee, 2014). The quality of commercial and on-farm aquafeeds formulated in Uganda is low which is partly due to the quality of ingredients. The quality concerns in *Rastrineobola argentea* dried for fishmeal and human food have mostly concentrated on contaminants associated with animal faecal matter, microbial and soil/sand and very limited (if at all) on lipid oxidation and/or nutrient degradation. While lipid oxidation (that gets into aquafeeds through fishmeal and oils) is a neglected quality aspect, it can affect the growth and survival of farmed fish. In Uganda, the poorly processed *R. argentea* fishmeal is used in livestock feeds while the better processed and of fairly good quality is sought for by humans (Masette, 2010). The practice is to dry *R. argentea* meant for fishmeal on dirty surfaces such as bare ground, mesh laid on ground, rock surfaces and

on pebbles, all of which affect the physical, microbial and nutrient quality (lipid spoilage) of the resultant fishmeal. Very recently, a few artisanal processors started drying *R. argentea* on air-ventilated raised racks (Masette, 2010). Moreover 53% of the free fatty acids in *R. argentea* are PUFAs (Mwanja *et al*., 2010) that are easily oxidized when exposed to high temperatures, UV light and/or heavy metals such as copper, iron and zinc (Frankel, 1984, 1998). In fact dried *R. argentea* exhibits off-flavours that are characteristic of secondary lipid oxidation (see Aidos *et al*., 2001; Antolovich *et al*., 2002) and their intensity tends to vary with drying surfaces. There is interest therefore to develop and put in use alternative methods of processing *R. argentea* fishmeal. Salting and indirect solar drying are particularly being sought to dry *R. argentea* in the wet season when spoilage mostly occurs. These methods are not necessarily new in fish processing, but they have not been extensively used when processing *R. argentea*. Accordingly, there is need to test the efficacy of these methods in controlling lipid oxidation of the fishmeal. Therefore, this study examined the effects of the rudimentary artisanal processing methods, salting and indirect drying, season (wet vs. dry), and storage time on lipid degradation and proximate composition of dried *R. argentea.* This study evaluated the available methods of processing *R. argentea* to identify the best that could be promoted among artisanal processors to ensure minimal lipid oxidation in fishmeal and human food made from *R. argentea*.

## Materials and methods

Lipid oxidation changes were monitored by assaying free fatty acids (FFA), peroxide value (POV) and thiobarbituric acid-reactive substances (TBARs). Proximate composition of dried *R. argentea* was determined by estimating the moisture, ash, crude protein (CP), crude fat (EE) and gross energy (GE) using standard procedures outlined by AOAC (1995). Samples were drawn based on processing method, season (wet vs. dry) and 30 days sampling interval for a total of 90 days in storage.

## Results

Lipid degradation was higher in *R. argentea* directly dried on bare ground and in the one on rock surfaces compared to that on mesh laid on ground and air ventilated raised racks (Fig. 1a). Lipid hydrolysis was significantly higher in the wet season ($P < 0.05$) than in the dry season. By day 60 in storage, the peroxide value (the measure of primary oxidation) of samples dried in the wet season was about 20 meq/kg of oil in *R. argentea* processed by artisan (Fig. 1a) and experimental (Fig. 1c) methods; and peaked by day 90 (Fig. 1a, c,d); except in sample processed in dry season by artisanal processors (Fig. 1b).

In the dry season, POV was neither affected by artisanal drying methods nor by storage time (Fig. 1b). For the experimental samples (salted vs direct drying or salted vs. indirect drying), POV was highest in salted and indirectly dried samples compared to the unsalted and directly dried ones (Fig. 1d). Moreover POV significantly increased with time in salted samples ($P<0.0001$), but remained fairly constant in the unsalted ones (Fig. 1d). Similarly, in the wet season, POV was significantly lower in the unsalted and directly dried samples ($P<0.05$) than in the salted and unsalted samples that were indirectly dried (Fig. 1c).

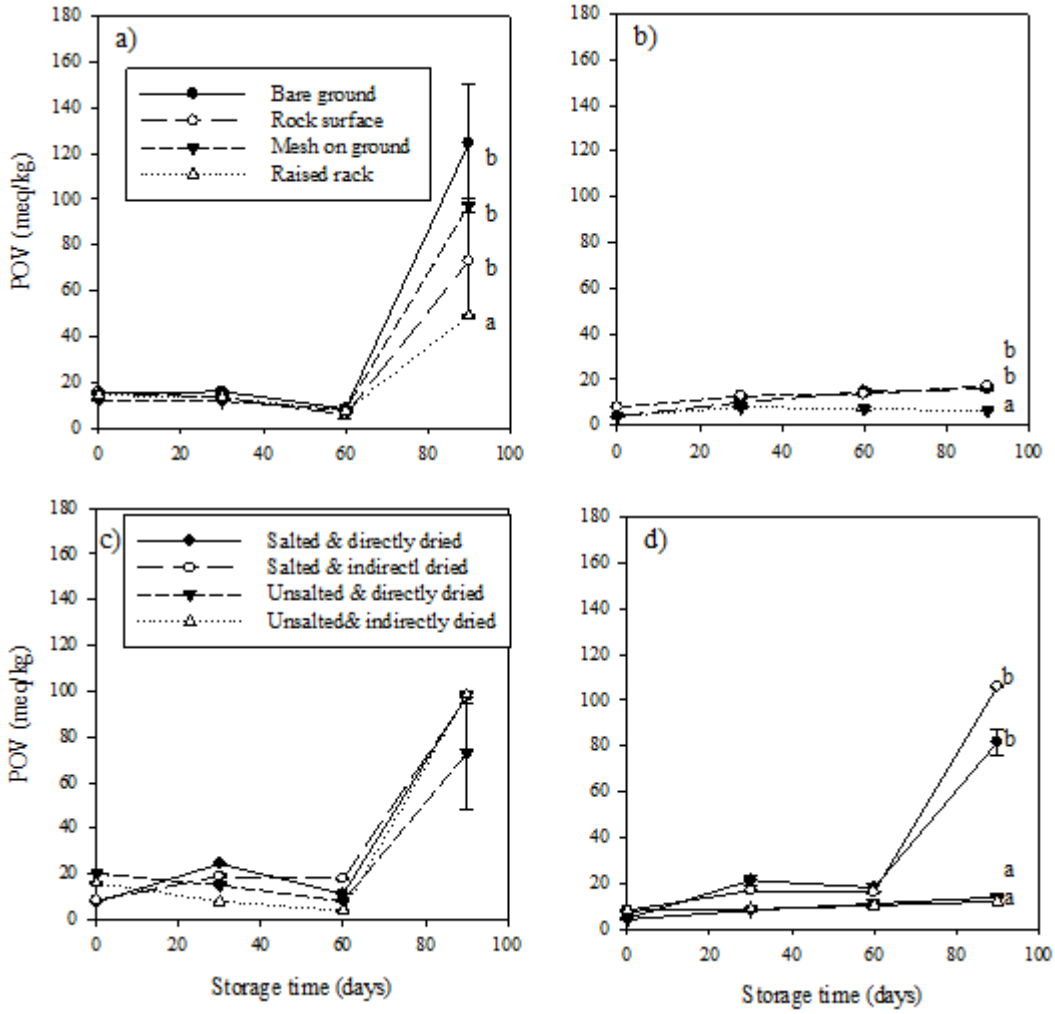


**Figure 1. Effect of processing methods and storage duration on the POV of dried *R. argentea* (Artisan: (a) wet and (b) dry season: experimental: (c) wet and (d) dry season)**

Crude lipid decreased with storage time as moisture increased (Figs. 2 and 3). However, crude protein and GE (data not shown) were not significantly affected by season, processing methods or storage time, but ash was highest in salted and fish dried on bare ground.

There was a strong positive correlation between fishmeal moisture content and FFA, POV and TBARS regardless of the season (Figs. 2 and 3). The FFA were also positively correlated with the observed POV and TBARS (Figs. 2 and 3).

## Discussion

The present results have demonstrated that lipid oxidation occurs in dried *R. argentea* regardless of the processing method, and that the intensity is high in samples dried on bare ground and rock surfaces. Drying *R. argentea* on air-ventilated raised racks was found to

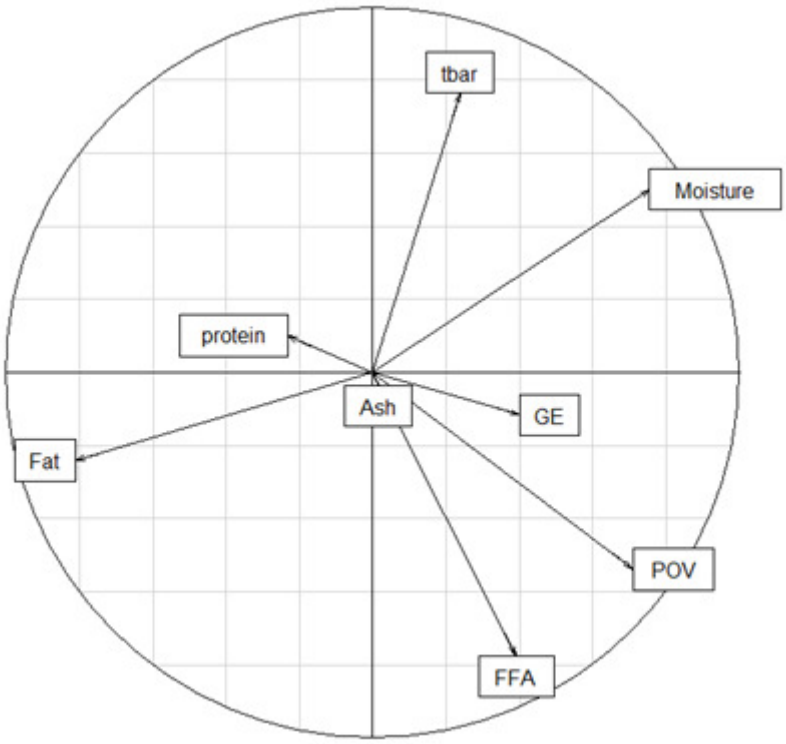


**Figure 2. Overall principle component analysis (PCA) bi-plot of scores and loadings for different parameters measured in the wet season in the artisan and experimental method dried *R. argentea***

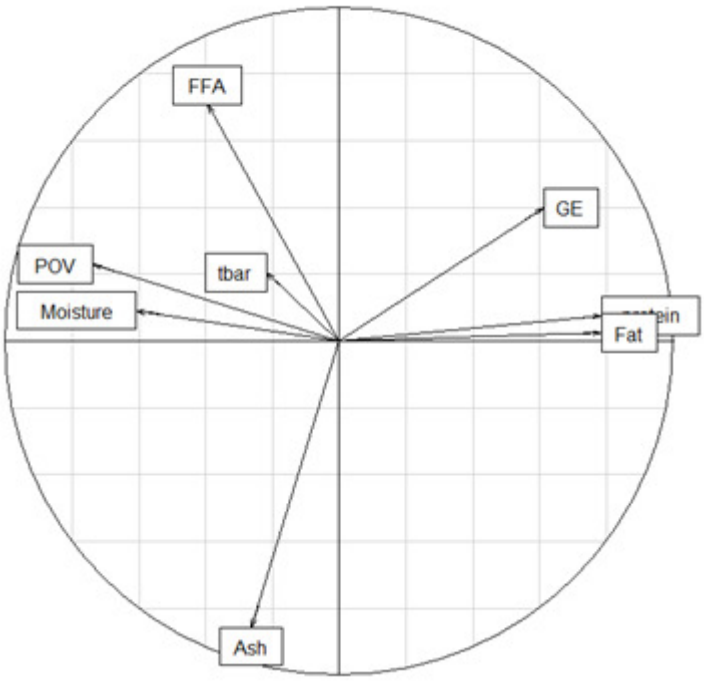


**Figure 3. Overall principle component analysis (PCA) bi-plot of scores and loadings for different parameters measured in the dry season in the artisan and experimental method dried *R. argentea***

reduce lipid spoilage and associated crude protein loss to an extent. Much as salting and indirect solar drying of *R. argentea* were thought to reduce lipid oxidation of dried *R. argentea*, they instead increased it. Therefore, the present results suggest that drying *R. argentea* on open raised racks only without salting is adequate at minimizing lipid oxidation and associated nutrient loss. Nutrient loss (i.e., crude lipid and protein content) tended to increase with storage time mostly in the wet season, indicating that *R. argentea* processed in wet seasons need not to be stored for long before use.

The general increase in lipid hydrolysis of *R. argentea* dried in the wet season reflects season-related quality detorioration attributed to both weather and fatty acid composition of the processed fish. It has been reported that phytoplankton are readily available to *R. argentea* in Lake Victoria during the wet/rainy season than in the dry season (Mwebaza-Ndawula, 1998). Moreover fish derive much of their polyunsaturated fatty acids (PUFAs), particularly the eicosapentaenoic acids (EPA) and decosahexaenoic acid (DHA) from unicellular phytoplankton (Chitra Som and Radhakrishnan, 2013). In the present study, lipid hydrolysis (FFA) and oxidation (POV and TBARs) were positively correlated with fishmeal moisture content (Figs. 2 and 3) suggeting that much lipid spoilage occurs in the wet season. These findings are in line with (Nguyen *et al*., 2012) who concluded that initiation and propagation of the reactive oxygen radicals that lead to oxidative spoilage is facilitated by substrate moisture content. Like in this study, Nguyen *et al*. (2012) found a positive correlation between lipid hydrolysis, moisture and salt content. The present results reflect an important interaction between drying methods and storage time in inducing lipid oxidation and subsequently affecting the extractable lipids from dried *R. argentea*. In agreement, Ladikos and Lougovois (1990) reported that lipid degradation is affected by processing methods and storage conditions. The decrease in crude protein (CP) with increasing lipid oxdiation (i.e., POV and TBARs) in dried *R. argentea* evaluated in this study (Figs. 2 and 3) could be a result of complex formation.

In conclusion, the current results have demonstrated that lipid oxidation occurs in dried *R. argentea* regardless of the processing methods; meaning that it is an outstanding impediment in the manufacture of quality aquafeeds in Uganda. To an extent however, these findings show that lipid oxidation in *R. argentea* can be mitigated through improved handling and processing methods, and more so by drying it on open air-ventilated raised racks. Importantly, in addition to being the main protein in livestock feeds, dried *R. argentea* is human food, hence the challenges of lipid oxidation are not limited to aquafeeds industry. Moreover consuming of oxidized lipids is associated with aging and in worst cases cancer in humans.Therefore, rigorous options like keeping the harvested *R. argentea* at low temperature, treating it with antioxidants, direct processing and use in animal feeds and/or human foods should be considered. Production of silage before the onset of lipid oxidation and using it in livestock feed production could be another feasible solution. Ultimately, while the present results reflect a strong association between the processing methods and lipid oxidation observed in *R. argentes*, there is need to validate these results by replicating this study in other areas of Lake Victoria and in other Lakes.

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