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INFLUENCE OF SELECTED WASHING TREATMENTS AND DRYING TEMPERATURES ON PROXIMATE COMPOSITION OF *DAGAA* (*Rastrineobola argentea*), A SMALL PELAGIC FISH SPECIE

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ABSTRACT

Proximate analysis for moisture, crude protein, crude fat and total ash was carried out on *dagaa* (*Rastrineobola argentea*), a small pelagic fish specie found in Lake Victoria. The first phase of the study involved sampling of fresh, sundried (for 1 day, 2 days, 3 days, 4 days) and retail market *dagaa*. The second phase of the study involved pre-washing of fresh *dagaa* with selected solutions namely, salted solution (3% NaCl), chlorinated solution (100 ppm) or potable tap water (control) and thereafter oven-drying the respective pre-washed samples at 30^{o}C (31hrs), 40^{o}C (23hrs) or 50^{o}C (15hrs). Results showed that the crude protein composition of fresh *dagaa* (74.4% dry weight basis, dwb) was significantly higher ($p<0.05$) than values in market samples (62.5% dwb). After oven-drying at 30^{o}C, the salted-wash treatments resulted to significantly lower ($p<0.05$) crude protein content of 60.4% (dwb) when compared with the chlorinated (64.6% dwb) and control-wash treatments (64.1% dwb).The crude fat content in fresh *dagaa* (14.8% dwb) was significantly higher ($p<0.05$) than levels in market samples (13.9% dwb).The salted-wash treatments showed significantly lower ($p<0.05$) crude fat content (15.9% dwb) than the chlorinated (17.0% dwb) and control (16.9% dwb) wash treatments after oven-drying at 30^{o}C.The total ash content in fresh *dagaa* (10.3% dwb) was significantly lower ($p<0.05$) than levels in market samples (13.5% dwb).The salted and chlorinated-wash treatments exhibited significantly higher ($p<0.05$) total ash content (19.9%, 16.7% dwb, respectively) than the control-wash treatment (15.9% dwb) after drying at 40^{o}C. In this study, oven-drying of *dagaa* at 40^{o}C after washing with chlorinated (100ppm) solution was suggested with regard to the optimal retention of the crude protein and fat levels of the dried *dagaa*.These conditions are achievable at the local community level through use of solar driers whereas sodium hypochlorite products are accessible to most of the households involved in dried fish processing.

Key words: fish, moisture, protein, fat, ash

INTRODUCTION

Food security is increasingly an issue of national concern in Kenya, and the fish industry has been identified as one of the sectors that if improved would effectively contribute towards alleviation of food insecurity. Commercially important fish species in the Kenyan markets include Nile perch (*Lates niloticus* L.), tilapia (*Oreochromis niloticus* L.) and *dagaa* (*Rastrineobola argentea*)[1]. However, a key feature of the Lake Victoria's fisheries ecosystem is the abundance of the small pelagic fish species, *dagaa*, which constitutes the second largest volume (62.9%) of the total fisheries resources landed from L. Victoria,Kenya [2].*Dagaa* plays a significant role in the livelihood of artisanal fisherfolk communities in terms of employment, income and nutrition. It is one of the most important fish food for the low-income households and is commonly referred to as 'poor man's food'. Fish is an important food of excellent nutritive value. It provides high quality protein, essential free fatty acids, vitamins A, B, D and a variety of minerals such as calcium, potassium, phosphorus, iron, copper and iodine [3,4].

Although *dagaa* landings are high, the value of the catch is very low. In Kenya, post harvest losses inthe *dagaa* sub-sector is estimated at between 20 - 30% and even up to 50% during the rainy season [5]. This is strongly attributed to physical losses, colour change, bacterial and mould spoilage, which lead to losses in nutritional quality and economic value [6]. Due to the rapid quality loss during the sun-drying process, *dagaa* is increasingly being used for production of fishmeal in the animal feed industry, rather than for human consumption[7].

The locals are increasingly loosing access to and control of these fisheries resources that are a vital component of the food supply. One of the indicators that could be considered is the high level of malnutrition among the infants living within the L.Victoria basin region. Accordingto GOK and UNICEF [8], about 30-50% of the children are moderately to severely malnourished. This is a pointer that the potential of *dagaa* as a source of the food nutrients such as proteins is vast, but has been largely unexploited. The improvement of the handling and processing conditions such as drying, therefore, becomes one of the most serious challenges for the artisanal fishery communities. However, as a prerequisite, it is important that there should be adequate information on the likely impact the various improved handling and processing techniques would have on the nutritional value of the fish products such as dried *dagaa*products.

This study was, therefore, undertaken to determine the proximate composition (moisture, crude protein, crude fat and total ash) of sun-dried market *dagaa* and to investigate the effect of selected pre-washing treatments and drying temperatures on the nutritional composition of oven-dried *dagaa*.

MATERIALS AND METHODS

The sampling for the study was conducted in two phases as described below:

Phase 1: Sampling of fresh, sundried (dried 1 day, 2 days, 3 days, 4 days) and market *dagaa*

One kg each of fresh, sun-dried (dried for 1 day, 2 days, 3 days, 4 days) *dagaa*were randomly sampled fromfishermen (3) and *dagaa* traders (12) who operate from the three fish landing sites namely Dunga, Tako and Block located on the shores of L. Victoria, Kisumu, Kenya, resulting to a total of 15 batches (15kgs) of samples. The fresh, sun-dried (dried 1 day, 2 days, 3 days, 4 days) from the three sites were then mixed separately to obtain representative samples of 9kgs for each sample category. All the above samples were transported on the same day in a cool box (4 - 9^{o}C), to the Department of Food Science and Technology at Jomo Kenyatta University of Agriculture and Technology (JKUAT). Sampling of the retail market *dagaa* was done at Kibuye municipal market by randomly collecting three batches (1kg each) of sun-dried *dagaa*from three traders to give a total of 3 batches. These samples had previously been stored under prevailing market conditions for 9 days. Kibuye is the largest retail market in Kisumu town. These market samples had previously been sun-dried for a period of four days by identified traders.

Phase 2: Preparation of oven-dried *dagaa* samples

Three batches (8kgs each) of fresh*dagaa*samples were collected from Dunga, Tako and Block fish landing sites, respectively. At each site, 2kgs of fresh *dagaa* were obtained randomly from 4 fishermen resulting to a total sample of 24kgs. The sampleswere transported on the same day in a cool box (4 - 6^{o}C) to Jomo Kenyatta University of Agriculture and Technology and stored frozen.

Washing and oven-drying of fresh *dagaa*

The fresh samples from respective sites were mixed to give a representative sample and then divided into 3 batches of 8kgs. Each batch was further divided into sub-units of 800g. Pre-wash solutions were then prepared namely salt solution (3% NaCl), chlorinated solution (100 ppm) or portable tap water (control).

The washing operation involved placing the fresh *dagaa*(800g) in a standard mesh stainless steel sieve no. 8, and separately passing respective chilled (4 – 6^{o}C) wash solutions (salt solution, chlorinated solution or potable tap water through the sieve. The washed *dagaa* was allowed to drain excess liquid and subsequently oven-dried separately at 30^{o}C (31hrs), 40^{o}C (23hrs) or 50^{o}C (15hrs) using the Eyela Windy oven

The ultimate drying duration for each of the selected temperatures was determined in the preliminary trials as the time it took to reduce the moisture content of the fish to below 10% in accordance withthe Kenyan standard requirement for dried *dagaa* products [9]. All the treatments were sampled after completion of the oven-drying operations and analysed for moisture, crude protein, and fat and total ash composition. The dried *dagaa* samples were then packaged in low-density polyethylene (LDPE) bags and stored in the laboratory at ambient temperature conditions, which ranged from 19 - 33°C, whereas the relative humidity varied between 69 - 84%. These were monitored daily using maximum/minimum mercury thermometer and dry/wet bulb hygrometer respectively. The stored oven-dried samples were sampled at 5 intervals (day 1,3,5,7 and 9) and analysed for moisture content.

Proximate analysis of moisture, crude protein, crude fat and total ash content in field sun-dried and oven-dried *dagaa*

Moisture content was determined using air oven method according to AOAC method 950.46 [10]. Crude protein was determined by the micro-Kjeldahl method according to AOAC method 928.08 [10]. A factor of 6.25 was used to convert percent nitrogen to percent protein.Crude fat was determined using the solvent extraction method using soxhlet extraction apparatus according to AOAC method 991.36 [10].Total ash was determined using muffle furnace method according to AOAC method 920.153 [10].

Statistical analysis

The proximate values of moisture, crude protein, crude fat and total ash are a mean of triplicate determinations. The means for the field sun-dried *dagaa* study were tested by comparing respective proximate valuesfor fresh, sun-dried (for 1 day, 2 days, 3 days, 4 days) and market samples.Oven drying experiments were conducted in a randomised complete design involving 3 wash treatments (control, salted, chlorinated) (WT), 3 drying temperatures (30°C, 40°C, 50°C) (DT) and 5 storage periods (day 1, 3, 5, 7, 9) (SP). Treatments of dried *dagaa* were prepared by a 3WT x 3DT x 5SP factorial arrangement. The differences among treatments were measured by use of ANOVA while Duncan's multiple range test was used to determine significant differences between means at 5% ($p<0.05$) level of significance. The statistical analysis was done by COSTAT statistical package [11].

RESULTS

Moisture content of field sun-dried and oven-dried *dagaa*

The moisture content of fresh *dagaa* (76.5%) was significantly higher ($p<0.05$) than levels in the market *dagaa* (9.8%) (Figure1). The moisture level of the fresh sample declined significantly ($p<0.05$) to 38.4% after first day of drying. Further reduction was observed to ultimate level of 9.8% after 4 days of sun-drying.

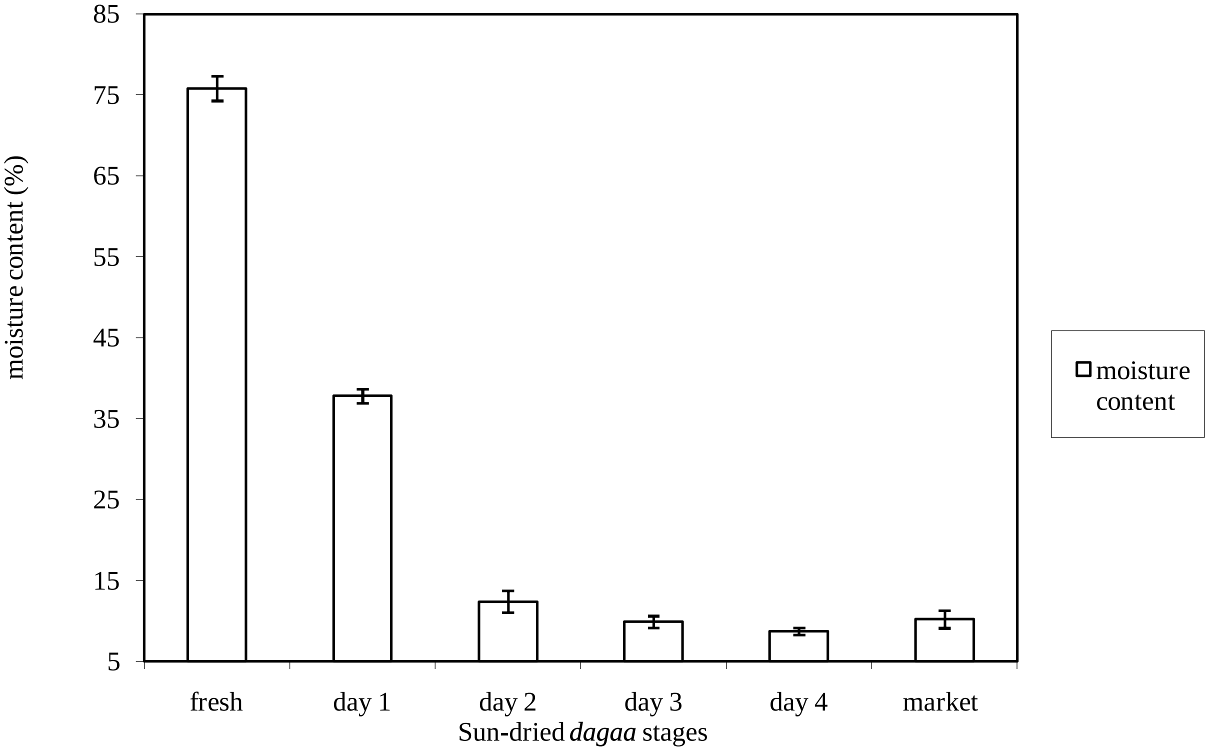

Figure 1: Moisture content of fresh, field sun-dried and sun-dried market *dagaa*

The *dagaa* that had been washed using chlorinated and salted-wash treatments showed significantly lower ($p<0.05$) moisture levels (6.6% and 7.7%, respectively) than the control wash treatment (8.2%) after oven-drying at temperatures of50°C (Figure 2). However, at 30°C the moisture levels in the chlorinated treatments (7.6%) were significantly ($p<0.05$) lower than in the salted (8.6%) and control-wash (8.5%) treatments. The resulting moisture contents of control-washed treatments of *dagaa* oven-dried at 40°C (8.6%) and 50°C (8.2%) were significantly ($p<0.05$) lower when compared with the moisture content of control-wash treatment (8.5%) after drying at 30°C. Moisture levels increased significantly ($p<0.05$) in all the oven-dried *dagaa* treatments after the 9 days storage period (Table 1). The highest and least moisture levels were observed in the 30°C control-wash treatment and the 40°C control treatments, which had 40% and 11.5% change in moisture content, respectively.

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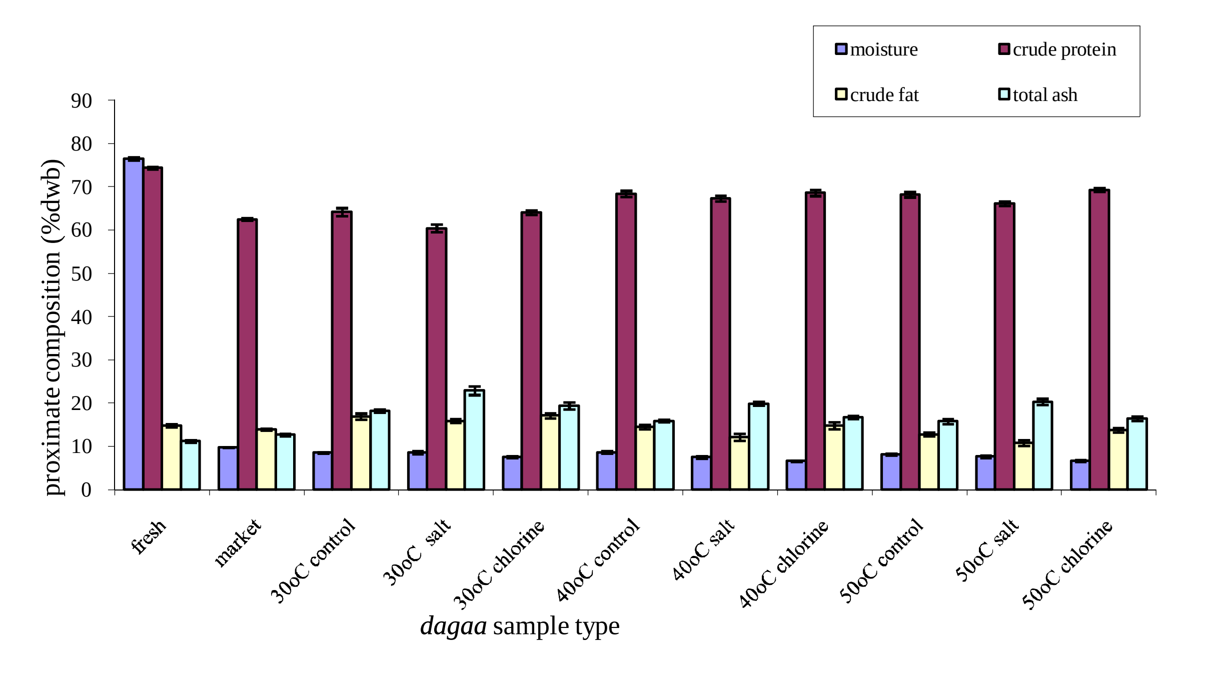

Figure 2: Proximate composition of fresh, sun-dried market and oven-dried *dagaa*

Crude protein content of field sun-dried and oven-dried *dagaa*

The crude protein content of 74.4% (dwb) in the fresh sample was significantly higher ($p<0.05$) than in the retail market *dagaa* (62.5% dwb) (Figure 2). After drying at 30°C, the crude protein content in the salted-wash treatments (60.4% dwb) was significantly lower ($p<0.05$) than the content in the chlorinated (64.6%dwb) and control (64.1%dwb) wash treatments. Similar trend was realized for equivalent wash treatments on drying at 40°C and 50°C. The protein levels of control, salted and chlorinated-wash treatments that were oven-dried at 30°C (64.1, 60.4, 64.1% dwb respectively) were significantly lower ($p<0.05$) than equivalent wash treatments dried at 50°C (68.2, 66.1, 69.3% dwb, respectively).

Crude fat content of field sun-dried field *dagaa*and oven- dried*dagaa*

The crude fat content in the market *dagaa* (13.9% dwb) were significantly ($p<0.05$) different from the levels in fresh *dagaa* (14.8% dwb) (Figure 2). The salted-wash treatments showed significantly lower ($p<0.05$) fat content (15.9% dwb) than the chlorinated (17.0% dwb) and control (16.9% dwb) wash treatments after oven-drying at 30°C. Similar trendwas realized after oven-drying equivalent wash treatments at 40°C and 50°C. The fat content of *dagaa* that had been subjected to the control (13.8% dwb, salted (11.8% dwb) and chlorinated (13.7% dwb) wash treatments were significantly lower ($p<0.05$) at elevated temperatures of 50°C, when compared to the fat composition at 30°C.

Total ash content of field sun-dried and oven-dried *dagaa*

The total ash content in the fresh *dagaa* (10.3% dwb) was significantly lower ($p<0.05$) than the values in the sun-dried market samples (13.5% dwb) (Figure 2). The salted and chlorinated-wash treatments showed significantly higher ($p<0.05$) total ash levels (22.9%dwb and 19.1% dwb, respectively) when comparedwith the control-wash treatments (18.2% dwb) after drying at 30°C. Similar trend was also noted after oven-drying *dagaa* at 40°C and 50°C. Though not significantly ($p<0.05$) different, the total ash content was generally higher at 30°C than at 40°C and 50°C after oven-drying.

DISCUSSION

Moisture content of field sun-dried and oven-dried *dagaa*

Studies have reported that the percentage of moisture of the raw flesh fish is inversely related to the lipid content [12]. Although the final moisture content of the day 4-dried *dagaa* was below the minimum level of 10%, above which moulds and bacteria can sufficiently grow on dried fish products [13], the rate of drying may not have decreased the water activity quickly enough in order to arrest the activity of spoilage microorganisms [14]. The drying regimes for the field sun-dried *dagaa* (4 days)were longer when compared with the *dagaa* oven-dried under controlled temperature conditions of 30°C (31 hrs), 40°C (23 hrs) and 50°C (15 hrs). This could be attributed to fluctuations in the prevailing temperatures and relative humidity of the environment during drying. In addition, since most *dagaa* are dried on ground, water accumulates around it instead of draining away during the drying process, therefore contributing to slow dry rate.

Given that chlorine is an oxidizing agent, it is possible that it may have influenced the water retention properties of proteins. This is because addition of NaCl leads to selective binding of chloride ions to the positively charged groups in the myofibrillar network, consequently affecting the capillary forces through increased electrostatic repulsion between the myofilaments [15]. The oven-drying process resulted to a substantial decline in the moisture to levels comparable to the standard limit (10%) for dried fish product [9]. The observed increase in moisture levels during the storage study reflected the tendency of the dried *dagaa* to equilibrate with the fluctuations in the prevailing temperatures (19 - 33°C) and relative humidity (69 – 84% RH) of the storage environment [16].

Crude protein content of field sun-dried and oven-dried *dagaa*

The crude protein values in the fresh and market *dagaa* were higher than the values that have been reported in other studies [7, 17]. The differences in the chemical composition of the various fresh fish have been largely attributed to the variations of the harvesting grounds [18].The low protein contents observed in the salted-wash treatments when compared with the chlorinated and control-wash treatments at temperatures of 30°C, 40°C and 50°C, could be attributed to the leaching effect of sodium chloride on the salt soluble proteins, particularly, myosin and actin proteins. The comparatively lower protein level observed in the 30°C treatments when compared to 40°C and 50°C conditions is attributed to the rapid degradation of proteins into amines and ammonia by the proteolytic microorganisms during the drying process, which ultimately reduce the recovery of protein. In a related study by Owaga *et al.* [19], it was established that total volatile bases-nitrogen, (an indicator of bacterial breakdown of protein in muscle tissues) were higher after oven-drying at 30°C than at 40°C and 50°C.

Crude fat content of field sun-dried and oven-dried *dagaa*

Based on the 5% fat composition criteria for discriminating lean from fatty fish species [3], it was apparent that the *dagaa* could be regarded as a fatty fish species. A fat content of 19.2% (dwb) [17] and 14.09% [7] has been reported in dried *dagaa.* The lipid composition of fish affects the post-mortem quality characteristics with respect to oxidative changes in the muscle tissues [20]. The substantial decline of the fat in the sun-dried market *dagaa*suggested the susceptibility of fish lipids to rapid oxidation overtime during field sun-drying and marketing operations [3].

The lower crude fat content in the salted-wash treatments is probably due to the pro-oxidant role of sodium chloride thereby leading to increased level of lipid oxidation [21, 22]. This loss in salted-dried fish has also been reported in other studies [23].The low crude fat levels observed at 50°C when compared to 30°C and 40°C conditions, was as a result of lipid oxidation, whose rate increases rapidly with increase in temperature. In meat muscles, a collagen sack surrounds fat. When heat is applied, proteins begin to denature and coagulate, thereby resulting to fat drip loss, which is more intense at higher temperatures of 50°C.

Total ash content of sun-dried and oven-dried *dagaa.*

Total ash is a test that is commonly used as an indicator of total mineral elements content of a food. The small fish such as *dagaa* have a particular nutritional advantage in mineral elements such as calcium over other fresh fish such as tilapia (*Oreochromis niloticus* L.) and Nile perch (*Lates niloticus* L.) because it is consumed as whole fish, inclusive of the skeletal tissues whereas in other fish, only the muscle tissues are considered [24]. The calcium and iron mineral levels in dried *dagaa* have been reported at 3600mg/100g and 10.2mg/100g respectively [17]. This explains the high total ash content when compared to the other fresh water fish species.

The total ash in the oven-dried *dagaa* experiment (especially salted and chlorinated wash)were generally higher than the values observed in the field sun-dried *dagaa* (13.5% dwb).This is probably due to the direct contribution of sodium chloride and sodium hypochlorite that was incorporated in the wash solutions. The generally high ash content in treatments oven-dried at temperatures of 30°C as opposed to 40°C and 50°C is attributed to the susceptibility of breakdown of certain volatile mineral components such as chlorides at higher temperatures of 40°C and 50°C, hence higher retention at 30°C.

CONCLUSION

The open field sun-drying and marketing process leads to nutritional losses of the crude protein and crude fat in sun-dried *dagaa* product.The incorporation of salt as a pre-washing treatment contributed to lower crude protein and crude fat levels in the oven-dried *dagaa* when compared with the control-wash treatments. In the oven-drying study, chlorinated (100ppm) pre-wash followed by oven-drying at 40^{o}C (23 hrs) would be recommended for dried *dagaa* process with regard to optimal retention of crude protein and crude fat composition in the dried *dagaa* product.

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Table 1: Changes in moisture content of oven-dried *dagaa* during storage[1]

days	30°C			40°C			50°C		
	Control	Salted wash	Chlorinated wash	Control	Salted wash	Chlorinated wash	Control	Salted wash	Chlorinated wash
day 1	8.52± 0.07[c]	8.60± 0.24[c]	7.62± 0.25[c]	8.63± 0.31[c]	7.53± 0.30[c]	6.62± 0.29[c]	8.21± 0.17[d]	7.68± 0.21[c]	6.61± 0.36[d]
day 3	8.55± 0.34[c]	8.62± 0.16[c]	9.58± 0.11[b]	8.63± 0.21[c]	7.85± 0.11[c]	6.40± 0.54[c]	8.56± 0.32[c]	9.46± 0.37[b]	8.43± 0.23[c]
day 5	8.67± 0.36[c]	9.52± 0.33[b]	9.65± 0.31[b]	9.24± 0.08[b]	9.56± 0.30[b]	9.34± 0.19[b]	8.73± 0.31[c]	10.61± 0.15[a]	9.47± 0.20[b]
day 7	9.50± 0.40[b]	9.46± 0.27[b]	10.62± 0.34[a]	9.51± 0.29[ab]	10.51± 0.40[a]	9.39± 0.23[b]	9.68± 0.17[b]	10.52± 0.24[a]	10.38± 0.25[a]
day 9	11.93± 0.34[a]	10.20± 0.33[a]	10.67± 0.28[a]	9.63± 0.23[a]	10.57± 0.38[a]	11.45± 0.33[a]	10.63± 0.25[a]	10.69± 0.14[a]	10.45± 0.35[a]

[1] Values are a mean of triplicate determinations. Means in a column followed by the same letter are not significantly different (p<0.05)

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