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PROCESS DEVELOPMENT, NUTRITION AND SENSORY CHARACTERISTICS OF SPICED-SMOKED AND SUN-DRIED *DAGAA* (*Rastrineobola argentea*) FROM LAKE VICTORIA, TANZANIA

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ABSTRACT

***Dagaa (Rastrineobola argentea),* also known as *Silver cyprinid,* are tiny fish (< 9 g) found mostly in Lake Victoria, Nabugabo and Kyoga, and also in the River Nile. *Dagaa* are very popular food around the Lake Victoria area and are used for formulating animal feeds due to their nutritional quality. Harvesting of *dagaa* is a demanding activity and the methods used include scoop net, seine net and catamaran or lift net. The harvesting of *dagaa* employs a lot of people along the lake carrying out the activities of fishing, preserving and selling. It is therefore considered to be a very important sector for job creation, income generation and food security. However, the traditional method of preserving *dagaa*, sun-drying *dagaa* (SDD) is often affected by heavy and prolonged rains in Tanzania. The present study was therefore undertaken to evaluate and compare the processing of spice-smoke *dagaa* (SSD) and SDD as preservation methods for all-year round supply and marketing. The results showed that SSD could be produced throughout the year and had a significantly ($p < 0.05$) lower moisture content (SDD in brackets), than SDD 1.81 % (2.4 %). It also had an insignificant increase in fat content 14.9 % (14.1 %) and a significantly higher ash content 17.3 % (15.7 %). Dry matter content was insignificantly increased, 98.2 % (97.6 %). Crude protein was more or less unaffected in the two products, 48.32 % (47.75 %). Sensory evaluation results showed that SSD (SDD in brackets) had significantly ($p < 0.05$) higher scores in appearance 4.2 (3.4), taste 4.1 (3.15), flavour 4.5 (3.2) and consumers preference or acceptability 4.47 (3.63). Similar results were also shown by the consumers on the open market around the lake. Both products however, had no sign of dirt or filth. The SSD was, therefore, considered to be superior. Despite SSD good qualities, preference and availability, this study revealed that it could not match the sales volume of SDD on the local market due to its unfamiliarity and higher price.**

Keywords*:* Acceptability, *Dagaa, Rastrineobola argentea,* sun-dried, spiced-smoked

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PROCÉDURE DE DÉVELOPPEMENT, CARACTÉRISTIQUES NUTRITIONNELLES ET SENSORIELLES DU *DAGAA* FUMÉ ET EPICÉ ET DU *DAGAA* SÉCHÉ AU SOLEIL *(Rastrineobola argentea)* DU LAC VICTORIA, TANZANIE

RÉSUMÉ

Les *Dagaa (Rastrineobola argentea),* également connus sous l'appellation d*e Silver cyprinid*, sont des poissons minuscules (< 9 g) que l'on trouve pour la plupart du temps dans les lacs Victoria, Nabugabo et Kyoga, et également dans le fleuve Nil. Le *Dagaa* constitue une denrée alimentaire très populaire autour de la région du Lac Victoria et sont utilisés pour leur qualité nutritionnelle dans la fabrication des aliments pour animaux. La collecte du *dagaa* représente une activité laborieuse et les méthodes utilisées dans cette opération incluent le demi-filet, la seine et le catamaran ou le carrelet. L'activité de ramassage du *dagaa* emploie une importante main-d'œuvre le long du lac effectuant des activités de pêche, de préservation et de vente. Ce secteur est donc considéré comme étant d'une importance essentielle dans la création de l'emploi, la génération de revenus et la sécurité alimentaire. Cependant, la méthode traditionnelle de conservation du *dagaa* par séchage au soleil (SDD) est souvent affectée par les pluies torrentielles et prolongées en Tanzanie. La présente étude a été donc entreprise en vue d'évaluer et de comparer le traitement du *dagaa* fumé et épicé (SSD) avec le SDD en tant que méthode de conservation pour un approvisionnement et une commercialisation couvrant toute l'année. Les résultats ont démontré que le SSD pourrait être produit tout au long de l'année et qu'il avait une teneur en humidité nettement inférieure ($p < 0,05$) (SDD entre parenthèses), en comparaison avec celle du SDD 1,81% (2,4%). Le SSD a également démontré une augmentation insignifiante en quantité de graisse 14,9% (14,1%) et une teneur sensiblement plus élevée de cendre 17,3% (15,7%). Les proportions des matières sèches ont augmenté de manière peu significative (98,2%, 97,6%). Les protéines brutes étaient plus ou moins les mêmes dans les deux produits, 48,32% (47,75%). Les résultats d'évaluation sensorielle ont prouvé que le SSD (SDD entre parenthèses) avait des notes considérablement plus élevées ($p < 0,05$) sur le plan de l'aspect 4,2 (3,4), du goût 4,1 (3,15), de la saveur 4,5 (3,2) et de la préférence ou de l'acceptabilité des consommateurs 4,47 (3,63). Des résultats semblables ont été également montrés par les consommateurs sur le marché libre autour du lac. Toutefois, les deux produits n'avaient aucun signe de saleté ou de déchets. Le SSD a été donc considéré comme étant supérieur. En dépit des bonnes qualités, de la préférence et de la disponibilité du SSD, cette étude a révélé qu'il ne pourrait pas atteindre le volume de ventes de SDD sur le marché local du fait qu'il est peu connu et également à cause de son prix plus élevé.

Mots-clés : Acceptabilité, *Dagaa, Rastrineobola argentea,* séché au soleil, épicé et fumé

INTRODUCTION

Lake Victoria is a very important fresh water, fish producing area in East Africa. The lake boarders Tanzania to the north, Kenya to the south-west and Uganda to the South-east. Lake Victoria has more than 290 fish species and among these are the small-sized species of fish, popularly known in East Africa as *Dagaa (Rastrineobola argentea*) [1, 2]. There are, however, considerable quality losses of these tiny fish as a result of the lack of modern fish processing and preservation methods [3]. In Tanzania, they are still processed and preserved by the traditional sun drying method [4, 5].

Consumption of *dagaa* could be greatly enhanced if they were brought into the human diet using modern and improved preservation and processing methods. The *dagaa* has played a very important role in job creation, nutrition, income generation and food security, especially during the dry seasons when agricultural activities are reduced to a minimum [6].

The current traditional method of sun-drying for preservation of *dagaa* in Tanzania is facing a lot of quality problems. High post-harvest losses are often experienced due to the rains in the fishing season. Sometimes the rainy season is prolonged, thereby preventing effective and quick drying [4]. Post harvest losses and product spoilage due to hydrolysis of fat and proteolysis of proteins are very common. As a result, the product has poor quality with a bitter and soapy taste, hence contributing to low acceptability and sales [5].

Also the traditional method of drying the fish in the sun, on beaches, on grass or rocks, results in contamination of the product with foreign particles such as sand or filth [7]. Market rejection of poorly processed *dagaa* results in about 70 % of the total annual harvest, and this is diverted to production of animal feeds or used as baits for catching bigger fish, such as the nile perch [3].

In Ghana, similar fish species are preserved by smoking [8]. Many people living close to the lakes in Tanzania do not believe that it is possible to smoke *dagaa* after spicing and salting, due to their small size that is delicate to handle [4].

The use of spices and salt, including smoke-drying to preserve food, is well documented [5]. Spicing, salting and smoking of fish are the main factors that contribute to the relish and anti-microbial activity in *dagaa.* The use of locally available spices for smoked *dagaa*, no doubt enhances good flavour as well as reduces or masks the bitter and soapy taste experienced in sun dried *dagaa.* This process also increases its palatability and acceptability levels for sustainable socio-economic aspects such as job creation, income generation and nutrition for thousands of people living around the lake [6]. No studies have so far been successfully conducted to produce such spiced-smoked *dagaa* on the shores of Lake Victoria.

The objectives of this study were therefore, to evaluate the potential of producing spiced-smoked *dagaa* for all year-round supply and to determine its quality in terms of proximate composition, sensory properties and its palatability and acceptability to the local market. This would in turn control spoilage and increase potential *dagaa* availability and sales in Tanzania.

MATERIALS AND METHODS

Collection of samples

The *dagaa (Rastrineobola argentea)* samples used in this study were purchased fresh during the wet and dry seasons from Kijiweni landing station, 2 km away from Nyegezi Freshwater Fisheries Institute in Tanzania. The *dagaa* were transported to the Nyegezi Institute processing plant, where they were weighed, washed in chilled water and stored in a cold room before further study. The sizes of *dagaa* purchased for this study ranged from 4.2 cm to 6.3 cm with an average weight of 9.4 g. 'Chorkor Oven' for smoking was locally made and was similar to the ones used in Ghana [8]. Spices, salt and firewood were also purchased from the local market in Nyegezi, Tanzania.

Preparation of the SDD and SSD

Fresh *dagaa* from the cold room were processed using the procedure described by Dampher, Dobson and Kuziwa [5, 10, 11]. The *dagaa* for SDD were washed in chilled water and dipped into brine solution containing 2 % salt for 15 mins (Fig. 1a). The *dagaa* for SSD (Fig 1b), were washed in chilled water and dipped in brine solution containing 2 % salt and 0.5 % hot pepper for 15 minutes. Both samples were then removed from the solutions and were spread on wire mesh trays to remove excess water. The SDD *dagaa* were then placed in the sun to dry during the dry season, and in the shed in wet season, and took days to dry. The SSD *dagaa* were put onto the 'Chorkor Oven' with hot smoke at 70 ^{0}C until they were smoked and dried. After drying, they were allowed to cool naturally to ambient temperatures of 23–25 ^{0}C. The project was carried out for a period of two years with two seasons each. The SSD and SDD (1 kg each) were then transferred into plastic bags, sealed and labeled ready for distribution. Samples for analyses and acceptability trials were packaged and set aside. The samples for sensory evaluation were boiled before tasting.

Chemical analysis

Three samples each of sun-dried and spiced-smoked *dagaa* were analyzed for moisture, dry matter, ash, proteins and fat contents [12]. Moisture and dry matter contents were determined by the oven drying method while ash was determined using muffle furnace at 550 ^{0}C for 3 h. Nitrogen was determined by the Kjeldahl method, and the crude protein was estimated by multiplying by a factor of 6.25. Crude fat content was determined by the Soxhlet Extraction method as described by James [13].

Sensory Evaluation

The boiled samples of SSD and SDD were evaluated for appearance, taste, flavour and overall acceptability on a 5-point hedonic scale, where 5 was excellent, 3 good, and 1 poor. Ten students and staff from Nyegezi Fresh Water Fisheries Institute (Tanzania), familiar with *dagaa* and sensory evaluation constituted the panel. Necessary precautions were taken to prevent carry-over flavour during the tasting by ensuring that the panelists passed a piece of lemon fruit in their mouths after each stage of sensory evaluation. The samples were also presented to *dagaa* consumers sensory evaluation tests at the open market.

Statistical analysis

All data was subjected to analysis of variance (ANOVA) (completely randomized design). Mean values were compared at $p < 0.05$ significant level using Duncan's multiple range test [14, 15].

RESULTS

Processing procedures

Figure 1a & 1b, show the steps used for the production of SDD and SSD along Lake Victoria in Tanzania, respectively. The processing of SSD was carried out throughout the year, regardless of the seasons, as it did not require the sun like SDD to produce. The SDD method was not very successful during the prolonged tropical rains in Tanzania as it took a long time to dry and the quality was affected. Large scale processing of *dagaa* for general market by the fishermen was not carried out during the rainy seasons for fear of spoilage.

Figure 1a & b. Flow diagrams for processing SDD (Fig 1a) and SSD (Fig 1b) around Lake Victoria in Mwanza, Tanzania.

Fig 1a: Sun-Dried *Dagaa* (SDD)

Chilling
↓
Fresh *dagaa* were stored at –4 ^{0}C to maintain freshness until sun drying
↓
Preparation
↓
Fresh *dagaa* were washed in chilled water to maintain freshness and remove dirt
↓
Brining
↓
Dagaa were dipped into 2 % brine solution for 15 min
↓
Dripping
↓
Dagaa were removed from brine and spread on trays to drip and dry
↓
Drying
↓
Trays were put on drying racks under the sun and turned severally to constant weight
↓
Cooling
↓
Dried *dagaa* were removed from the sun and scattered in a room to cool (23–25^{0}C)
↓
Packaging
↓
Dagaa were weighed (1 kg) in plastic bags, sealed and labeled for sale and experimentation

Fig 1b: Spiced-Smoked Dagaa (SSD)

Preparation
↓
Dagaa were washed in chilled water before processing
↓
Spicing/Salting
↓
They were dipped into brine solution containing 2 % salt and 0.5 % hot pepper for 15 min
↓
Dripping
↓
Dagaa were removed from brine and spread on trays to drip and dry
↓
Smoking
↓
The dry *dagaa* were put onto Chorkor Oven with hot smoke (70 ^{0}C) and tray rotated at intervals
↓
Cooling
↓
Smoked *dagaa* were then removed from Chorkor Oven and left to cool (23–25^{0}C) by air
↓
Packaging
↓
Smoked *dagaa* were weighed (1 kg) in plastic bags, sealed and labeled for sale and experimentation

Proximate composition

The SSD lost a significantly higher ($p < 0.05$) amount of moisture (SDD in bracket), 1.81 % (2.40%), retained insignificantly higher dry matter 98.9 % (97.6 %) and had a significantly higher ash content 17.29 % (15.66 %) compared to the sun-dried *dagaa* (Table 1). There was no significant differences ($p < 0.05$) between the two products in terms of protein 48.32 % (47.75 %) and fat 14.86 % (14.06 %) contents.

Sensory evaluation results

The sensory score results of SSD (SDD in brackets) appearance were; 4.2 (3.4); taste 4.1 (3.15); flavour 4.5 (3.2) and acceptability 4.43 (3.63) and were significant higher ($p < 0.5$) in SSD than those given to SDD (Table 2). No dirt or filth content was reported in both products. Spices which included hot pepper, hot smoke and salt changed the colour, taste and flavour of the SSD and masked the bitter and rancid taste experienced in SDD. The normal silvery colour of *dagaa* was changed to an attractive brownish colour which increased the SSD appeal and acceptability level. Similar sensory results were obtained from the general *dagaa* consumers at the open market.

DISCUSSION

The SSD method of preserving *dagaa* had a higher loss of moisture content and a significant increase in ash contents. Dry matter was marginally increased. The product resulted in higher palatability and acceptability. This quality was attributed to the combined processes of spicing, salting and smoke-drying, as was also observed by Donson [10]. Makene and Bhandary noted that high water activity (aw) in food products harbour spoilage microorganisms, and therefore, one way of improving shelf life of *dagaa* is by smoke-drying and salting [16, 17]. Smoke that is hot (70 ^{0}C) can inactivate a number of spoilage microorganisms and enzymes and it also contains bactericidal compounds such as phenols, formaldehyde, formic acid, acetic acid, alcohol, carbonyls and hydrocarbons that can control the levels of spoilage microorganisms [10,18]. Although the shelf-life of the SSD was not determined, the reduced water activity (aw), and presence of salt and bactericidal compounds, including the heat found in the smoke, could actually prolong the shelf-life of SSD further.

The production of SSD was carried out throughout the year, regardless of the rains, as it did not require the sun like SDD to dry. However, the SSD was more expensive to produce due to the cost incurred for purchasing spices, firewood and hiring of extra labour for smoking. The SDD method of processing was not very useful during the prolonged tropical rains that prevail in Tanzania. Prolonged rains delayed drying of *dagaa* and caused the SDD to become moldy and with a stale taste. It also increased the rate of proteolysis and lipolysis due to high water activity (aw), resulting in oxidized, rancid and bitter tastes, which gave SDD lower scores in the sensory evaluation.

The use of wire mesh racks or trays for dripping and drying purposes improved the acceptability and quality of both SSD and SDD tremendously. Thus, the contamination of the products with foreign bodies such as sand and filth particles was not possible as the wire trays were used instead of drying the *dagaa* on the ground. The acceptability scores of both SSD and SDD were greatly increased by cleanliness of the products.

Sensory evaluation scores for SSD were higher and the product was superior to SDD in appearance, taste, flavour and acceptability, as shown in Table 2. Spices, which included hot pepper, salt and smoke, changed the colour of *dagaa* from silvery-dark to an attractive brownish colour. This increased taste, flavour and acceptability of the product and also masked the bitter and rancid taste experienced in SDD. The salt, heat, low water activity (aw) and the smoke could also extend the shelf life of SSD on the market. However, for infant formulations and for people with high blood pressure, who are sensitive to pepper and salt, *dagaa* could still be made in small scale for them but without the addition of hot pepper and salt. The process could be carried out during the dry season as the quantities would not be much.

When the SSD was tested on the market around the lake areas, the sales were lower compared to the SDD, as it was a new product to the community and that it was more expensive due to the cost of spices, firewood and labour for smoking.

CONCLUSION

The present study has shown that *Rastrineobola argentea (dagaa)* can be used, though tiny and delicate, to produce the SSD that is new, tasty and acceptable. The product can also be produced and made available throughout the year instead of on a seasonal basis. Spiced-smoked dagga was, however, more expensive, per kilogram, due to additional costs caused by

the purchase of spices, firewood and hiring of extra labour for smoking. This was also observed when the product was displayed and tested on the open market. A significantly lower quantity of the SSD was purchased on a daily basis, compared to the SDD and the reasons given were as mentioned above including the unfamiliarity of the product to consumers. The SSD therefore, requires a lot of publicity and higher level of promotion to make consumers more aware of the existence of the new product, and its advantages over the SDD in terms of taste, flavour, colour, acceptability and its availability all-year round. For young consumers and patients of high blood pressure, *dagaa* can still be produced using both smoking and sun drying methods as long as salt and hot pepper are eliminated from the processing.

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Table 1. The mean proximate composition of the sun-dried (SDD) and spiced-smoked *dagaa* (SSD) samples

Attributes	Sun-Dried *Dagaa*	Spiced-Smoked *Dagaa*
Moisture	2.4 ± 0.2a†	1.81 ± 0.3b
Dry Matter	97.6 ± 0.2a	98.9 ± 0.3b
Protein	47.75 ± 1.63a	48.32 ± 1.81a
Fat	14.06 ± 0.5a	14.86 ± 0.4a
Ash	15.66 ± 0.5a	17.29 ± 0.6b

†Means for the same attributes followed by the same letter are not significantly different ($p > 0.05$).

Table 2. Mean sensory evaluation scores of sun-dried *dagaa* (SDD) and spiced-smoked *dagaa* (SSD) samples

Attributes	Appearance	Taste	Flavor	Acceptance
SDD	3.40 ± 0.1a†	3.15 ± 0.85a	3.20 ± 0.56a	3.63 ± 0.94a
SSD	4.20 ± 1.0b	4.10 ± 0.20b	4.50 ± 0.30b	4.43 ± 1.22b

† Means for the same attributes followed by the same letter are not significantly different ($p > 0.05$).

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