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Towards valorizing spinach and amaranth's leaves in Eastern democratic republic of Congo

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Abstract

Spinach and amaranth are among the most consumed vegetables in Eastern DRC where mothers are encouraged to consider them in their daily diets as source of vitamins and minerals and to fight against infantile malnutrition. During dry season prices are higher as compared to wet season due to low productions; at the same time considerable production losses are encountered during wet seasons due to poor conservation facilities. It's in the regards that this study was conducted aiming to reduce post-harvest losses by drying leaves; specifically in this study two methods of drying leaves (sun and oven drying) will be assessed to come up with the best; this study will help also diversify consumption pattern in Eastern DRC. Organoleptic and physicochemical analyzes showed that sun-dried vegetables have high values of moisture, iron, fat and ash compared to oven dried vegetables; however, no significant difference was observed between the two methods of drying as regards to protein and calcium contents. Oven drying reduced the aroma, color, taste and flavor of amaranths compared to the sun drying, but no difference was found between the two methods for spinach. These results imply that drying is a good method of preservation, making these vegetables available during the period of scarcity. Oven and sun drying are both good for spinach but precaution should be taken when applying oven drying on amaranths.

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Introduction

Vegetable daily intake in the sub-Saharan African is below what is recommended; the joint FAO/WHO 2003 Consultation on Diet, Nutrition and the Prevention of Chronic Diseases recommended a minimum daily intake of 400 g of fruits and vegetables (Vorster *et al.,* 2003). In Uganda, an average consumption of 160g/person/day during the rainy season was reported while another study amongst urban dwellers quoted in the same report estimated per capita consumption of 12g/day. Oguntona (1998) reported a mean intake of 65g/day in western Nigeria while in a more recent study in south eastern Nigeria, Hart *et al.* (2005) reported adult per capita consumption of 59-130g/day during the months of May-July, the peak season of vegetable production in the study area. In the Democratic Republic of Congo, the frequency of consumption of vegetables is 5,7 days per week (PAM, 2014), in Kinshasa, the daily consumption of fresh fruits and vegetables in Kg per person increased from 0,068 in 1975 to 0,067 in 2000 (Houyoux, 1986).

Amaranth is the most widely grown leafy vegetable in the tropical humid zone and, as such, comparable to spinach in temperate regions (Grubben, 1975). Spinach has the advantage of being easily available almost everywhere in the world. In the tropical zone indeed, this vegetable is easily cultivated in a half shaded garden corner (Inaki, 2012).

Despite that they are indispensable ingredients of soups or sauces that accompany carbohydrate staples in many African countries post-harvest losses have been reported (Chweya and Eyzaguirre, 1999). These losses differ according to the geographical situation and the particular conditions of each country (FAO, 2011). Scientific and empirical research shows that 25% of tropical crops are lost even before being used (Asiedu, 1991). These losses are not to be neglected for leafy vegetables that contain large quantities of water (80% at 90%). In sub-Saharan Africa they are estimated at more than 40% (Silou, 2003). Vegetables are perishable and difficult to preserve as fresh products. Drying has been applied to vegetables in order to preserve, store and transport these food products. However, drying implies not only physical changes, easily detectable by the consumer through visual assessment, but also chemical modifications. Quality changes associated with drying of fruit products include physical, sensory, nutritional, and microbiological, these are not always visible, but are responsible for alterations in colour, flavour and nutritional value, which compromise the overall quality of the final product.

In Eastern Congo and in North Kivu Province particularly, a province with great agricultural potential thanks to its favorable climate for agriculture, post-harvest technologies for leafy vegetables are almost non-existent; these vegetables are usually consumed in the fresh state, which increases the losses during full production and limits consumption during the period of shortage. Thus, to preserve them for long periods, they must undergo a specific treatment that prevents physiological aging, the action of enzymes and the multiplication of microorganisms (Ife and Bas, 2003).

Among the many food preservation methods described in the literature to ensure their availability throughout the year, the technique of solar drying is increasing in the tropics (Onayemi and Badifu, 1987). It is among the simplest and least expensive techniques that ensure the conservation of food, certainly. However, and it should be mentioned, when the products are exposed to the open air, they are attacked by animals and microorganisms causing qualitative and quantitative losses. (Diamante and Munro, 1993; Mennouche *et al.*, 2007). Efficient, economical and easy, it would reduce wastage and remarkable losses during the period of abundance (Ife and Bas, 2003), reduce the duration of meal preparation (Uffet, 2003) and help maintain the sanitary quality of products (Harisoamahefa 2013, Moussa 2009). This technique will be compared to the drying of vegetables in the oven that we will also perform. In spite of this body of evidence confirming the advantages of drying leafy vegetables, there has been very little concerted effort towards exploiting this technique in Eastern DRC Congo. The objective of this work is to diversify the consumption of leafy vegetables, through promotion of drying techniques of vegetables and specifically to compare solar and oven drying techniques on nutritional values of Amaranths and Spinach.

Material and methods

Material

- Leaf samples of Amarath (*Amaranthus Hybridus*) and Spinach (*Spinacia Oleracea L*)
- Drying racks
- Lab materials
- Reagents

Methods

Sample preparation

Both Amaranth and Spinach leaves were manually harvested at the same time early morning on plants located in the middle of the experimental plot to avoid boarder's effects. The following step was the control of their integrity and sorting (removal of damaged vegetables: crushed, sick, attacked by microorganisms); leaf samples were packed, weighed and labeled in a paper bag and transferred directly to the laboratory. Two drying techniques were compared. For the sun drying technique, fresh amaranth and spinach vegetables were laid out in a single layer on a drying rack maid from small wood slats, bamboo, grill grates, and stainless steel screen mesh after being washed properly. Racks were placed in open areas so that they receive direct sunlight for four days. This drying was operating with natural convection, without auxiliary heating, heat storage or air recirculation.

The oven drying technique consisted of putting the vegetables sorted and washed in six petri dishes and introducing them into the oven for 24 hours to ensure a good drying.

Physicochemical and organoleptic analyzes of dried vegetables

The crude protein content was determined by the Kjedahl method; the direct extraction of the fats was done in a soxhelet with petroleum ether (fraction of 40 to 60°C); the raw ash content was obtained by incineration of vegetables in the muffle furnace at a temperature of 550°C; water content was determined by drying leaf samples in the oven at 105°C to constant weight; the dry matter content has been deducted from the moisture content; the iron and calcium contents were directly obtained using a spectrometer.

Flavor, aroma, color and overall flavor of the dried vegetables were appreciated by a team of 20 tasters. They were required to rinse their mouths when tasting from one product to another. The intensity of perceived sensation for the four chosen descriptors was noted on a discontinuous rating scale ranging from 1 (absent) to 5 (very strong).

Statistical analysis

The Analysis of Variance for each descriptor was conducted using the R statistical package. Mean separation was conducted using Tukey Test at a significance level of 0.05.

Results and discussion

Physico-chemical parameters

Results shown in the graphs below indicate that humidity, fat, ash and iron content are higher with sun drying treatment compared to oven drying with exception for spinach fat content which was not affected by the drying type; with oven drying humidity percentage was around zero percent; while with sun drying humidity range was respectively 11.4 and 9.8% respectively for amaranth and spinach (Fig. 1) which is a tolerable level for a good vegetable conservation.

In fact, the humidity percentage threshold according to Burden et Wills (1992) ranges between 10 and 15%. Moisture decrease by heat generally improves the digestibility of food, increases the concentration of nutrients and may make certain nutrients more available (Morris, 2004). The moisture content of vegetables creates a favorable environment for the growth of microorganisms (Kavitha and Saradha, 2013). It must be reduced if vegetables are to be stored for a long time, which can inhibit autolytic enzymes (Ladan *et al.*, 1997).

Protein content although it was almost higher in amaranth as compared to spinach was not affected by drying type. Similar results were reported by (Yadav *et al.,* 1995) who found no drying effect on spinach chemical properties. Our results match with the findings of (Mutila, 2011, WFP, 2006) who reported that sun drying provides advantages over oven drying because vegetables preserve a large part of their non-volatile constituents, unlike oven-dried vegetables that lose certain elements such as iron, proteins and proteins, fat due to increased heat.

Calcium content was higher in amaranth and was affected by drying type compared to spinach in which calcium content were between 2.15 and 2.35 while it reached 10.9% with sun drying on amaranth (Fig. 1).

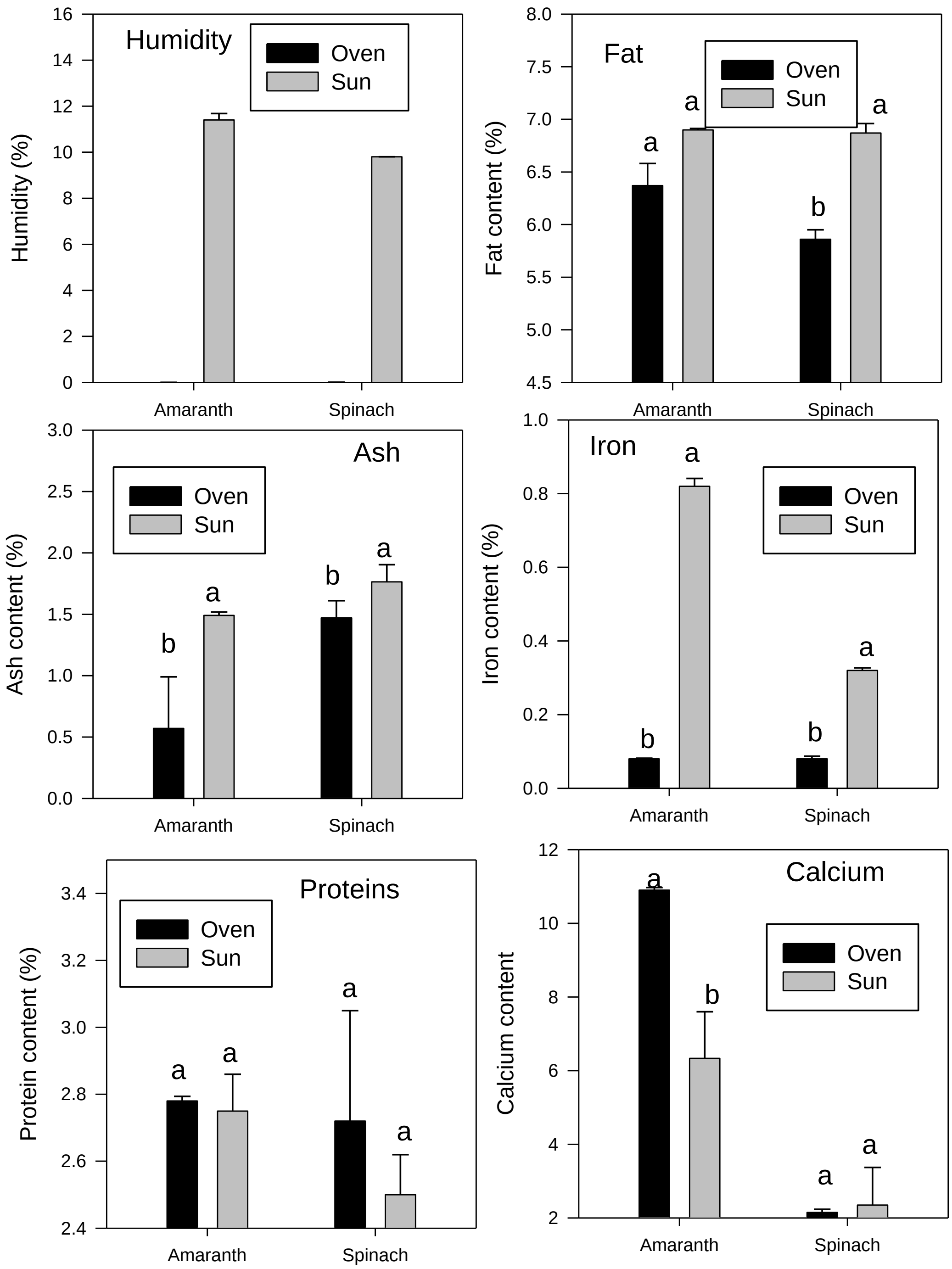

Fig. 1. Humidity, fat, ash, protein, iron and calcium content of amaranth and spinach as affected by oven and sun drying.

These results indicate that heat-treating and sun drying of amaranth and spinach can result in significant reduction in levels of fat, calcium, iron and ash; such losses during drying have been reported for other vegetables (Mziray *et al.*, 2000) and Morris (2004). It is generally recognized that dehydration of leafy vegetables results in losses of vitamins, the extent of loss depending on the type of vegetable (Belitz *et al.,* 1987). According to Susanne (2014), the more spinach is oven dried, the more certain physico-chemical properties decrease and others disappear. The experience of drying spinach under the oven in Gabon in 2013 by the FAO shows that only calcium and protein remained after the process.

Heat treatment induce leaching of ascorbic acid and emzymatic and chemical degradation that may explain the decrease in chemical elements in oven drying treatments, similar observations were reported by (Tannenbaum, 1976) and Labuza (1972).

Sensory properties

Mean separation analysis showed that the type of drying affected the sensory parameters for amaranth not for spinach. Higher values were obtained with the sun drying as compared to the oven drying (Table 1).

Indeed, the process of dehydration affects to different degrees the organoleptic properties of vegetables. This may be due to the type of vegetables, different stages of maturity, harvesting methods, cultural practices, type of pretreatment and drying methods, etc. (Onayemi and Badifu, 1987).

The sun-dried vegetables are appreciated to those dried in the oven, this should be attributed to the loss of aroma, flavor and taste by the heating process which is more pronounced with oven drying process According to (FAO, 2006), oven-dried market garden products lose a good deal of their organoleptic qualities; this is emphasized by the results of this study.

The organoleptic quality of the sun-dried leafy vegetables is also appreciated by the tasters because they have not been dried in the open air. To avoid attack by animals and microorganisms, and the possible loss of their organoleptic quality, these leafy vegetables are dried in a natural convection indirect drier (Bassey, 1989).

Table 1. Sensory parameters as affected by drying type.

	Amaranth		Spinach	
	Oven drying	Sun drying	Oven drying	Sun drying
Color	$1.6^{a}\pm0.59$	$2.5^{b}\pm0.68$	$2.15^{a}\pm0.81$	$2.05^{a}\pm0.82$
Aroma	$1.5^{b}\pm0.60$	$1.9^{a}\pm0.64$	$1.45^{a}\pm0.68$	$1.55^{a}\pm0.60$
Taste	$1.4^{b}\pm0.50$	$2.15^{a}\pm0.67$	$1.75^{a}\pm0.64$	$1.6^{a}\pm0.68$
Flavor	$1.4^{b}\pm0.50$	$2.25^{a}\pm0.64$	$1.7^{a}\pm0.57$	$1.9^{a}\pm0.72$

Figs in the table are mean values with their standard deviations.

Conclusion

Sun drying technique showed high values of moisture, iron, fat and ash as compared to oven drying. Oven drying slightly decreased the physico-chemical, nutritional and organoleptic qualities of amaranth and spinach. Nevertheless, the values obtained fall in the acceptable threshold as compared to fresh vegetables. Although natural drying, consisting of exposing and drying products directly to the sun has the double advantage of being simple and cheap but on the other hand products exposed to the sun are also prone to dust and animals causing huge losses. Sun drying should be promoted due to its advantages as compared to oven drying by precautions should be taken to avoid exposure of vegetables to dust and animals.

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