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Influences of Storage Conditions, Cultivation and Culinary Practices, On the Antioxidant Capacity of Red Bulbs of Some Onion Varieties Grown in Burkina Faso

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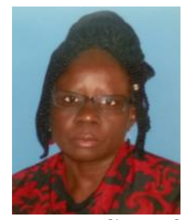

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Abstract

Red onion bulb is a vegetable containing micronutrients with antioxidant properties. However, certain factors can have an impact on the content of these compounds. The present research evaluate the effects of parameters such as cultural practices, storage conditions and culinary practices, on the antioxidants content of red onion bulb of some varieties grown in Burkina Faso. The identification of the factors was carried out through field surveys, and their effects on the antioxidants content were assessed and appreciated through especially specific related bibliographic and laboratory test data. The results showed that84.78% of farmers use chemical fertilizers and all of them use chemical pesticides on onion crop. They don't use premises or equipment suitable for storage. About dishes,7.61% of cooks, peel, cut and wash onion bulb before steam cooking, boiling water cooking or oil frying them at high temperature during 30 minutes to 3 hours. Some cooks use to braise onion bulb scales as ingredients for different dishes such as barbecue. Only 02,72% of cooks grind the onion bulbs with a pestle, before using the crushed as such on barbecue, or slow cooking it in different sauces. Research results show that these culinary practices contribute declining significantly the final intake of antioxidant for the consumer's body.

Keywords: Crops, Cultivation, Storage, Culinary practices, Onion.

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Ethical: This study follows all ethical practices during writing.

Contents

1. Introduction

Onion is a plant native from Central Asia [1]. It is now grown worldwide and is one of the basic ingredients in many dishes [2]; [3].

Onion is rich in trace elements including manganese, selenium, phosphorus, zinc, vitamins (B, C, E, β-carotene), polyphenols [4]. Some of these compounds have antioxidant properties [5] which gives onion therapeutic virtues. Indeed, many studies attribute to onion bulb the properties to fight against certain diseases related to oxidative stress such as cancer, cardiovascular disease, diabetes, age-related diseases [2]; [6]; [7]; [8]; [9]. All of these diseases are increasingly important causes of disability and premature death in both developing countries such as Burkina Faso and developed countries. In 2001, they were responsible for about 60% of the 56.5 million deaths worldwide, and 46% of the global burden of disease. This morbidity rate will rise to 57% in 2020, and these oxidative stress-related diseases will account for nearly 3/4 of all deaths worldwide [10]. In developing countries, deaths from these diseases dominate mortality statistics [11]. Burkina Faso is not left out of this situation. The epidemiological profile of the country is marked, among other things, by the gradual increase in the prevalence of diseases related to oxidative stress [12]. Although there are no national survey data, these diseases are currently a real public health problem nowadays [13].

One of the main causes of these diseases is the action of free radicals, chemical molecules naturally produced in the body during different metabolic reactions. When they are in excess in the body, they are responsible for oxidation of biological molecules such as proteins, lipids, carbohydrates and even DNA [5]; [14]; [15]; [16].

Antioxidants are chemical molecules that help the body fight free radicals and repair the damage they cause [17]; [18]; [19]. They play a very important role in the prevention of diseases related to oxidative stress.

Synthetic antioxidants exist but are very difficult to access because of their cost. In addition, in high doses, they become pro-oxidant agents potentially dangerous for health Favier [5]; Pelli and Lyly [20]; Defraigne and Pincemail [21]; Edeas [22]. Pincemail, et al. [23] and also many studies pointed out that a high level of antioxidants in the body obtained thanks to a diet rich in fruits and vegetables, makes it possible to reduce without danger the relative risk mortality due to oxidative stress.

Many foods are used as a source of antioxidants, but do not cover the need of this natural substance. It is necessary to look for other more abundant and easily accessible sources of antioxidants and the way to optimize the body intake, hence the present investigation on the onion.

Burkina Faso is one of the major producers of onions in West African (4th rank after Nigeria, Niger and Senegal). This production is lower than domestic demand [24]. It could be used as a natural source of antioxidants and would therefore enable vulnerable populations such as children, pregnant women, old people, and AIDS patients to prevent diseases linked to oxidative stress by strengthening the immunity of their bodies against other opportunistic diseases.

However, some factors such as cultivation techniques, environmental conditions, could have an impact on the biosynthesis of antioxidant compounds in plants [25]; [26]; [27]; [28]; [29].

The aim of this work is to evaluate the effect of storage conditions, cultivation and culinary practices, on the antioxidant content of red bulb of some onion varieties grown in Burkina Faso, and thus to propose the ways for optimizing antioxidant intake in the consumer's body.

2. Material and Methods

2.1. Study Areas

Data on cropping practices, storage conditions and culinary practices were collected through field surveys carried out in nine (09) regions of Burkina Faso, namely Mouhoun, Waterfalls, High-basins, North, Central, West-central, Central-plateau, East-central and East. Figure 1.

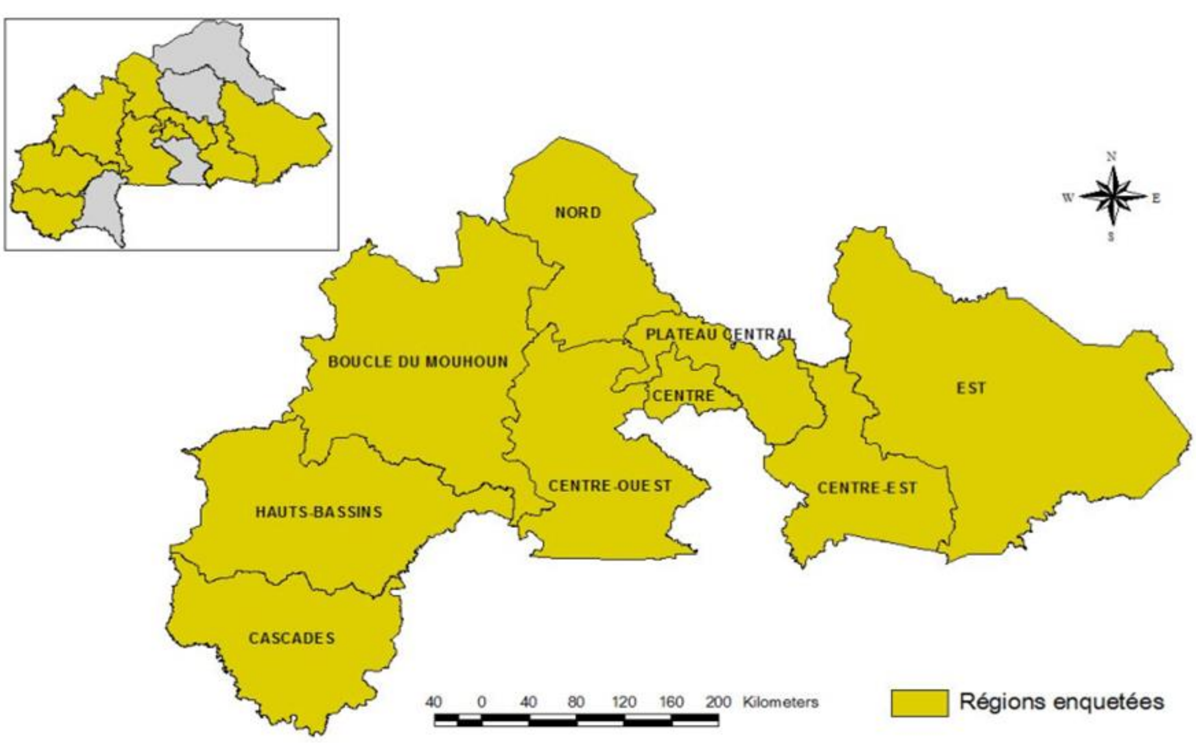

Figure-1. Map of Burkina Faso and location (in yellow) of the study areas.

Source: PAFASP (Agro Sylvo Pastoral Support Program) [24].

2.2. Methodology for Field Data Collection

2.2.1. Sampling

The nine (09) regions selected are those where the production activity of onion bulb is very promising. Among these regions are the three largest regions producing onions, namely, the regions of Mouhoun, North and West-central. Sampling was random and involved 30 producers and 20 households in each locality.

2.2.2. Field Data Collection Tools

Field data collection was conducted from surveys by interviews of producers and consumers in the nine (09) regions. The technique adopted was the semi-structured interview where the respondent must answer exhaustively with his own terms and his own frame of reference to the questions asked to him by the investigator [30]; [31]. A survey form was designed and administered in local languages (Mooré, Dioula, Karaboro, Goulmatchéma).

Information about culinary practices was collected only from women as they are those who deal with culinary issues within households.

The survey data were processed, analyzed and commented in relation to specific bibliographic data and laboratory test results.

3. Results and Discussion

A total of 276 producers and 184 households were surveyed.

3.1. Cultural Practices and Influence on the Antioxidant Content of Onion Bulb

The data collected on the cultural practices applied to onion bulb among 276 people surveyed are presented in Table 1. These practices concern soil fertilization and the use of chemical pesticides for the treatment of plants.

Table-1. Cultural practices applied to onion bulb by 276 respondents.

Operation	Number of respondents practicing it	Percentage
Use of chemical fertilizers	234	84,78 %
Use of organic manure	42	15,22 %
Use of chemical pesticides	276	100 %

Source : Field work data.

Data show that the majority of respondents (84.78%) use chemical fertilizers, which are generally NPK (Nitrogen, Phosphorus, Potassium) and urea in onion bulb production, and only 15.22% use organic manure for this purpose. All the producers surveyed (100%) use chemical pesticides for the treatment of onion crops.

The use of chemical fertilizers and pesticides may have a negative impact on the antioxidant content of onion bulbs grown. Indeed, previous work has shown that the application of chemical fertilizers including large amounts of nitrogen allow an increase in yield at the expense of the antioxidant content of plants [32]; [33]; [34]. This phenomenon called "dilution effect" has also been highlighted by Farrell [35] and Davis, et al. [36]. As for the effect of plant chemical pesticides studies have shown that more the plant is left on its own to deal with aggressors and diseases, more it synthesizes antioxidants to defend itself [37]; [38]; [39]. Thus, the application of pesticides could prevent plants from being in a defense situation and thus synthesize antioxidants.

Organic production methods are characterized by a culture without chemical fertilizers or chemical pesticides. Organic production of onions is difficult because of the inaccessibility of biological fertilizers and pesticides due to their high cost. While a lot of research has shown that such production methods could therefore make it possible to ensure that bulbs have better levels of phenolic compounds and a high antioxidant capacity. Ren, et al. [40] have shown that the antioxidant capacity of organic onions is 20 to 50% higher than those of conventional onions. These data were confirmed by Benbrook [41] who pointed out that 85% of the cases studied showed that organic farming practices can increase the antioxidant content of plants by more than 30% compared with plants derived from conventional agriculture. The same source states that, soils rich in humus with high biological activity can positively modify the concentration and the combination of antioxidants in harvested fruits and vegetables, compared to soils that are regularly fumigated and extensively chemical fertilized, and which have a generally lower bioactivity [41]. It could be argued that the ability of organic farming practices to increase the antioxidant content of fruits and vegetables would come from the use of organic fertilizers and pesticides, which are very rich in organic and probably other agro-ecological parameters could explain the increase of antioxidant content in organic farming according to many authors, Dakéné, et al. [42]; Sereme, et al. [43]; Dabire, et al. [44].

3.2. Storage Conditions and it Influence on the Antioxidant Content of the Onion Bulb

Onion bulb storage facilities used by producers in surveyed areas are presented in Table 2. Data shows that only 8.33% have a sufficiently ventilated store with shelves for onion bulbs storing Photo 1. Some (15.22%) have a room (shed or straw hut) Photo 2 for the bulbs storage, and 56.52% of the respondents use their dwelling house Photo 3 for the storage. It is noticed that 19, 93% of the respondents have no means of storing for the bulbs after the harvest.

Table-2. Storage conditions of the onion bulb among the respondents (n = 276).

Storage medium	Number of respondents owning it	Percentage
Store ventilated and provided with shelves	23	8,33%
Case or shed made of straw	42	15,22 %
Living house	156	56,52 %
No way	55	19,93 %

Note: Storage temperature: ambient temperature, uncontrolled.
Relative humidity (RH), oxygen and carbon dioxide content (CO_2): uncontrolled.
Source: Field work data.

Photo-1. Store ventilated and. equipped shelves.

Photo-2. Straw box.

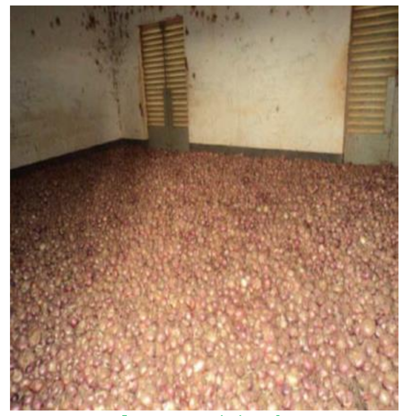

Photo-3. Living house.

(Field work photos).

In addition, the storage is done in the ambient air and the shelves are often overloaded. The temperature, relative humidity, oxygen content and carbon dioxide (CO_2) of the storage room are not controlled.

These storage conditions, if they make it possible to minimize losses due to rotting of the bulbs, could have a significant impact on the nutritional quality of the product, particularly its antioxidant content. Indeed, Agblor and Waterer [45] have shown that to maintain the nutritional quality of onion bulbs during storage, the optimal temperature should be 0 °C and the relative humidity between 65 and 70%. The storage could also be done at room temperature as is the case for the producers surveyed, but provided that it is between 20 and 30 °C and that the bulbs are properly dried [46]. The oxygen in the air should be as low as possible to limit bulb respiration as Renard and Chervin [47] have shown. In this study, among the producers surveyed, no storage room is equipped with a device for monitoring and adjusting these parameters in order to ensure that they are suitable for the proper storage and preservation of the nutritional quality of the bulb. It is therefore possible that such an environment is unfavorable to maintaining the antioxidant content of stored bulb.

3.3. Culinary Practices and Influence on the Antioxidant Content of Onion Bulb

In order to identify the culinary practices and their influence on the antioxidant concentration of the onion bulb, a household survey was carried out especially among women those are in charge of the family's cooking issues. One hundred and eighty-four (184) households were surveyed for this purpose. The information sought was related to onion bulb culinary practices as an ingredient of different dishes.

3.3.1. Modes of Preparation of the Onion before Consumption or Cooking

Data on the methods of processing of onion bulb before consumption are presented in Table 3.

Table-3. Modes of preparation of the onion bulb before consumption or cooking in the households surveyed (n = 184).

Operation	Number of households surveyed practicing it	Percentage
Peeling and cutting	23	12,50 %
Peeling, cutting, washing	106	57,61 %
Peeling, washing, cutting	55	29,89 %

Source : Field work data.

From these data, it appears that 57.61% of respondents peel, cut the onion scales into small pieces and wash them before eating without any processing, or after cooking. 29.89% peel, but wash before cutting the onion scales, and 12.50% only peel before cutting them. Peeling, cutting and washing are a set of practices that could contribute to a decrease in the antioxidant content of bulbs. Indeed, previous work has shown that antioxidant micronutrients are generally more concentrated in the epidermal parts of fruits and vegetables [41]; [48]; [49]. Peeling, although essential in some cases, such as the red bulb of onion, could therefore contribute to reducing these compounds in ready-to-eat products. The losses during the cutting would be explained by the fact that during this operation, there is an alteration of the cellular integrity. This would then bring into contact the soluble compounds generally accumulated within the vacuoles, and the degradation enzymes initially present in the cell walls and the cytoplasm [50]. Washing, meanwhile, would lead to the loss of water-soluble compounds by diffusion in water, as shown by Arroqui, et al. [51]. However, the losses could be at different levels: 57.61% of the households surveyed practice washing after cutting, which could cause more losses of water-soluble compounds because the diffusion of these is facilitated and therefore higher. 29.89% of the households surveyed practice washing before cutting, which would cause fewer losses. Thus, a best practice will be to perform: (i) peeling consisting simply of the removal of dry outer scales; (ii) washing of peeled bulbs before cutting; (iii) cutting while avoiding the reduction of onion bulb into too small pieces.

By taking into account these improvements, the loss of anti-oxidants during cooking operations could be significantly reduced.

3.3.2. Cooking Methods Used and Cooking Time of the Bulbous Onion in the Households Surveyed

The different cooking methods of the onion bulb used by the respondents are presented in Table 4.

Table-4. Modes, time and cooking temperature of the onion bulb among the respondents (n =184).

Onion bulb cooking method among respondents	Number of households surveyed practicing it	Percentage
Cooking with oil and then with water	184	100 %
Cooking with water	117	63,59 %
Oil cooking	49	26,63 %
Steam cooking	20	10,87 %
Braising	13	07,07 %
Muffled cooking	5	02,72 %

Note: Duration of cooking: between 30 minutes to 3 hours.
Cooking temperature: uncontrolled.
Source: Field work data.

The data show that frying followed by cooking with water is the one most practiced by the households surveyed (100% of the respondents).For 63.59% cooking is done with water and 26.63% of the households surveyed are oil frying. Steaming and braising are used respectively by 10.87% and 07.07% of respondents. As for the braising, it is used only by 02.72% of the households surveyed.

It is noted that heat processing is the common factor in all these practices. Heat causes loss of antioxidant compounds such as carotenoids and vitamin C. This loss is explained by the sensitivity of these compounds to heat and oxidation as shown [47]. Cooking time is also a factor that could contribute to the decline the antioxidant content of onion bulbs. Indeed, Renard and Chervin [47] have shown that the importance of losses during cooking depends on the time-temperature pair: the higher the cooking temperature and the longer the duration, the more the destruction of the heat-sensitive compounds is important. This destruction can reach 95% of the content with regard to vitamin C. In the case of the consumers surveyed, the possible losses of antioxidant compounds could be explained by maladjustment of the time-temperature pair: the cooking times (30 min to 3h) are sufficiently long to cause losses. Indeed, Eduvigis, et al. [52] showed that for a heat processing up to 100 ° C, the cooking time should be 11-17 minutes to maintain a good antioxidant capacity. The time-temperature pair must therefore be taken into consideration when cooking the onion bulb. For a high cooking temperature, the time should be short and vice versa.

4. Conclusion

This study shows that: (i) certain cultural practices, namely the use of chemical fertilizers and chemical pesticides, (ii) room storage conditions such as temperature, relative humidity, oxygen and carbon dioxide content, (iii) culinary practices such as peeling, cutting, washing, cooking time and cooking temperature, are a combination of factors that could contribute to a decrease in the antioxidant content of onion bulbs. Therefore, the use of an organic farming, the conservation of the onion bulb under ideal conditions of storage (temperature of 0 °C, relative humidity between 65 and 70%, limitation of the respiration of the bulb by reducing the degree of oxygenation in the storage room and increasing the carbon dioxide content); the use of appropriate cooking process (peeling only external dry scales, washing peeled bulb before cutting, cutting onion bulb into big pieces, cooking time from 11 to 17 minutes for a temperature under 100°C, cooking with water retention or steaming), could on the one hand maintained the antioxidant content of the bulb, and on the other hand, minimize losses in antioxidant compounds during the processing.

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