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ONION BULB CONSERVATION: CASE OF AN EXPERIMENTAL STUDY

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ABSTRACT

Storage losses of onion bulbs are enormous, hence the need to contribute to the search for solutions. Our experimental work on the conservation of onion bulbs with the "violet de Galmi" variety took place effectively in the thermal conditions of 24.21 ° C - 27.84 ° C, and hygrometry of 42.65% - 84.81%, in the storage room. The storage checking was done every week. This is a natural convection storage that lasted seven (07) months. At the end, 141.068 kg over 666 kg or 21.18% were lost. It highlighted the rate of rotten bulb contagion among the loss. This work has also highlighted the difficulty of determining the mass lost precisely.

KEYWORDS: onion, conservation, moisture content, hygrothermal properties.

1. INTRODUCTION

Seasonality of onion production in Sahelian countries requires storage for the benefit of producers and consumers. Indeed, at harvest the prices are very low (7500 CFA francs for the bag of 120 kg according to [1] and 100 CFA francs for the 1kg, according to [2] and a problem of slump arises. Three (03) to four (04) months after harvest, onion is becoming increasingly rare on the market and prices are rising, causing an increase of more than 700% (60,000 CFA francs per 120 kg bag, [1] and 700 CFA francs for the 1kg, [2]. At this time, the local producers do not have any more onions and they resort to importation from France, the United Kingdom or Morocco. Generally, garden crop production constitutes an off-season activity: Onion accounts for 43% of vegetable production [3]. Storage attempts face enormous losses: 35.2 ± 3.9% in three (03) months of storage [4], 59.32% of weight are lost in storage within a cement house, and 52.11% in a banco house in four (04) months of storage [5] .... This is due to the inadequacy of the technological conservation devices available, but also to the complexity of the conservation of onion bulbs. Indeed the conservation of onion bulbs depends on several parameters:

- The type of onion bulb (Variety) [6] and [7]**,**
- The technical route of production: irrigation [8], [9], [10],
- The technical route of harvesting, harvest time, the temperature at the time of harvest [11], leaf cutting, drying or curing [12],
- The composition of the bulbs, the number of external skin layers and the dry matter content [11],
- The management of the stock.

Another big handicap for the conservation of onion bulbs is the very high cost of energy and its unavailability. This is a hindrance for the practice of cold storage: conservation in controlled atmosphere, refrigeration.

Taking into account all the above, we designed and realized a device for the conservation of onion bulbs whose experimental study is presented here. The preserved onion bulbs are of the "violet de Galmi" variety acquired directly from producers.

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2. MATERIALS AND METHODS

2.1. Study of the water content of onion bulbs

In order to deduce the dry matter content, we determined their water content. This study was conducted in two phases: before storage and at the end of storage.

2.1.1. Before storage

The success of storage depends greatly on several parameters including the water content of onion bulbs. This is why it is important to know its value beforehand. So to determine its value, we took a quantity of bulbs that we cleaned **(Figure 1** (a)) and cut into slices. Using an electronic scale, a mass sample m_h (g) is taken. Then, this mass is placed in an oven at 70 ° C and left there for 24 hours to obtain a dry mass m_s (g). Using the formula (1), the water content is deduced.

$$w = \frac{m_h - m_s}{m_h} \times 100 \qquad (1)$$

From the water content, the dry matter content is deduced using the relation:

$$\tau = 100\% - w \qquad (2)$$

w is the water content,
m_h (g) is the mass of the sample in the wet state,
m_s (g) is the mass of the dried sample,
τ is the rate of dry matter.

By unavailability of the oven we had to first dry the onion slices in a solar dryer to prevent the sample from spoiling. Then, the drying had been completed as soon as the oven was available **(Figure 1** (b)).

(a)  (b)

Figure 1: (a) Cleaned bulbs (b) drying of onion slices

2.1.2. At the end of storage

The bulbs are sliced (**Figure 2 (a)**, and dried in the oven at 70 ° C for 24 hours 00. This is a complete dehydration of the sample. **Figure 2 (b)** and **(c)** correspond respectively to the beginning and the end of this operation.

Figure 2: sliced bulbs (a), oven with onion slices before (b) and after (c) drying

2.2. Conservation

The onion bulbs are acquired with the producers. After sorting, 666 kg were in good condition for storage, a lot of which is shown on (**Figure 3** (a)). The size of the bubbles is homogeneous. The bulbs were stored in trays organized in two rows. Each row consisted in three (03) racks superimposed and spaced with 50 cm distance between them to promote the circulation of air in the storage chamber **Figure 3 (b).**

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Figure 3: (a) sorted bulbs in racks (b) at the end of conservation

2.3. Mass loss

2.3.1. Solid mass

A follow-up of the conservation was organized. It involves periodically sorting the stock in order to eliminate the rotten and sprouted bulbs and to evaluate the loss of mass. Storage losses are characterized by the loss of mass that results in germination, decay and water loss. Thus, the periodicity of two weeks was initially defined for sorting. But with the effect of contagion by rotten bulbs, this periodicity was reduced to one week. At each sorting period, the sprouted and rotten bulbs are weighed separately using an electronic scale **(Figure 4).** The sum of the mass of sprouted and rotten bulbs gives the total solid mass.

Figure 4: Weighing the rotten or sprouted bulbs

2.3.2. Water loss

The loss of water corresponds to the mass of water evaporated through the product. its experimental study consisted in taking a quarter of the total quantity (666kg) or 166.5kg divided into three (55.5kg) on each of the trays of the West and placed at the bottom of the room for practical reasons. At the end of the month, the mass mi of the bulbs in good condition is determined by weighing. The difference between the mass mi-1 of the previous month and this mass mi is made. The masses mi and mi-1 are subtracted from the sprouted and rotten masses during the corresponding month.

$$P_{eau} = m_{i-1} - m_i \quad (3)$$

P_{eau} is the loss of water (kg)

2.4. Hygrothermal parameters of the conservation chamber

The thermo-hygrometric environment in the storage chamber determines the quality and performance of the bulb storage. This is why it is essential to have the means to master it and to determine the characteristic parameters (temperature and humidity of the air). This atmosphere was evaluated thanks to a data logger hygrometer **(Figure 5)** which simultaneously records the temperature, the dew point and the relative humidity with respectively the uncertainties of ± 1 ° C, ± 2 ° C and ± 3%.

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Figure 5: photograph of the Hygrometer

3. RESULTS AND DISCUSSIONS

3.1. Water content of bulbs

The water content determined prior to the conservation of the onion bulbs and that determined at the end of the conservation experiment are shown in *Table 1.*

The rates of dry matter content, found through this study: 12.01 ± 0.3% and 15.80 ± 0.4% *(Table 1)* is included in the 7% and 18% range found by [13]. Also with reference to the more recent results reported in *Table 2*, we can say that the dry matter content is satisfactory because only [5] and [14] had maximum values (21.15% and 20.80%) significantly different.

There is a decrease in the water content from 87.99 ± 2% to 84.20 ± 1.6% and therefore an increase in dry matter from 12.01 ∓ 0.3% to 15.80∓0, 4%. It could be said that this difference in water content (87.99% vs. 84.20%) is due to pre-drying in the solar dryer, which has certainly allowed the formation of a cutaneous membrane which does not facilitate the migration of water during the total dehydration in the oven. But, referring to the scientific literature, we note that it is not the only reason because for [15] they found that the water content gradually decreases from 88.91% in 15 days storage to 86.56% in 90 days storage. [16] Showed that water content decreased from 86.85% to 83.71 in 12 weeks and [17] also found that water content decreased from 85.75 ± 1.00 to 83.99 ± 1.0 in two months.

Table 1: Water content and dry matter

	Wet Mass m_h (g)	Dry mass m_s (g)	Water Content w (%)	Rate of the dry matter τ (%)
Before storage	1692.9 ∓0.1	203.3 ∓0.1	87.99 ∓2	12.01 ∓0.3
After storage	500 ∓0.1	79 ∓0.1	84.20 ∓1.6	15.80∓0.4

Table 2: Moisture content and dry matter value in the literature

Autors	Moisture content %	Dry matter content %
[5]	78,85 to 86,95	13,05 to 21,15
[18]	82,02 to 86,77	13,23 to 17,96
[19]	87 to 88	12 to 13
[14]	79,20	11.40 to 20.80
[20]	86.24	13,76
[21]	85,9 to 91,6	8.4 to 14.1
[17]	86.60	13,4
[22]	84,4	15.6
[15]	88.91	10.08

3.2. Hygrothermal properties of the storage chamber

Figure 6 (a), (b), (c), (d), (e) and (f) present the hygrothermal environment in the storage chamber for six months (July, August, September, October, November and December) except the month of June because of the unavailability of the hygrometer.

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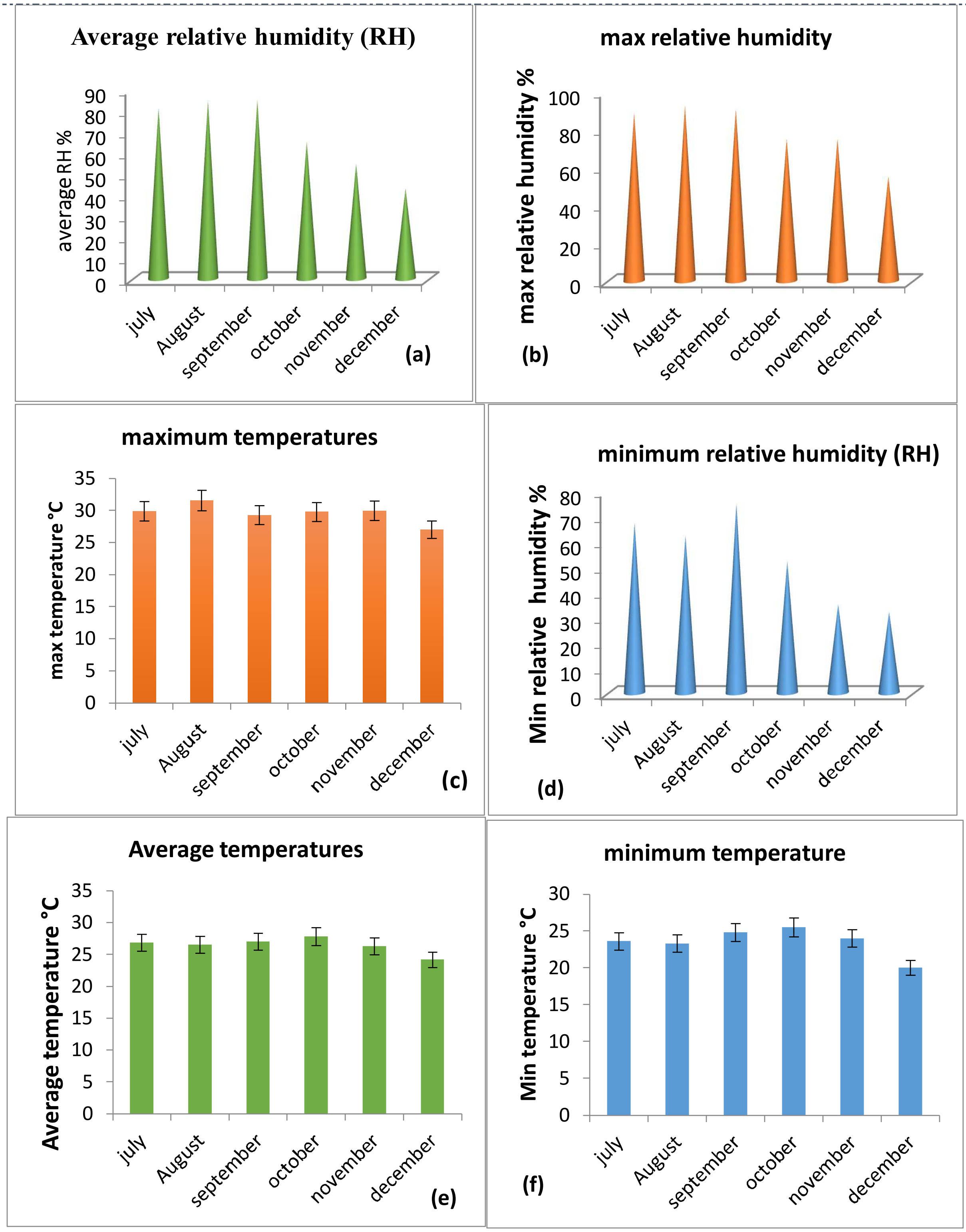

Figure 6: Mean Relative Humidity (a), Maximum (b) and Minimum Relative (c) and Average (d), Maximum (e) and Minimum (f) Temperatures in the Storage Chamber

The average relative humidity in the storage chamber increases (80.84%, 84.36%, 84.81%) for the first three months. However, during the last three months there is a decrease (64.93%, 54.39 and 42.65%). The same is true

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for maximum and minimum humidity. This phenomenon of variation of humidity follows that of the seasonal variation in Burkina-Faso where the wettest period is generally from July to September.

It can be noticed that it is only in October that the average humidity is in the optimum humidity range (60-75%) for the storage of onion bulbs. This shows that hygrometric insulation is not sufficient.

As for the average temperature in the storage room, it has a low increase from 26.85 ° C to 27.84 ° C from July to October with a slight decrease in August (26.57 °C) before decreasing until December to 24.21 °C. The temperature drop in August is due to cloudy clutter and generally abundant rainfall in this month. The temperatures are almost in the range of thermal comfort (25 -30 °C) sought for the conservation of onion bulbs.

The minimum temperatures vary in the same direction as the average temperatures. However, for maximum temperatures, it is found that the peak (31.6 °C) is obtained in August. This can be justified because in the absence of cloudiness, there may be high solar radiation.

3.3. Conservation-Storage-follow up

These results are shown in **Figure 7**. Note that there are two peaks of loss. A first peak occurs between August and September. A second peak occurs between late October and late November. In these same periods, the maximum number of rotten bulbs is recorded. Peaks of loss coincide with those of rotten bulbs. This shows the preponderance of decay on loss. The moments of high loss are those in which optimum storage conditions are not completely satisfied, with relative humidity averaging between 80% and 84.81% for the first peak (Figure 6 (a)). For the second peak, the relative humidity is less than 60% (Figure 6 (a) and (c)) and the temperature in the storage chamber has dropped below 25 ° C (Figure 6 (d) and (f)) .

The balance sheet gives 50,864 kg of rotten bulbs, 54.473 kg of sprouted bulbs. The water loss is 27.052 kg, i.e. a measured loss of 122.088 kg or 18.33% loss. The overall balance making the difference between the initial mass and the final mass gives 141.068 kg or 21.18%. It can be seen that there is a difference of 2.85% between the measured lost mass and that resulting from the global balance sheet. This difference is due to the fact that there are lost masses that cannot be measured. In particular, the mass lost in the form of liquid secreted by the rotten bulbs and the mass lost by the effect of drying rotten bulbs during the period of low relative humidity.

In two hundred and seven (207) days, about seven (07) months of storage in the solar cell, 21.18% mass loss was recorded.

Authors like [7] and [23] have achieved results similar to ours. Indeed, [7] were able to store in 6 months the varieties of the creole group with an average of 20-30% loss and [23] could limit the loss to 20% in 4-5 months of conservation of one of the four devices they tested. Meanwhile, we recorded 21.18% loss in 7 months of storage in the solar cell. However others have found results worse than ours: [24] suffered a loss of 33.62% in just three months of conservation in natural ventilation. For [5] the loss reaches 59.32% in four (04) months. [6] found that by keeping the onion bulbs of the yellow sweet Spanish and Azarshahr varieties the total loss was respectively 41.86% and 21.4% in 3 months.

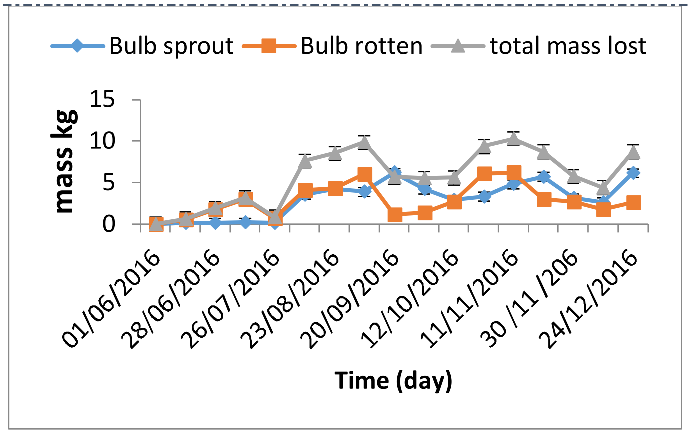

Figure 7: Evolution of the sprouted mass, rotten and the total mass lost

3.4. The loss of water

It gradually increases during storage Figure 8. The water loss is very low between July and August certainly because of the abundant humidity, combined with the low mobility of the air and the lowering of the wind speed. The mass of water lost is increasing dramatically between the end of October and the end of December. At this time of year the air becomes dry (relative humidity down to 35% Figure 6 (c)), the wind speed increases.

This dry air could be at the origin of a drying phenomenon. This leads to increased water loss of the bulbs. Taking into account the rot and germination loss (**Figure 8**), the period from November to December is unsuitable for conservation and should correspond to that of stock sale. The loss of water led to a mass loss of 27.052 kg.

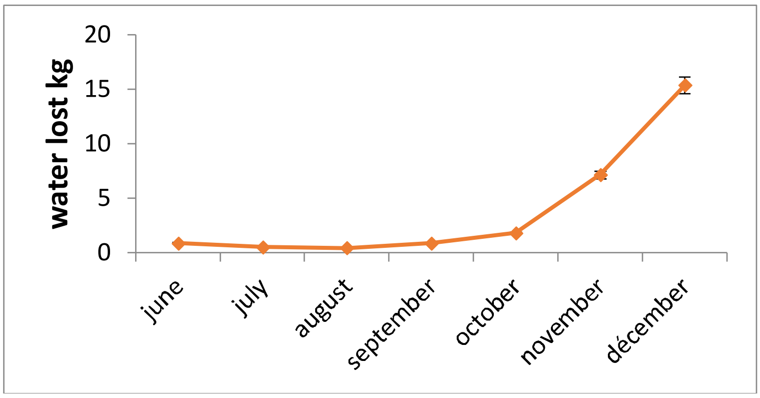

Figure 8: Evolution of mass loss due to water loss of onion bulbs

3.5. Effect of rot contamination

One of the parameters aggravating rot loss is contagion. Indeed, when the rotten bulbs are not quickly detected, their decomposition generates a liquid **Figure 10** (especially before the first six months when the bulbs always contain a "high" rate of water) which humidifies the healthy bulbs resulting in the same way their deterioration as shown in **Figure 9**. Therefore, to reduce the influence of contagion, it is desirable to reduce the intervals between sorting. Instead of sorting every two weeks most often, switch to weekly sorting.

Figure 9: Presentation of the contagion effect by decay

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Thus, to study the effect of contagion on the loss of mass by decay, the bulbs moistened by the liquid of those in decomposition are set aside at each sorting and kept until the end of conservation. The balance is done every month. This made it possible to know periodically the contaminated but not spoiled mass, shown in **Figure 11**. Contamination is critical in August, obviously because of the excess moisture of the air which causes rot; paired with the high water content of the bulbs at this time, which produce the "contaminating" liquid (**Figure 10**). The influence of contagion falls very quickly after August. The rotten bulbs dry up, but no longer moisten to finally secrete the liquid responsible for the contamination.

Figure 10: Rotten bulbs containing the liquid responsible for the contamination of the neighbors

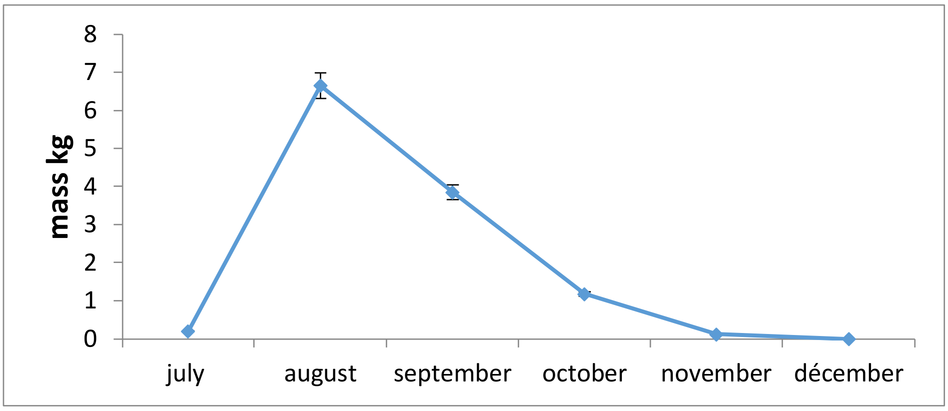

Figure 11: Evolution of contagion during conservation

3.6. Difficulties

3.6.1. Difficulties of follow-up

The rotten bulbs are not always detectable by the sight, nor the touch because according to their positions, the visible part may not present an aspect of degradation whereas the hidden part has begun to rot, as testified by the images of the photograph (**Figure 12**) which show the faces of the rotten bulbs where a, b, c present the non-rotten sides a ', b' and c 'present those rotten.

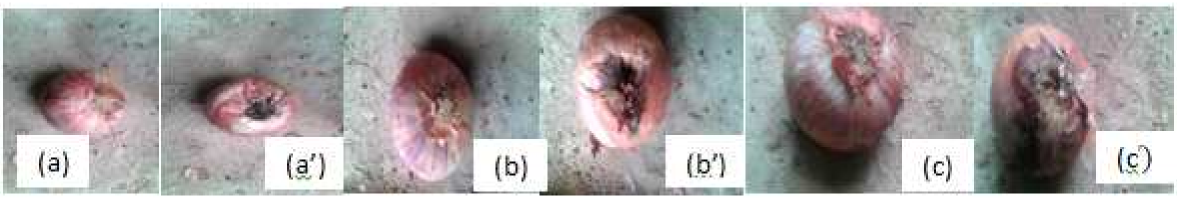

Figure 12: Difficulties in detecting rotten bulbs

3.6.2. Difficulties of the study of the lost masses

The mass losses studied are tainted by errors. During the very humid period (August-September), the rotten bulbs secrete a liquid which cannot be taken into account in the lost mass weighing because it flows to humidify the neighboring bulbs. In a less humid period, rotten bulbs dry out **Figure 13** (c). So this mass cannot be taken into account in the calculation of rotten mass. Also when the bulbs germinate or germinate and rot, there is loss of fluid and weight gain (new foliage) if the bulbs do not rot **Figure 13** (a), (b). These gains or loss of mass are also sources of error. Thus, the study of germinated, rotten masses and water loss are all subject to inevitable errors. So the most accurate balance is that done at the end of conservation, that is to say the lost mass.

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Figure 13: (a), (b), (d) Sprouted bulbs with leaves (c) dry rotten bulbs

4. CONCLUSION

In the context of the conservation of onion bulbs, the critical period with negative influence due to the high relative humidity of the air is that going from August to September respectively with an average humidity of 84.36% and 84.81 %. Conversely, the period of negative influence due to the low humidity is between November (average relative humidity 54.39%) and December (average relative humidity 42.65%). This is because the optimum humidity is 60% to 75%.

As for the temperature whose average is between 24.21 ° C and 27.84 ° C, it does not negatively influence the conservation because its average deviates very slightly from the optimum interval (25 ° C to 30 ° C). C).This thermal performance of the conservation chamber is explained by its good thermal inertia.

At the end of seven (07) months storage of 666 kg in the solar cell, 141.068 kg (rotten bulbs, sprouted bulbs and water loss) or 21.18% are lost.

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