

## Influence of peeling and the drying method of *Curcuma Longa* Rhizome on its drying speed, antioxidant and sensory properties

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### Abstract

This work provides information on the influence of drying method on the antioxidant and organoleptic properties of *Curcuma longa*, known as turmeric, Indian saffron, yellow ginger. The study is carried out on rhizome, peeled and unpeeled, dried directly in the sun and indirectly in a dryer box. The antioxidant activity is measured by the DPPH method. The hedonic test is implemented to evaluate the appreciation of sensory characteristics. A rating scale ranging from 0 to 9 is used to assess separately the taste, color, smell. A ranking order is given by each tasting judge.

The peeled rhizome dries after 27 hours of exposure to the open air and 24 hours in the dryer box ; the samples' final water contents are respectively 8.7% and 8.5%. The unpeeled rhizome dries after 30 hours of exposure to the open air and in the dryer; their respective water contents are 9% and 11%. In both methods, turmeric loses almost half of its weight.

In powder and essential oil form, the antioxidant activity is better preserved in indirectly dried samples. Regardless of the drying method, the antioxidant power of the essential oil is low, only between 1/3 and 2/3 of that of the powder. Indirect drying and not peeling seem to have a positive influence on color while peeling provides an odor and taste appreciated by consumers.

**Keywords:** *Curcuma longa*, peeling, direct and indirect solar drying, antioxidant capacity, organoleptic properties

### Introduction

Currently, scientists have investigated in the nutritional and medicinal properties of foods, condiments and spices for their beneficial effects on health. Spices are used in all seasoning food preparation to improve taste, give color, but also provide essential compounds. Thanks to their biologically active constituents, they reduce the risk of developing cardiovascular diseases, cancers such as colon cancer and age-related degenerative diseases (Chu *et al.*, 2002 [3]; Oboh *et al.*, 2009) [13].

The lush vegetation of Madagascar contains a diversity of spices, some of which have a well-established reputation. The best known are vanilla, ravintsara, cloves, turmeric, ginger, niaouli, cinnamon, pepper seeds, etc... Most of them are renowned for their beneficial effects. *Curcuma longa* is known by different names: *Indian saffron* (in French), *safran Peï* (in Réunion Creole), *tamotamo* (in Malagasy), *turmeric*, *yellow root* (in English) (Lamouche, 2011 [12]; Denys, 2013) [5]. Multitude of therapeutic virtues are detected in its rhizome, it is used to empirically treat or cure different illnesses: skin diseases, headaches, intestinal disorders or colds (Razafindrazaka, 2012) [14]. For several years, scientists have suspected this plant of having a preventive effect against the development of carcinogenic cells, and of stimulating the immune system, particularly against Alzheimer's disease (Bleu *et al.*, 2011) [2]. It is also recognized for its antioxidant properties and its coloring power. Its strong antioxidant and anti-inflammatory properties make it a potential candidate for prevention and treatment of cancer or other chronic diseases (Denys, 2013) [5]. But its use is mainly intended for food, its rhizome is used as dried powder or whole. Although it is an ingredient for making curry, this spice is little used in Malagasy recipes.

The essential oil sector has strong socio-economic potential for our country because aromatic plants in Madagascar are

numerous and have good qualities. This form is starting to develop but still occasionally used and considered luxurious product. Benefits of essential oils were highlighted during the period of the COVID pandemic recently. Ar-turmerone, the majority component of this oil, gives its high antioxidant activity (Denys, 2013) [5]. *Curcuma longa* oil has a hypocholesterolemic effect and prevents damage to liver tissues (Ling, 2012). However, these benefits could be compromised by the rhizome's pre-treatment. To date, no standard exists on the quality of whole, powder or essential oil of turmeric, which facilitates trade and protects consumers (Codex alimentarius, 2018). This is how this study was carried out in order to define qualities (marketable, nutritional, organoleptic and hygienic) of turmeric grown in Madagascar. It aims to contribute to the establishment of such a standard. Particularly, it is a question of evaluating the combined effects of drying and peeling on rhizome quality i) on its antioxidant capacity, ii) on the essential oil concentration, iii) on the sensory characteristics.

### Materiel and methods

#### 1. Plant material

The rhizome of *Curcuma longa* (Zingiberaceae) is collected in Beforona Moramanga (Madagascar, Alaotra Mangoro region). This collection area is known for the cultivation of ginger and turmeric. Samples are collected from the same field to avoid variations linked to edaphic and climatic conditions.

In order to determine the type of treatment which gives the best drying speed while maintaining better physico-chemical quality, tests are carried out to compare the quality of turmeric dried directly under the sun (S) and that passed in a indirect solar dryer (I).

## 2. Sample preparation

The samples are sorted, cleaned in water, drained, then divided into 2 ; one part is peeled manually using a knife (P), another part kept as is (unpeeled or U). In order to maximize the evaporation surface, the rhizomes are sliced into thin strips and spread evenly on racks. After preliminary tests, the loading density of the racks is set at 700 grams and is carried out on rectangular racks, 2 m long and 1 m wide, the meshes of which allow air to pass through. A rack is exposed directly to the sun (S), 3 others spread over 3 floors of the indirect solar dryer (I) and whose

arrangement is as follows: one located on the lowest level, just above the heat duct or level 1 ( $I_1$ ), the second located halfway up the dryer corresponding to the level 5 rack ( $I_5$ ) and the last located far from the heat duct, corresponding to level 9 ( $I_9$ ).

Thus, 4 types of treatment are studied

- Peeled rhizome dried directly in the sun (PS)
- Indirect dried peeled rhizome (PI:  $PI_1, PI_5, PI_9$ )
- Unpeeled rhizome dried directly in the sun (US)
- Unpeeled rhizome dried in indirect dryer (UI:  $UI_1, UI_5, UI_9$ )

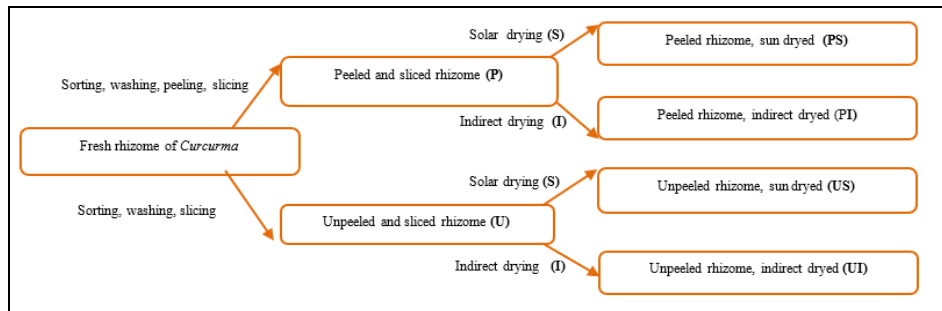


Fig 1: Drying process of the turmeric rhizome

## 3. Evaluation of the drying method on moisture content and yield

### 3.1 Comparison of moisture content depending on the drying method

The effectiveness of the drying method used (outdoors in the open air or in a dryer box) is monitored through two indicators: the temperature on the rack and the turmeric's water content. A thermometer is permanently placed on each rack, at different levels and on the one exposed to the sun. Temperature readings are done every 3 hours on each rack, before samples are taken to determine the dry matter content (DM) which is done in triplicate (ISO, 2021). Rhizomes are considered dry when moisture content is less than 12% (ISO, 1983).

### 3.2 Determination of drying yield

A quantity of rhizome is weighed before drying, after each processing operation and at the end of drying to establish the material balance which is obtained by the ratio of the final weight to the initial weight.

### Sample packaging

Once dried, half of the samples are reduced to powder using a grinder (Blender Robot coupe: GT 500), according to the methodology of ISO 2825-1981 (ISO, 1981), in which 98% of the powder passes through a 500  $\mu\text{m}$  mesh. The other half is preserved in the form of dried rhizome. The powders and dried rhizomes are placed in hermetically sealed containers to protect them from air oxidation. Both are used for all analyses.

## Study of the physicochemical quality of turmeric

### 1. Extraction of essential oil

Essential oils are all volatile compounds carried by water vapor in a part of plant. The hydrodistillation method using clevenger type equipment is used to extract volatile substances as described by standard ISO 6571-2008 (ISO, 2008). Approximately 100 g of dry rhizomes of *Curcuma longa* are used for each extraction. The yield Y (%) of an

extraction is calculated by the ratio between the mass of the essential oil extracted and the mass of the raw material.

### 2. Evaluation of antioxidant activity

Sample's antioxidant activity is determined by the 2,2'-diphenyl-1-picrylhydrazyl or DPPH (oxidants), it is a direct measurement described by Serpen (Serpen *et al.*, 2007) <sup>[15]</sup> to which some adaptations were made (Ranovona, 2012). A calibration curve is first established by preparing a range of solutions of Trolox (synthetic antioxidant which is a structural analogue of vitamin E). Then, 20  $\mu\text{l}$  of each daughter solution is added with 1.7 ml of the 10<sup>-4</sup> M DPPH solution and then the mixture is shaken quickly by vortexing. Absorbances are measured at 517 nm using a spectrophotometer against methanol as a blank. For the sample, 20 mg of powder are put in a test tube protected from light and added 1.7 ml of DPPH solution, vortexed, centrifuged. After 30 minutes, the optical density (OD) is read at 517 nm. Antioxidant activity is expressed in micromole Trolox equivalent per gram of dry matter ( $\mu\text{mole TE/g DM}$ ).

### Study of organoleptic quality

The effects of the different treatments (peeling and drying method) are evaluated on the sensory properties and acceptability of the turmeric powder. Five samples are presented monadically to 20 initiated judges. A scoring test and a ranking test are carried out according respectively to ISO 6658: 2017 (ISO, 2017) and ISO 8587: 2006 (ISO, 2006). Each judge must express their opinion on a 9-point rating scale based on the criteria mentioned (taste, color, smell). A ranking order is given by each jury member based on the overall assessment indicated by the rank. Then, Friedman's test is used. The samples are presented in an identical manner, anonymously, used in Cantonese rice. In addition to the 4 samples from the 4 treatments mentioned in paragraph 2, a control sample (T) is also used, this is turmeric purchased on the market.

**Results and discussions**

**1. Evolution of the temperature and dry matter content of the rhizome**

Drying starts at 12 p.m. high temperatures are recorded during the day, both for solar drying and indirect drying. The thermal peak observed in the sun is between 30-37°C, and near 60°C in the dryer box. It corresponds to a period of strong sunlight during the morning, between 11-14 h P.M.

In the sun, at the beginning of exposure (at 12 P.M.), the average temperature noticed is 36°C, it gradually decreases until reaching 17°C at midnight followed by a slow gradual rise to reach again a peak of 37°C at 12 P.M. the following day. The same variation trend is observed as the previous day.

Inside the dryer box, during the period of strong sunlight, the temperature can go up to 52-60°C and also decreases when the ambient temperature drops but remains higher than this. The rack closest to the solar collector is the warmest and the one furthest away is the least hot. However, during the night, when it is below 20°C, the temperature inside the dryer box is lower than that outside. The rack furthest from the heat pipe is always the coldest. Inside the dryer, a difference of up to 4°C is recorded between the lowest rack and that in middle position (1 and 5), and 8°C between rack 1 and rack 9. The same variation of temperature is observed both for the 2 types of peeled or unpeeled samples.

Concerning the water and DM content, initially, the fresh rhizomes are very rich in water, 87.67% for US (*i.e.* 12.33% DM) and 83.49% for PS (16.51% DM). During the period of strong sunshine, water loss is progressive, then slows down when the temperature drops. Rhizomes are considered dry when DM is less than 12% (ISO, 1983).

**1.1 Unpeeled rhizome**

When the rhizome is exposed to the sun, the humidity drops from 88% to 9% after 30 hours. In the dryer box, the

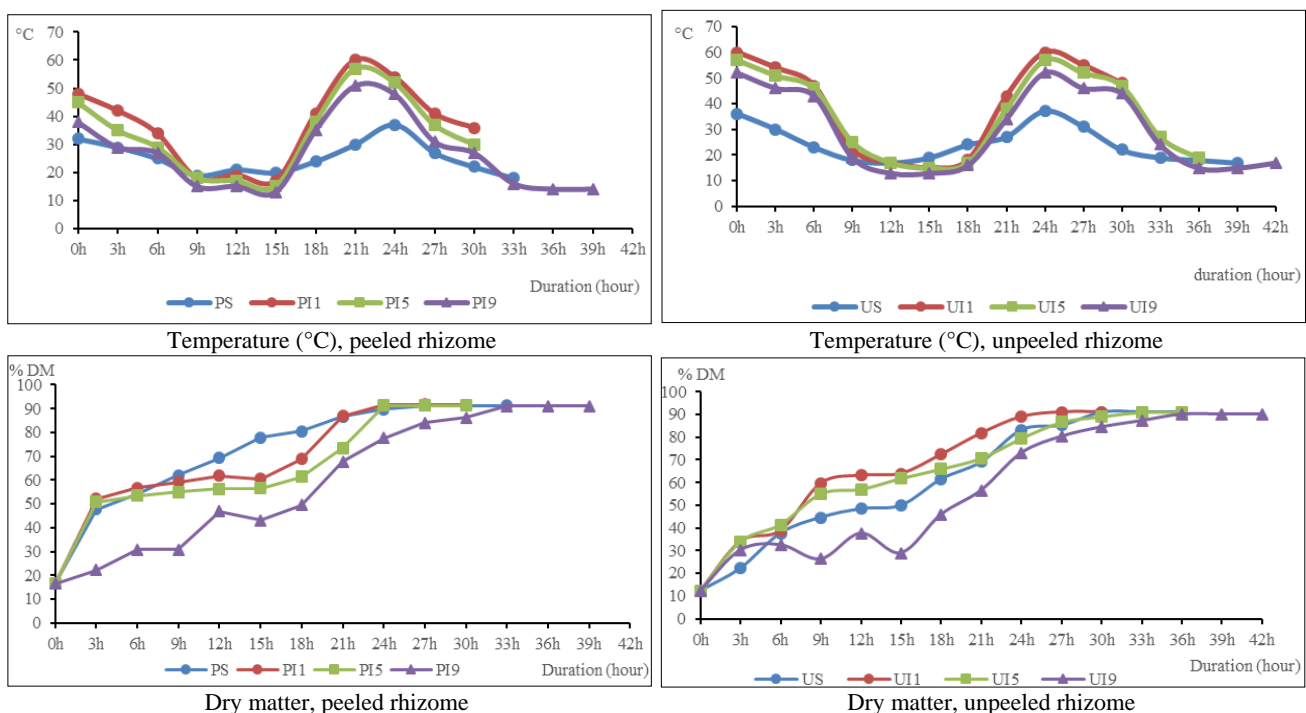
samples exposed on rack 1, closest to the solar collector, have the lowest water content 9%, reached in 27 hours; those placed on rack 5, in intermediate position, have a humidity of 9%, reached in 33 hours; those placed on rack 9, further away from the sensor, reached this value in 36 hours.

**1.2 Peeled sample**

Humidity drops from 83.5% to 8.8% after 27 hours of exposure to the sun. The initial water content is the same for the three levels of racks (83%) but the drying time and the final humidity are different: samples exposed on rack 1 and 5, the closest and in the intermediate position of the sensor solar, have a low final water content of 8%, reached in 24 hours; those placed on rack 9, further from the sensor, have a humidity of 8.8%, obtained in 33 hours.

Thus, sun drying during the dry and hot period requires 27-30 hours of exposure. For samples introduced into the box, the speed of water loss depends on the position of the racks in relation to the heat pipe. The rhizomes placed on rack 1 took 3 hours less than those in the sun. Those at level 5 peeled dry quickly, exceeding 90% DM after 24 hours; while unpeeled ones are only dried after 33 hours. Finally, those placed on rack 9, further away from the sensor, are considered dried after 33-36 hours.

Depending on the intensity, duration of sunshine and wind speed, the drying speed can vary and influence the quality of the rhizome obtained. The water content gradually decreases. After drying, stable values at the end of process are less than 12%, threshold value for good conservation (ISO, 1983). Furthermore, drying in the sun is faster by peeling the sample. The use of the indirect dryer and the location of the samples at the level closest to the sensor have the advantage of a short drying time with minimal humidity.



**PS:** peeled, solar dried **PI1:** peeled, indirect dried, rank 1 **PI5:** peeled, indirect dried, rank 5 **PI9:** peeled, indirect dried, rank 9  
**US:** unpeeled, solar dried **UI1:** unpeeled, indirect dried, rank 1 **UI5:** unpeeled, indirect dried, rank 5 **UI9:** unpeeled, indirect dried, rank 9

**Fig 2:** Evolution of temperature (°C) and dry matter (g%) depending on the duration (hours)

## 2. Drying Yield

The average drying yields are evaluated on four batches of 7 kg of fresh rhizome each. Peeled samples show a lower yield, the rhizome loses almost 2/3 of its fresh weight if it is peeled and more than half if it is not. The yield appears not depending on the type of drying even if rhizomes indirectly dried keep higher weight.

**Table 1:** Processing and drying yields of turmeric rhizome (% based on fresh material)

Step	Peeled rhizome		Unpeeled rhizome	
Sorting - Washing	100,0		100,0	
Peeling	78,36		-	
Slicing	77,24		98,85	
Drying	solar	indirectly	solar	indirectly
	36,72 (PS)	36,94 (PI)	49,01 (US)	49,85 (UI)

## Essential oil yield

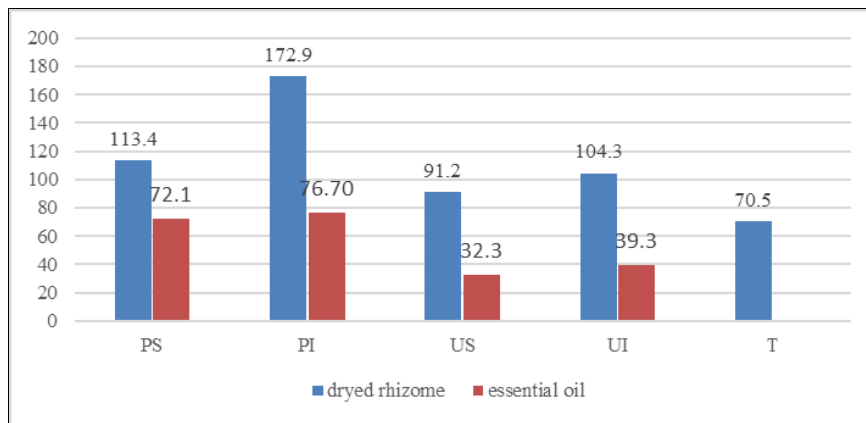
The extraction of essential oils by hydrodistillation from dry rhizomes permitted to collect 4 types of oil. Higher concentration of oils are noticed in peeled rhizomes whatever the drying method, respectively 0.32% for PS and 0.37% for PI. Those of unpeeled samples have a slightly lower yield, 0.28% for US and 0.25% for UI

**Table 2:** Essential oil yields (Y%)

Sample	PS	PI	US	UI
% Dry Matter	0,32	0,37	0,28	0,25

## Antioxidant activity

The measurement of the antioxidant capacity is carried out on dried rhizomes and on essential oils. Method of preparation clearly influences the total antioxidant capacity.



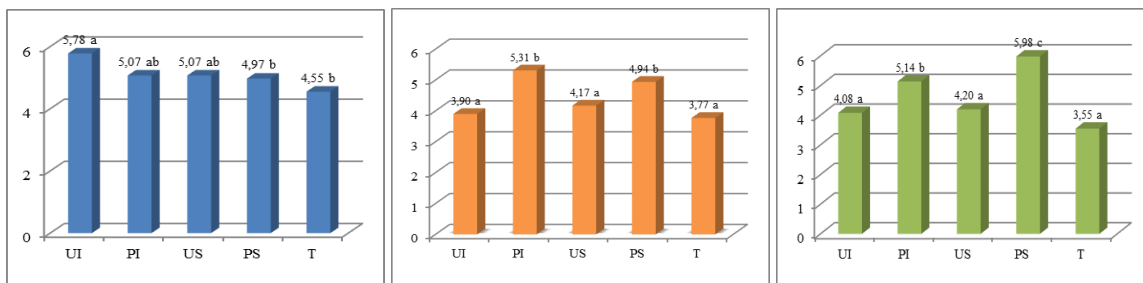
**Fig 3:** Antioxidant capacity of rhizomes and essential oils (in μmol TE/g DM)

The antioxidant capacity seems depending on peeling because peeled rhizomes have overall higher activity than unpeeled. This data seems to indicate that the antioxidant constituents are located in the pulp and not in the skin. However, indirect drying exerts a conservative effect on these molecules, because samples placed in the dryer box (PI, UI) have higher antiradical activity than those dried in the open air (PS, US). Thus, use of the solar dryer better preserves antioxidant activity. Compared to a commercially sample used as control (T), the samples studied have more anti-radical activity. In essential

oil form, between 1/3 and 2/3 of this activity remains. This result can be explained by the fact that essential oils are obtained by hydrodistillation, the extraction temperature makes some biomolecules sensitive. Also, essential oils are volatile. hydrodistillation does not remove all the antioxidant constituents in the rhizome.

## Organoleptic characteristic

The sensory evaluation based on three criteria (taste, smell and color) are given below.



**Fig 4:** Average scores obtained by each product on each criterion

The judges' assessment of color is reflected by an average score of 5.78 for UI which stands out significantly from the other samples, the control sample (T) has the lowest score with 4.55. Thus, indirect drying and/or unpeeling allow the samples to keep a better color. It is thought that the higher temperature resulting in a warm atmosphere less rich in oxygen and the lack of peeling would be less favorable to

the action of polyphenol oxidase and would thus allow the rhizomes to keep their color. The smell of PI is appreciated, followed by PS and in last position is the sample T. It is recorded that peeled samples have significantly higher scores than unpeeled samples. The smell is significantly better when rhizome is peeled. Peeling

Regarding taste, the peeled samples have high averages with respectively 5.98 (PS) and 5.14 (PI). The T sample represents an average of 3.55. Peeled samples have the significantly most appreciated tastes. According to the comments collected, peeled turmeric (PS) has a moderately pronounced taste (and therefore more appreciated).

Thus, indirect drying and not peeling positively affects colour the color while peeling significantly permit to

acquire better smell and better taste. The overall preference of the panel is reflected by the ranking. The first position is assigned to PS then PI followed by UI, US and finally T. Overall, the peeled samples are more appreciated. By applying Friedman's formula, there is a significant difference between each item. When comparing the products 2 to 2, each product is valued significantly differently from each other.

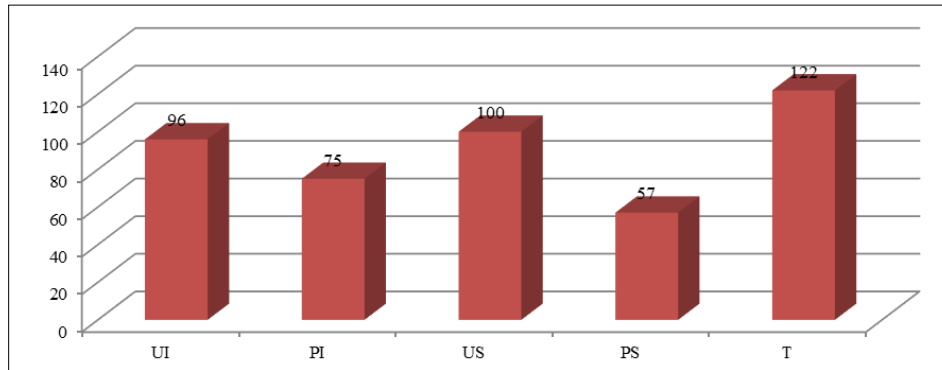


Fig 5: Sum of product ranks

### Conclusion

This work underlines the effects of the drying method and the pretreatment of turmeric rhizome on its quality. It also gives information on the right process to apply for a suitable conservation.

Indirect drying allows rapid dehydration of the product and better protects the biomolecules. Indeed, the color is well preserved and the rhizome has a slightly higher antioxidant capacity than that directly sun exposed. However, the 2 drying methods make it possible to obtain a product of good quality and suitable for conservation (water content less than 12%). The rack located closest to the solar collector allows rapid drying compared to that located further away at which the drying speed obtained is comparable to that of traditional drying.

Peeling causes a greater loss of material but has the advantage of providing more essential oils and a higher antioxidant capacity, which seems to indicate that the molecules responsible for the anti-radical capacity and the essential oil are located in the pulp. It is also the peeled products which keep better "smell and taste", most appreciated by the judge.

Additional work must be undertaken to find other extraction processes in order to optimize the yield of essential oils, identify their constituents by gas chromatography and the identification and quantification of other compounds with an antioxidant activity. It is also important to check the level of microbial contamination after drying in order to establish a standard on the food quality of Malagasy spices.

### Conflict of interest

This work is entirely realized at the laboratory of Department of Food Science and Nutrition. The authors declare that there is no conflict of interest.

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