

MICROSCOPIC CHARACTERISTICS OF RHIZOMES OF *Curcuma longa* AND *Zingiber officinale* (Zingiberaceae) - A SELECTION OF LIGHT MICROSCOPY IMAGES

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Abstract

The Zingiberaceae, the ginger family, is a family of monocotyledonous herbaceous plants with creeping horizontal or tuberous rhizomes. The plants are aromatic, characterized by the presence of volatile oils and oleoresins. The Zingiberaceae are especially abundant in Southeast Asia and they have been widely used as spices, ornamental, or medicinal plants. The most important commercial spices in the family are ginger (*Zingiber officinale*), turmeric (*Curcuma longa*), green cardamom (*Elettaria cardamomum*) and black cardamom (*Amomum subulatum*), that also have a great number of health properties. Due to their use in the food and pharmaceutical industries, the microscopic analysis and other parameters of the whole rhizomes/powder of turmeric and ginger provide valuable information in the identification of the plant material, followed by biochemical analysis. In the current study, a microscopic analysis of ginger and turmeric rhizome was carried out to record some of the parameters of taxonomic relevance using a simple method.

Key words: ginger, light microscopy, microscopic images, rhizome, turmeric.

INTRODUCTION

Zingiberaceae is a family of monocotyledonous plants in the Order Zingiberales that includes perennial aromatic plants with horizontal rhizomes, comprising of about 53 genera and more than 1200 species, with pantropical, but mainly Indomalayan distribution (Pandey et al., 2023). The type genus of the family is *Zingiber* (ginger), the source of the aromatic “ginger root”, which is an important spice. The rhizome (underground stem) of the edible ginger (*Zingiber officinale*) is harvested every year and is used fresh or dried and ground into a powder. Similarly, aromatic rhizomes of *Curcuma longa* (turmeric) are used fresh or boiled in water and dried, then grounded into powder. The orange-yellow turmeric powder, rich in curcumin, has been used as a flavour and colouring agent in many Asian dishes since ancient times. Some other Zingiberaceae species have seeds used as a spice, for example *Elettaria cardamomum*, commonly known as green cardamom or true cardamom and *Amomum subulatum*, known as black cardamom. The rhizomes of *Zingiber officinale* and *Curcuma longa* contain volatile compounds (essential oil) and non-volatile compounds,

including oleoresin and other biological active compounds, some compounds have application in the pharmaceutical and cosmetics industries (Gird et al., 2009).

Other plants of the family have also important economic uses as source of food, condiments and spices, medicinal plants used in traditional medicine or the pharmaceutical industry, or as horticultural ornamentals.

Various parameters, including plant morphology, microscopy and phytochemical profiles of plant material or their powder are used to characterise the true plant material and ensure its quality using standard techniques (several reference books are listed in Amel, 2015).

The current study presents a microscopic analysis of fresh rhizomes of *Zingiber officinale* and *Curcuma longa* to record some of the parameters of taxonomic relevance using a simple method.

MATERIALS AND METHODS

The biological material was obtained commercially in June 2021 and in May-June 2022 and was brought fresh to the Laboratory of

Biology of the Faculty of Biotechnology (UASVM Bucharest) where the practical activity was carried out. A Micros Austria optical microscope equipped with an S-Eye 2.0 digital camera was used for the microscopic analysis, but some of the pictures were taken with a Sony digital camera (Sony Cyber-shot®, Carl Zeiss Vario-Tessar 5× zoom lens).

Wet mount slides of hand section or surface preparations were used according to the techniques described by Andrei & Paraschivoiu (2003) with or without staining (toluidine blue and iodine tincture). Relevant microscopic structures were identified using the descriptions found in the literature for *Curcuma longa* and *Zingiber officinale*: Abraham et al. (2018) for *Curcuma longa* and Aye (2020) and Prakash et al. (2011) for *Zingiber officinale*.

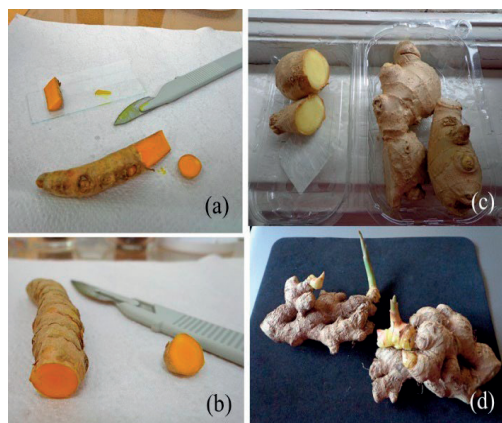


Figure 1. The biological material used in the present work: (a) rhizome of *Curcuma longa* (turmeric); (b)-(d) rhizome of *Zingiber officinale* (ginger)

RESULTS AND DISCUSSIONS

Microscopic analysis of turmeric rhizome

Images of the hand sections through the rhizome of *Curcuma longa* show several structures, as follows:

In transverse sections:

- epidermis formed by epidermal prosenchymatous cells can be seen;
- cork - made of 5-6 layers of cells (Fig. 2);
- cortical parenchyma - consisting of large, thin-walled parenchymal cells (Figs. 3-5);
- distinct endodermal cells (Fig. 6);
- the pith consists of parenchymal cells similar to those in the cortex.

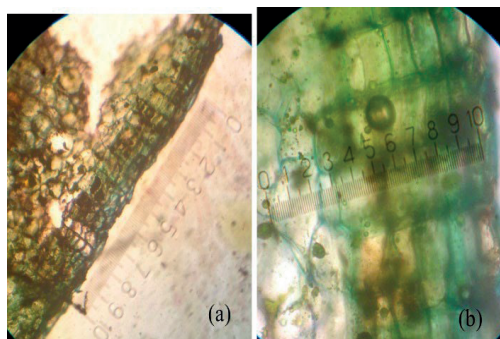


Figure 2. Microscopic images showing cork layers in a transverse section through the rhizome of *Curcuma longa* (toluidine blue stain), (a) ob. 10×, (b) ob. 40×

The microscopic images show parenchymal cells with bright orange oily content - oleoresin (curcumin and volatile oil) (Figs. 3, 4, 5, 7), as well as parenchymal cells containing yellow lipid droplets, which almost fill the cells (Figs. 3, 5, 8, 9).

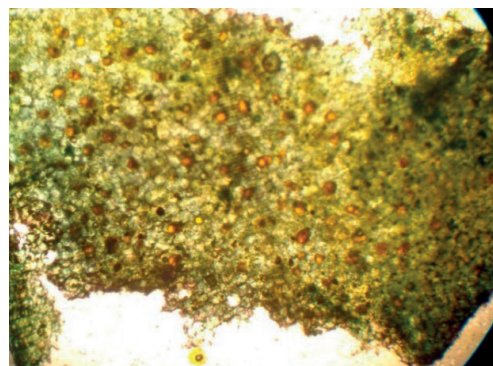


Figure 3. Transverse section through *Curcuma longa* rhizome - cork and cortical parenchyma

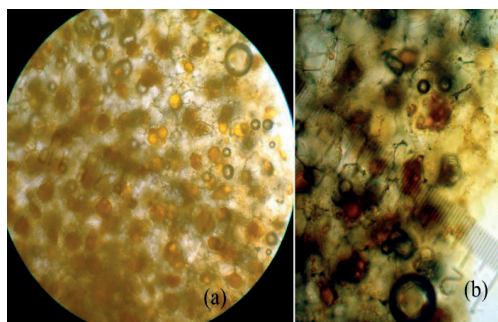


Figure 4. Transverse sections through *Curcuma longa* rhizome showing parenchymal cells with bright orange oily content due to curcumins, (a) ob. 10×, (b) ob. 40×

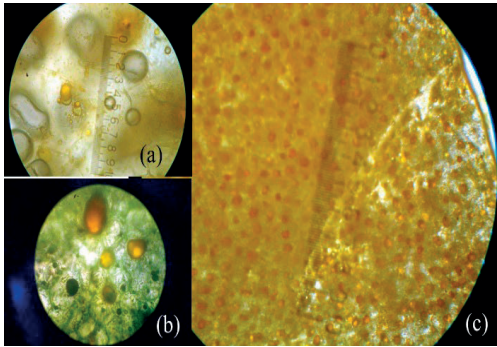


Figure 5. Transverse sections through *Curcuma longa* rhizome: microscopic images show the characteristic bright orange colour of curcumins (oleoresin) and the yellow colour of lipid droplets, (a)-(b) ob. 40×, (c) ob. 4×

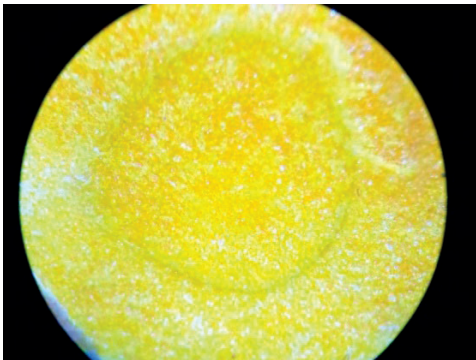


Figure 6. Transverse section through the rhizome of *Curcuma longa* - the endoderm is visible

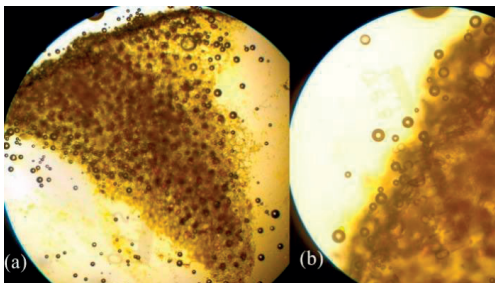


Figure 7. Light microscope images of transverse sections through *Curcuma longa* rhizome: (a)-(b) numerous dispersed oil droplets

Numerous starch granules are also present (Figs. 8, 9). Starch granules are simple, elongated, with the hilus towards the narrow end of the granule. The number and size of starch granules is an important character in the identification of *Curcuma* species (Abraham et al., 2018).

In the longitudinal sections, wide vessels with spiral thickening can be seen.

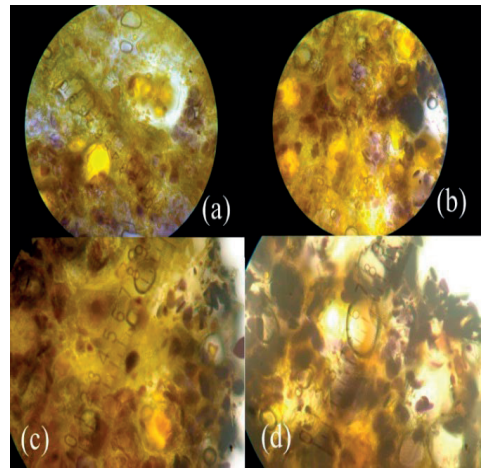


Figure 8. Light microscope images of transverse sections through *Curcuma longa* rhizome: (a)-(d) parenchymal cells with starch granules (stained violet with iodine tincture); (detail - ob. 40×)

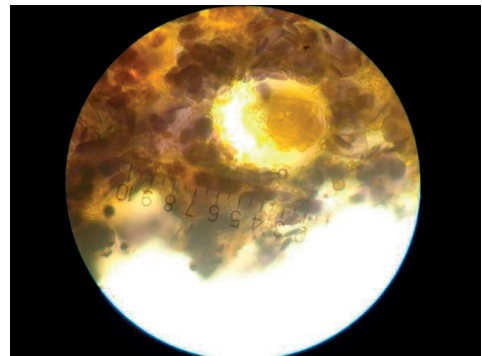


Figure 9. *Curcuma longa* rhizome – microscopic image of transverse section showing a parenchymal cell with yellow oily content and parenchymal cells filled with starch granules (iodine tincture, detail - ob. 40×)

Microscopic analysis of ginger rhizome

Surface preparations/hand sections of ginger rhizome (*Zingiber officinale*) showed several structures:

- cork on the the outside (Fig. 10);
- parenchyma that includes cells with yellow oil (oleoresins) and cells with starch granules (Figs. 11-14);
- abundant, simple, globoid starch granules, with a size of ~ 11 μm (Figs. 12, 14);

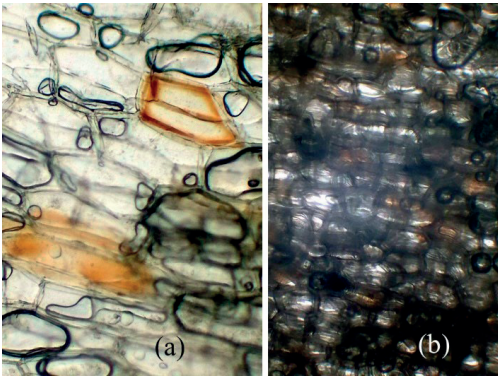


Figure 10. Light microscope images of ginger rhizome (*Zingiber officinale*): (a)-(b) cork cells in apical view

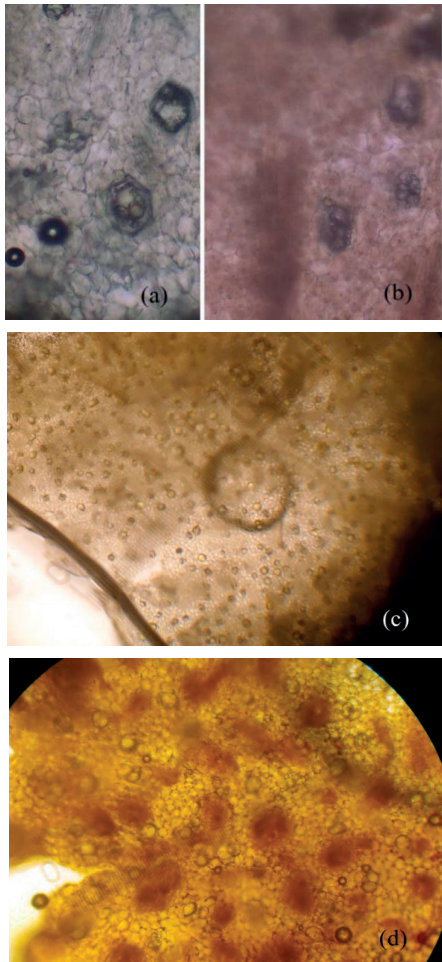


Figure 11. Different microscopic images in transverse sections through the rhizome of *Zingiber officinale*: (a)-(d) parenchyma cells with yellow oil and cells with starch granule

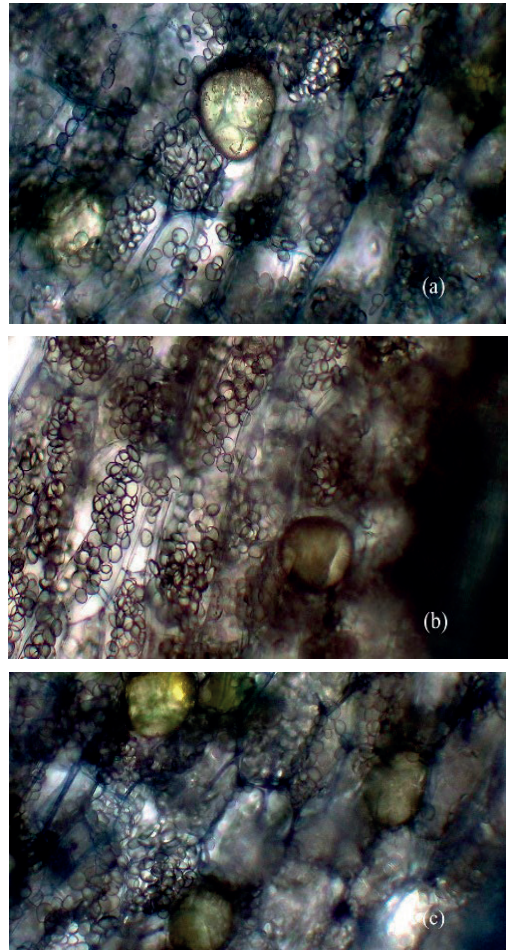


Figure 12. Light microscope images of longitudinal sections through the rhizome of *Zingiber officinale*: (a)-(c) amyliferous parenchyma and yellow oleoresins

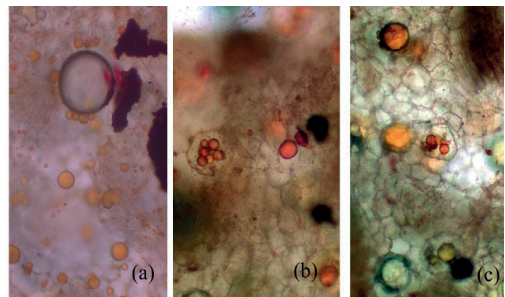


Figure 13. Sections through ginger rhizome: (a)-(c) microscopic images after histochemical staining for lipids (Sudan III)

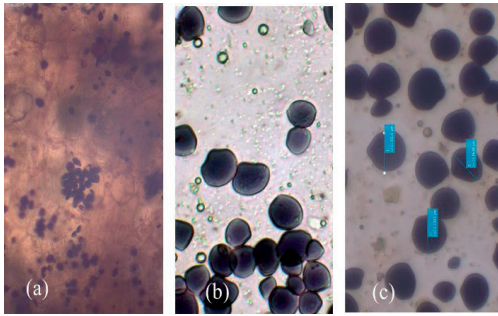


Figure 14. Section through the rhizome of *Zingiber officinale* (iodine stain): (a) amyliiferous parenchyma; (b)-(c) simple, globoid starch granules with a size of ~ 11 μ m

Figure 15 shows conducting vessels with spiral and annular thickening in longitudinal sections through the rhizome of *Zingiber officinale*.

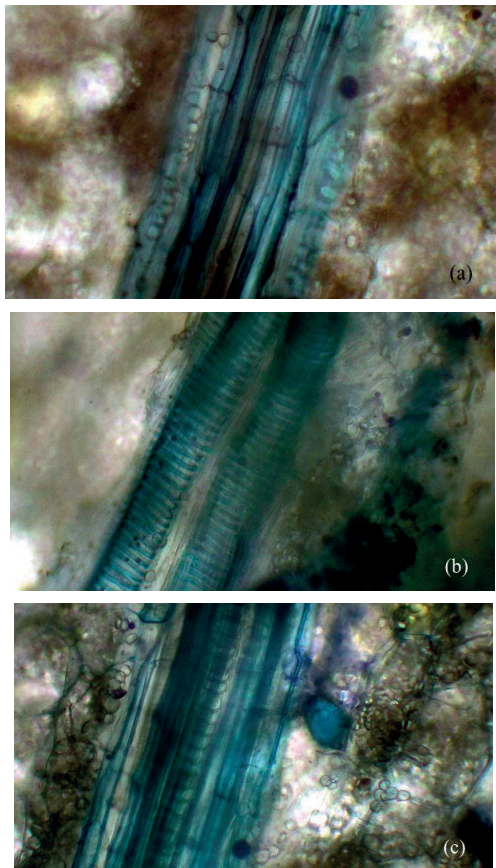


Figure 15. Microscopic images of longitudinal sections through the rhizome of *Zingiber officinale*: (a)-(c) conducting vessels (toluidine blue staining); (b) vessels with spiral thickening; (c) vessels with annular thickening

CONCLUSIONS

In this paper, several microscopic characteristics mentioned in the specialized literature for turmeric rhizome and ginger rhizome were shown, as follows:

In *Curucuma longa* (turmeric): the epidermis; cork; cortical parenchyma; parenchymal cells with bright orange oily content - oleoresin (curcumin and volatile oil); other parenchymal cells containing yellow lipid droplets, which almost fill the cells; amyliiferous parenchyma, starch granules; endoderm; and conductive vessels.

In *Zingiber officinale* (ginger) section we detect: cork; cells with yellow oil (oleoresin); amyliiferous parenchyma, starch granules; conductive vessels.

The substances in the composition of turmeric and ginger or the rhizomes as such are used in the food industry, but also in the pharmaceutical industry and the microscopic, macroscopic and organoleptic analysis of the rhizomes/powder of turmeric and ginger constitutes the first stage of the qualitative analysis aimed at the botanical identification of the plant material, followed by biochemical analysis, all of these analyses being carried out using standardised methods. Thus it is possible to detect the falsification of some products or the presence of some impurities in the plant material intended for food consumption or use in the pharmaceutical industry.

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