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Original Article

Pharmacognostic Analysis of Fennel, Caraway and Coriander Seeds belong to Apiaceae family

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ABSTRACT

Introduction: Fennel (*Foeniculum vulgare*), caraway (*Carum carvi*), and coriander (*Coriandrum sativum*) belong to the same botanical family, Apiaceae, but they have different macroscopic and microscopic features that distinguish them. **Aim:** The purpose of this work is to minutely study and analyze the characteristics of fennel, caraway, and coriander seeds, along with their microscopic & powder character. **Material and Methods:** Seeds of fennel, caraway, and coriander were collected from the Wardha region market, authenticated by a botanist, and were analyzed macroscopically for size, shape, color, odor, and taste. The microscopic analysis was done with the cross-sections of seeds stained with suitable reagents. Powdered microscopy included powder of each drug with glycerine to see the structures. **Results:** Microscopic and powdered microscopic examination revealed distinct anatomical features such as oil cells, parenchyma cells, and vascular bundles, etc., that were characteristic to each seed. **Conclusion:** This study had an in-depth comparative analysis of the macroscopic, microscopic, and powdered microscopic characteristics of fennel, caraway, and coriander seeds.

Keywords: Apiaceae, Aromatic, Macroscopic, Microscopic, Powdered Microscopic

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INTRODUCTION

Members of the Apiaceae (Umbelliferae) family, fennel (*Foeniculum vulgare*), caraway (*Carum carvi),* and coriander (*Coriandrum sativum*) have long been a part of traditional diets in many countries. In addition to being significant culinary spices, these fruits have been shown to have therapeutic benefits in a number of traditional medical systems. Each species has distinct structural characteristics even though they are members of the same botanical family. Their internal architecture, powder properties, and outward morphology all show discernible variances. These differences are crucial for accurate identification and aid in preventing adulteration or substitution. As a result, separating these closely related plant medications requires careful pharmacognostical analysis.

Fennel seeds are the fruits of the fennel plant that have an elongated, slightly flattened oval shape and greenish-brown color and are sweet-flavored and anise-like and frequently used as digestive aids and flavoring agents[1]. Coriander seeds are mainly spherical and yellowish-brown, giving a mild citrus flavor to the culinary dishes and medicinal decoctions[2]. Often confused, caraway seeds and cumin seeds which are different from each other and have nearly the same look; however, their form is distinctive and crescent-shaped, and the color of caraway is darker brown or blackish. They give off a very intense spicy aroma and are considered very good in savories as well as in medicines for digestion[3]. The proper utilization of these seeds in various industries like pharmaceuticals, food, and herbal medicine is subject to an authentic identification and quality assessment primarily based on their macrospecific characters like size, shape, color, odor, and taste. However, the microscopic examination, which deals with a better idea of internal structures like oil cells, parenchyma cells, and vascular bundles, provides a detailed ascertainment of their botanical identification and probable pharmaceutical attributes.

Here we present a comprehensive macroscopic, microscopic, and powdered microscopic characterization of fennel, caraway, and coriander seeds in order to study their anatomical features and possible applications. This work aims to explore both the macroscopic and microscopic structures of these seeds in order to optimize their use through sectors of the economy and to assure precise botanical identification of herbal spices for possible contemporary utilization. This introductory part emphasizes the cultural, culinary, and medicinal importance of these seeds and the importance of their identification by comprehensive macroscopic and microscopic analysis. It also instills the aims and objectives of the study, helping the reader to follow along.

AIM AND OBJECTIVES

Aim

To establish comparative pharmacognostic standards for the fruits of *Foeniculum vulgare* (fennel), *Carum carvi* (caraway), and *Coriandrum sativum* (coriander) for accurate identification and authentication.

Objectives

1. To document and compare the macroscopic (organoleptic and morphological) characteristics of fennel, caraway, and coriander fruits.
2. To study and record the diagnostic anatomical features of the fruits through transverse section microscopy using standard staining procedures.
3. To evaluate distinguishing characteristics of each drug through powder microscopy.

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4. To identify key pharmacognostic parameters useful for differentiation, detection of adulteration, and quality control of these Apiaceae fruits.

MATERIALS AND METHODS

Collection and Authentication of Plant Material

Dried fruits of fennel (*Foeniculum vulgare* Mill.), caraway (*Carum carvi* Linn.), and coriander (*Coriandrum sativum* Linn.) were procured from the local crude drug market of Wardha, Maharashtra, India. Botanical authentication was carried out by a qualified taxonomist from the Department of Botany, Mahatma Gandhi Ayurved College, Wardha.

Voucher specimen numbers:

- *Foeniculum vulgare* — MGAC/DG/2025/13
- *Carum carvi* — MGAC/ DG/2025/14
- *Coriandrum sativum* — MGAC/DG/2025/15

Sample Size

Three separate market samples were examined for every medication. To guarantee uniformity and reproducibility of anatomical and powder microscopic features, all observations were made in triplicate.

Macroscopic Evaluation

Each fruit sample weighed about 50 g, and its organoleptic and morphological characteristics—such as size, shape, color, surface features, odor, and taste—were assessed. A magnifying lens and a digital vernier caliper were used to take measurements.

Microscopic Evaluation (Transverse Section Study)

Preparation of Sections

About 10–15 fruits of each sample were soaked in distilled water for 2 hours to soften the tissues. A sharp stainless-steel blade was used to manually cut transverse sections.

Staining Procedure

- Sections were stained with 1% safranin solution for 2–3 minutes.
- Excess stain was removed by washing gently with distilled water.
- Sections were mounted in glycerin on clean glass slides and covered with a coverslip.

Microscopy and Imaging

Slides were observed under a compound trinocular microscope at 10× and 45× magnifications. A digital microscope camera attachment linked to imaging software was used to take photomicrographs for documentation. Multiple sections from each sample were examined to confirm diagnostic characters.

Powder Microscopy

Powder Preparation

Each fruit sample was shade dried (if required) and coarsely powdered using a mechanical grinder. Approximately 5 g of powder from each sample was used for analysis.

Slide Preparation

- The cleared powder was mounted in glycerin on a glass slide and covered with a coverslip.
- Observation

Slides were examined under 10× and 40× magnifications for identifying diagnostic characters such as vittae fragments, endosperm cells, sclerenchyma, oil globules, and calcium oxalate crystals. For each drug's three samples, the same observations were made.

OBSERVATIONS & RESULTS

Fennel

Macroscopic features

The fruits were long mericarps that were about 4 mm wide and 4–10 mm long. They had five noticeable major ridges, a smooth, glabrous surface, and a greenish-yellow hue. There was a stylopod at the apex and a wide commissural surface. The fruits had a distinctively fragrant smell (Figure 1).

Microscopic Characteristics

The fennel fruit's transverse slice has a classic cremocarp structure, with two mericarps connected to a central carpophore. The outermost layer, known as the outer epidermis (a), is made up of a single layer of cuticle-covered tangentially elongated cells. The mesocarp (b), which is composed of parenchymatous tissue and has noticeable vittae (c), or oil conduits, scattered throughout the mesocarp, is located beneath this. These vittae appear as big, round secretory cavities filled with volatile oil. The inner epidermis (d), which is composed of radially elongated cells with thin walls, is located inside the mesocarp. The compressed cells that surround the seed make up the endocarp (e), which is the innermost layer of the pericarp. The carpophore (f), a sclerenchymatous structure that separates the two mericarps and offers mechanical support, is shown near the fruit's center. The raphe (g) that runs down each mericarp's inner side represents the vascular supply. The meristeles (h) or vascular bundles, which are made up of xylem and phloem components, are found just below the ridges. The endosperm is surrounded by the seed coat, also known as testa (i), which resembles a thin layer of defense. The endosperm (j), which is made up of thick-walled parenchymatous cells with fixed oil, aleurone grains, and occasionally calcium oxalate micro-rosette crystals, forms the majority of the seed[8,9] (Figure 2).

Powdered microscopy

The fennel powder had a distinctively fragrant scent and was grayish-yellow to light brown in color. Several identifiable fragments were found when the powder was examined under a microscope. Endosperm cells were found to be polygonal, parenchymatous cells with thick walls that contained a lot of aleurone grains and oil globules (Figure 4). Vittae fragments showed up as long, thin-walled secretory structures (Figure 5). Pieces of the endocarp were visible as compressed, reddish, thick-walled cells (Figure 6). There were also fibrovascular fragments made of lignified fibers connected to vascular tissues (Figure 7).

Coriander

Macroscopic Characteristics

Macroscopically, Fruit globular, mericarps that are typically joined by their borders to create a cremocarp that is roughly has diameter of 2 to 4 mm, consistently glabrous, brown or brownish-yellow, and occasionally topped with the remnants of styles and sepals. The main ridges are 10 in number and secondary ridges are 8 which is wavy and barely noticeable, coelospermous endosperm, with a pungent, spicy, and distinctive smell and flavor[6] (Refer figure 8).

Microscopic Characteristics

The coriander fruit's transverse section reveals a typical cremocarp with two mericarps joined to a central carpophore. There are noticeable

Figure 1. Fruit of Fennel

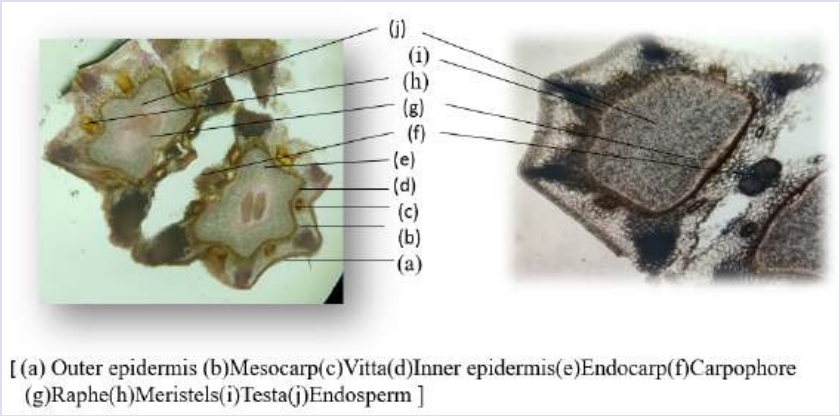

Figure 2 and Figure 3. Transverse section of fennel fruit

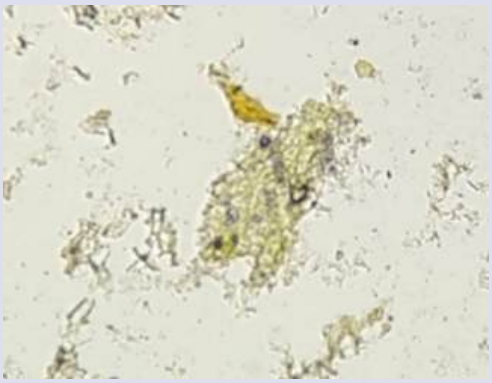

Figure 4. Endosperm of fennel

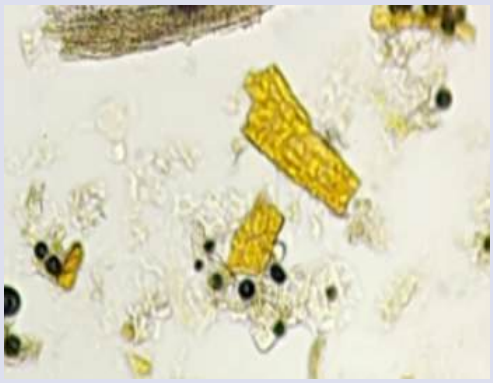

Figure 5. Vittae of fennel

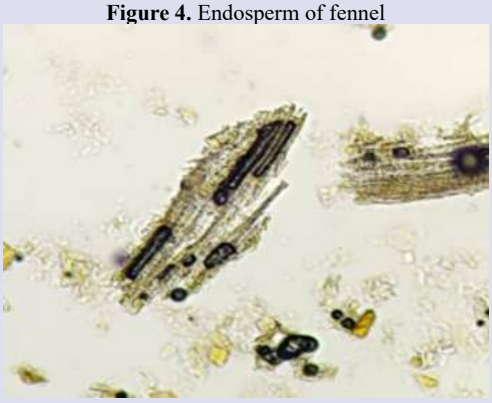

Figure 6. Endocarp of fennel

Figure 7. Fibrovascular fragment of fennel

Figures 4,5,6,7. Powdered microscopy of fennel

major ridges (b) and less noticeable secondary ridges (a) on the exterior. The pericarp is divided into layers beneath the ridges. The majority of the pericarp is made up of parenchymatous tissue, or the mesocarp (h). Within the mesocarp, large vittae (e) are apparent as oval-shaped secretory oil channels. The seed is surrounded by a thin coating of testa (d). Each mericarp's inner surface has the raphe (c), which is connected to the vascular supply. The carpophore (f), a supporting element that extends between the two mericarps, connects them centrally[10,11]. The endosperm (g), which is made up of thick-walled parenchymatous cells with fixed oil and aleurone grains, makes up the majority of the seed part (Figure 9).

Powdered Microscopy

The coriander fruit powder had a distinctive flavor and was yellowish-brown in hue. Several identifiable fragments were found upon microscopic examination. The lengthy, thick-walled, pitted cells that made up the sclerenchymatous layer were grouped together (Figure 11, Figure 12). Endocarp fragments were seen as thick-walled, reddish, compressed cells that formed irregular pieces (Figure 13). Polygonal, thick-walled parenchymatous cells with several aleurone grains and fixed oil were used to simulate the endosperm (Figure 14). The endosperm tissue occasionally included calcium oxalate micro-rosette crystals[12].

Caraway

Macroscopic Characteristics

The fruits are elongated, somewhat curved, and laterally compressed, measuring around 4–7 mm in length and 1–2 mm in breadth. They are glabrous and range in color from brown to dark brown. Each mericarp has five distinct, pale or yellowish-colored main ridges and is slender, tapering at both ends. The fruit is aromatic with a characteristic agreeable odour and a warm, slightly bitter, and spicy taste. The majority of the fruit is occupied by the orthospermous endosperm (Figure 14).

Microscopic Characteristics

A typical schizocarp structure with two mericarps connected to a central carpophore can be seen in the transverse slice of caraway fruit. A single layer of dense, thin-walled cells coated in a cuticle makes up the outer epidermis (a). The mesocarp (d), which is made up of parenchymatous cells with embedded vascular tissue and secretory processes, is located beneath it. The mesocarp has distinct vittae (c), which are oval oil ducts lined by epithelial cells that act as volatile oil repositories. Each principal ridge region has a well-developed vascular bundle (b) made up of phloem and xylem components. The two mericarps are joined at the center to a thin carpophore (e), which resembles a column of sclerenchymatous tissue that provides support. The testa (f), also known as the seed coat, is thin and firmly attached to the endosperm[13]. The endosperm (g), which is made up of thick-walled, polygonal parenchymatous cells with fixed oil and many aleurone grains, occupies the majority of the seed[14] (Figure 15).

Powdered microscopy

Caraway fruit powder has a potent scent and is brown to yellowish-brown in hue. Characteristic diagnostic pieces are seen under a microscope. Vittae fragments (Figure 16) are long, thin-walled secretory structures that occasionally include leftover volatile oil. Mesocarp fragments (Figure 18) are frequently connected to vascular tissue and appear as parenchymatous cells without reticulate thickening. The endosperm (Figure 17) is made up of several tiny aleurone grains and thick-walled, polygonal parenchymatous cells that are filled with fixed oil. Occasional calcium oxalate micro-rosette crystals may also be detected within the endosperm cells. The powder may also contain pieces of epidermal tissue with striated cuticles and sporadic sclerenchymatous cells.

DISCUSSION

The fruits of *Foeniculum vulgare, Coriandrum sativum,* and *Carum carvi*—all members of the Apiaceae family but significantly different at the morphological and microscopic levels—are compared using pharmacognostic standards in this study. The trustworthiness of the diagnostic traits revealed is confirmed by the good match between the observations made in this study and the standard descriptions found in the Ayurvedic Pharmacopoeia of India (API)[4] and other traditional pharmacognostic references.

Standard Pharmacognostic Literature Comparison

Macroscopically, fennel fruits were seen to be elongated and greenish-yellow, coriander fruits globular and yellowish-brown, and caraway fruits generally curled and narrow. These results align with the morphological standards described in API and Trease & Evans, which highlight fruit form and ridge pattern as the main characteristics that distinguish Apiaceae medications.

Significant variations in mesocarp composition, vittae (oil duct) distribution, and pericarp structure were found under a microscope. According to published anatomical descriptions, fennel and caraway have numerous prominent vittae, but coriander has relatively fewer vittae, mostly on the commissural side. Similarly, the narrower pericarp of caraway and the sclerenchymatous mesocarp of coriander are identified differentiating characteristics in pharmacognostic literature[5].

Additionally, distinctive elements such vittae, endosperm cells rich in fixed oil, sclerenchymatous tissues, aleurone grains, and calcium oxalate crystals were visible under powder microscopy. Because these medications are often sold in powdered form, these diagnostic powder characteristics are particularly significant and in line with accepted pharmacopoeial standards[6,7].

Significance in Drug Authentication

These closely related Apiaceae fruits can be distinguished using reliable criteria based on the structural differences found in this study. Due to their similar popular names and overall look, fennel, caraway, and cumin are frequently mistaken in crude drug marketplaces. Nonetheless, variations in fruit shape, vittae organization, mesocarp structure, and powder characteristics are trustworthy indicators for accurate botanical identification. When macroscopic identity is lost after grinding, microscopic and powder microscopic analysis is especially useful. Diagnostic structures such as vittae fragments, endosperm cells with oil globules, and unique sclerenchymatous tissues assist establish authenticity and avoid substitution.

Role in Adulteration Detection

In the commerce of herbal raw drugs, adulteration of aromatic seeds is a frequent problem. Therapeutic efficacy and safety may be jeopardized by substitution with pharmacologically distinct but physically similar species. For the purpose of identifying adulterants, the pharmacognostic criteria listed above can serve as reference standards. For instance, substitution may be shown by differences in the quantity and location of oil ducts or by the lack of distinctive sclerenchyma layers. When visual inspection is not feasible, powder microscopy provides a quick and economical way to detect adulteration in powdered formulations.

Pharmaceutical and Industrial Relevance

These fruits' essential oil concentration, which dictates their taste and therapeutic qualities, is strongly correlated with the distribution of vittae and oil-rich endosperm found in them. In the food, pharmaceutical, and nutraceutical industries, where these medications are used as flavoring agents, carminatives, and digestive stimulants, accurate identification guarantees consistency in raw materials. Thus,

Figure 8. Coriander fruit

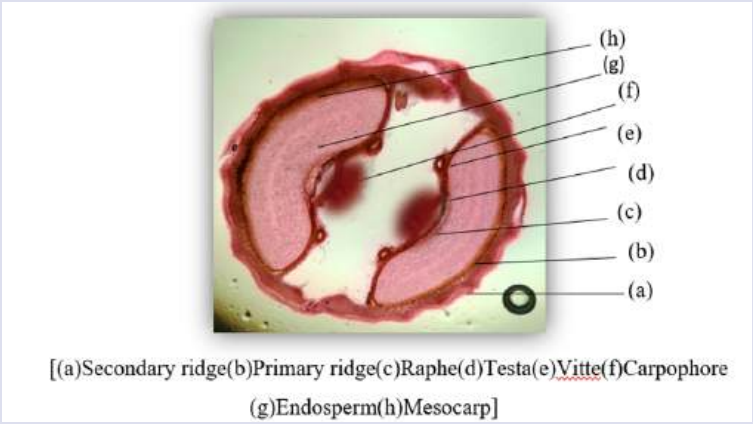

Figure 9. Transverse section of Coriander fruit

11. Sclerenchymatous layer of coriander

Figure 12. Sclerenchymatous layer of coriander

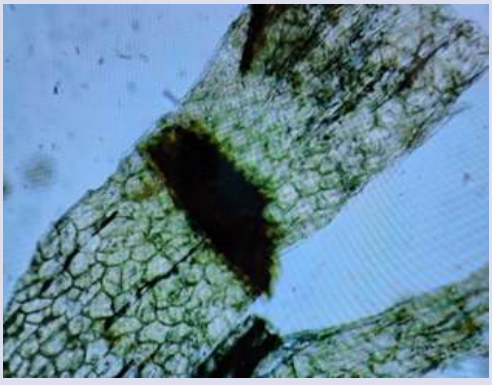

Figure 13. Endocarp of coriander

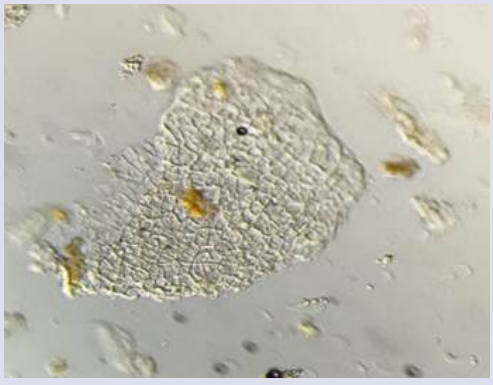

Figure 14. Endosperm of coriander

Figures 11,12,13,14. Powdered microscopy of coriander fruit

Figure 14. Caraway

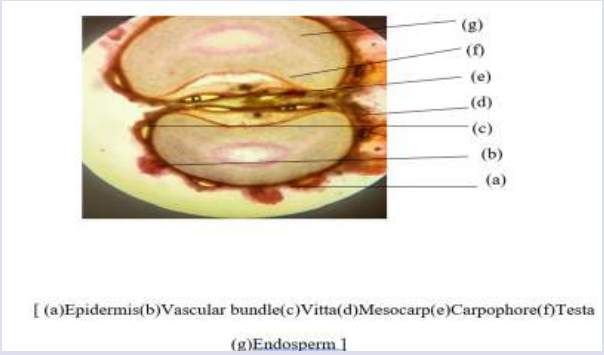

Figure 15. Transverse section of Carway

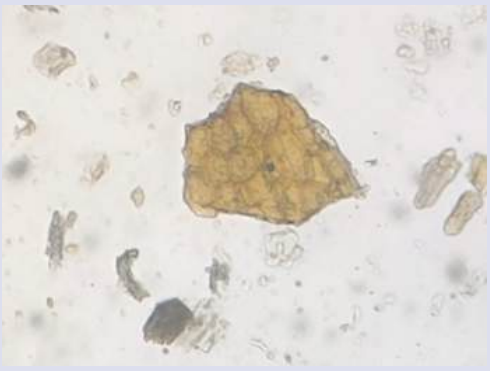

Figure 16. Vittae of jeerak

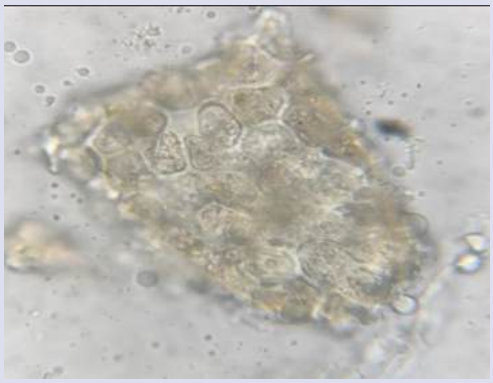

Figure 17. Endosperm of jeerak

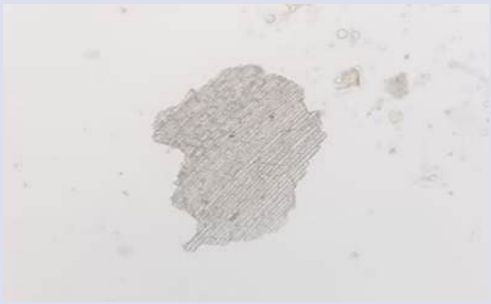

Figure 18. Mesocarp of jeerak

Figure 16,17,18. Powdered microscopy of caraway

batch uniformity, safety, and quality control of herbal formulations are all enhanced by standardization through pharmacognostic evaluation. Routine quality assessment procedures for Apiaceae fruits can include the anatomical markers reported in this study.

CONCLUSION

A suitable approach for differentiating fennel, coriander, and caraway seeds was established by the combination of macroscopic, microscopic, and powdered microscopy analysis. The botanical resource benefits from each of these unique insights, which when combined can ensure precise identification and quality control.

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