

# The Sheep in Wolf's Clothing: Vegetable and Fruit Particles Mimicking Cells and Microorganisms in Cytology Specimens

Sue Chang<sup>1</sup>, Neda A Moatamed<sup>1</sup>, Christina KY<sup>2</sup>, Nikki Salami<sup>1</sup> and Sophia K Apple<sup>1\*</sup>

<sup>1</sup>David Geffen School of Medicine at UCLA, Pathology and Laboratory Medicine, USA

<sup>2</sup>Pathology Inc., 19951 Mariner Ave, Torrance, CA 90503, USA

## Abstract

**Background:** Microorganisms and contaminants, including food contaminants, can be difficult to distinguish in various cytologic specimens. Vegetable and fruit contaminants can be found in specimens from the gastrointestinal tract, as in anal Pap smears, or aspirated into the respiratory tract, as in bronchiolar-alveolar lavage. Some of these materials mimic microorganisms, normal human cells, and even malignant cells, making correct diagnosis of the cytology specimen a challenge. A catalogue of the cytologic appearance of these contaminants will increase awareness of these diagnostic stumbling blocks.

**Methods:** Commonly eaten fruits and vegetables were selected. In each preparation, a small amount of the edible portions of the fruit or uncooked vegetable were ground with mortar and pestle, and smeared onto glass slides. The slides were fixed in 100% alcohol for Papanicolaou (PAP) stain or air-dried for May-Grunswald-Giemsa (MGG) stain.

**Results:** All vegetable cells contained nuclei, cytoplasm, and cell walls. Fruit cells contained nuclei and cytoplasm, but variably contained cell walls. Many of the deeply stained nuclei resembled overly stained malignant nuclei or dysplastic cells. Vegetable contaminants can resemble anucleated to intermediate squamous cells, respiratory columnar cells, viral inclusions such as cytomegalovirus or Molluscum contagiosum, fungal elements, and even organisms such as nematodes, Strongyloides, and Toxoplasma. Fruit contaminants can mimic similar infectious parasites or fungal spores, and contribute to a seemingly necrotic background.

**Conclusion:** The distinctive morphologic pattern of fruit and vegetable cells make identification of these mimickers of pathologic processes possible, and differentiates them from human cells.

**Keywords:** Contaminant; food; Mimicker; Microorganism; BAL; anal Pap

## Introduction

It is important to recognize contaminants in cytologic specimens. These contaminants can be environmental exogenous materials, as well as food contaminants. In particular, Bronchiolealveolar Lavage (BAL) and anal Papanicolaou (PAP) smears may contain food contaminants that resemble pathogens. The vegetable and fruit contaminants can pose a diagnostic challenge by mimicking microorganisms, viral changes, or malignant cells. There are a few papers illustrating the basic characteristics of vegetable contaminants, but none has systematically described the morphology of fruits [1-6]. In this paper, we describe some of the basic identifying characteristics of fruits and expand upon a more comprehensive list of vegetables. We also illustrate the morphologic resemblance of some of these cells to various normal cells, pathogenic microorganisms, or malignant cells. Our attempt is to generate a more comprehensive catalogue of food contaminants and to decrease diagnostic error in cytologic specimens.

## Materials and Methods

Commonly available fresh fruits and vegetables were purchased, and a small amount of each uncooked fruit or vegetable was ground using mortar and pestle, to simulate chewing and partial digestion. The particles were smeared on glass slides. All smears were fixed immediately in 100% alcohol for Papanicolaou (PAP) stain or air-dried for May-Grunswald-Giemsa (MGG). Vegetables used are listed as follows: artichoke, asparagus, baby corn, beet, broccoli, Brussels sprouts, cabbage, carrot, cauliflowers, celery, cucumber, cilantro, corn, eggplant, fava beans, garlic, green onion, ginger, green beans, lettuce, mint leaves, onion, mushroom, parsley, potato, radish, snow pea, sweet

potato, and water chestnut. Fruits used are listed as follows: apple, banana, blueberry, date, grape, grapefruit, mango, orange, raspberry, strawberry, pineapple, pomegranate, and tomato.

## Results

All vegetable cells contained nuclei, cytoplasm, and cell walls (Figures 1-13). All fruit cells contained nuclei and cytoplasm but lacked cell walls (Figures 14-18). Vegetable cells are invariably different from human cells due to the presence of cell walls in vegetables. Fruits cells are also different from human cells due to much larger size of cells. Although both vegetable and fruits cells are fairly easy to depict as foreign, some can mimic microorganisms, normal human cells, and even malignant cells under the right conditions, making correct diagnosis of the cytology specimen a challenge.

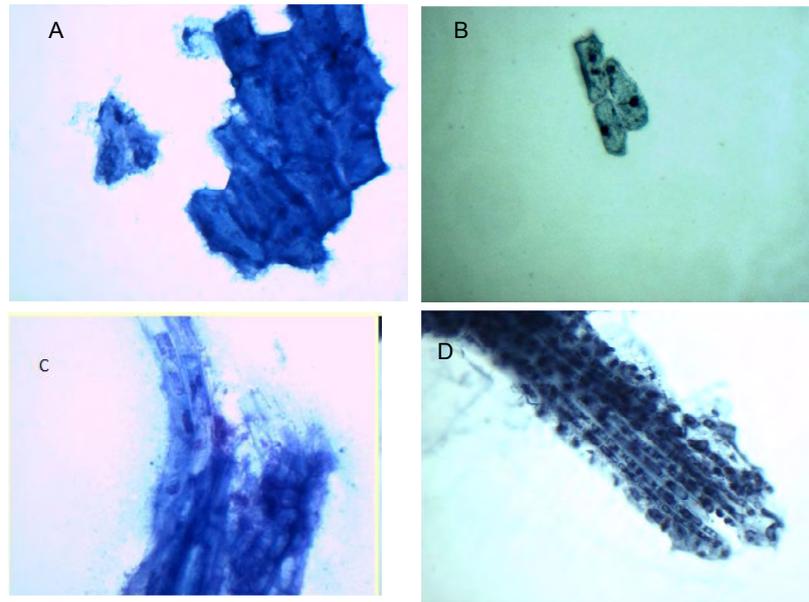
Vegetable cells can take on an epithelioid look of varying degrees of malignancy. For example, cells from asparagus are arranged in a single file, giving the appearance of invasive lobular breast carcinoma

\*Corresponding author: Sophia K Apple, UCLA Department of Pathology & Laboratory Medicine, BOX 951732, 1P-244 CHS, Los Angeles, CA 90095-1732, USA, Tel: (310) 825-9288; E-mail: [sapple@mednet.ucla.edu](mailto:sapple@mednet.ucla.edu)

Received September 03, 2013; Accepted December 18, 2013; Published December 20, 2013

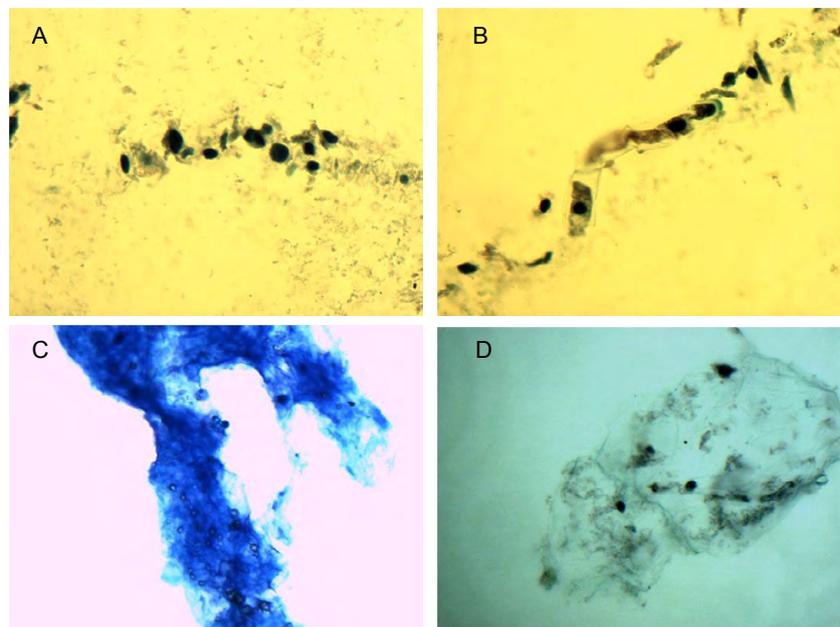
**Citation:** Chang S, Moatamed NA, Christina KY, Salami N, Apple SK (2013) The Sheep in Wolf's Clothing: Vegetable and Fruit Particles Mimicking Cells and Microorganisms in Cytology Specimens. J Cytol Histol 5: 207. doi:10.4172/2157-7099.1000207

**Copyright:** © 2013 Chang S, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.



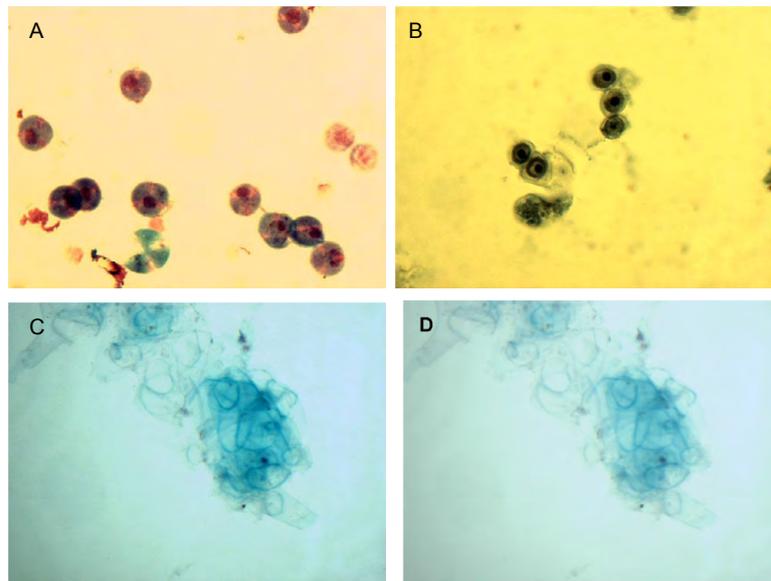
**Figure 1:** Figure 1: Artichoke present as a densely stained, flat sheets with sharp-cornered borders (A). The individual cells are elongated and polygonal to rectangular in shape. The cellular boundary appears shared because each angle of the cells is tightly joined. When seen individually or in small group, they resemble intermediate squamous cells seen in cervicovaginal smears (B). Asparagus smears have long chains of rectangular cells arranged end-to-end with discrete intercellular spaces between each cell junction (C). A recurrent light and dark pattern gives the impression of single-filing, which can be seen in mammary lobular carcinoma (D).

A: Artichoke, MGG stain, 60x magnification  
B: Artichoke, PAP stain, 60x magnification  
C: Asparagus, MGG stain, 60x magnification  
D: Asparagus, PAP stain, 60x magnification



**Figure 2:** Cells from baby corn are varied in shape: angular, columnar, and roughly spherical in form. Within the cell, the nucleus is opaque and homogenous (A). An intact, columnar cell with the central nucleus resembles columnar respiratory cells present in BAL specimens (B). Beets stained with MGG have small spherical bodies interspersed among an amorphous, bright blue background (C). The uniform, round structures have a lighter inner core, which contrast with the thickened capsular wall. The PAP stain reveals the same round bodies, but they are opaquely black in color and the wall is not as conspicuous (D). The amorphous debris is not taken up by PAP stain.

A: Baby corn, PAP stain, 60x magnification  
B: Baby corn, PAP stain, 60x magnification  
C: Beet, MGG stain, 60x magnification  
D: Beet, PAP stain, 60x magnification



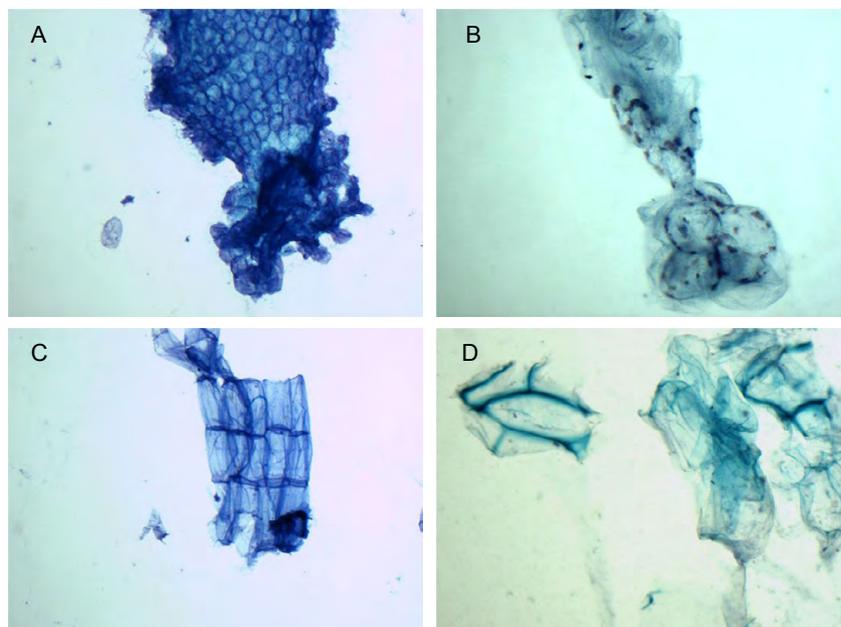
**Figure 3:** FBroccoli cells are reminiscent of *Trichomonas vaginalis* (A). These single, round balls have a frothy, blue cytoplasm and a distinct outline. A unique feature is the contrasting pink, cross-fork shaped pattern, which radiates from a centrally located dark nucleus. The PAP stain (B) shows a different type of round cells that on first glance resemble virally infected cells. The nucleus is homogenously opaque and mimic the intranuclear inclusions of Cytomegalovirus (CMV). When bilobed, they resemble Reed-Sternberg cells of Hodgkin lymphoma (C). The Pap smear reveals a loose array of light blue cells overlaying one another. Cabbage cells are slightly polygonal and have translucent, polished quality to them (D). Even though the cells appear empty, its borders are well-defined and each cell is distinct from one another. A: Artichoke, MGG stain, 60x magnification

A: Broccoli, MGG stain, 100x oil magnification

B: Broccoli, PAP stain, 60x magnification

C: Broccoli, PAP stain, 100x oil magnification

D: Cabbage, PAP stain, 60x magnification



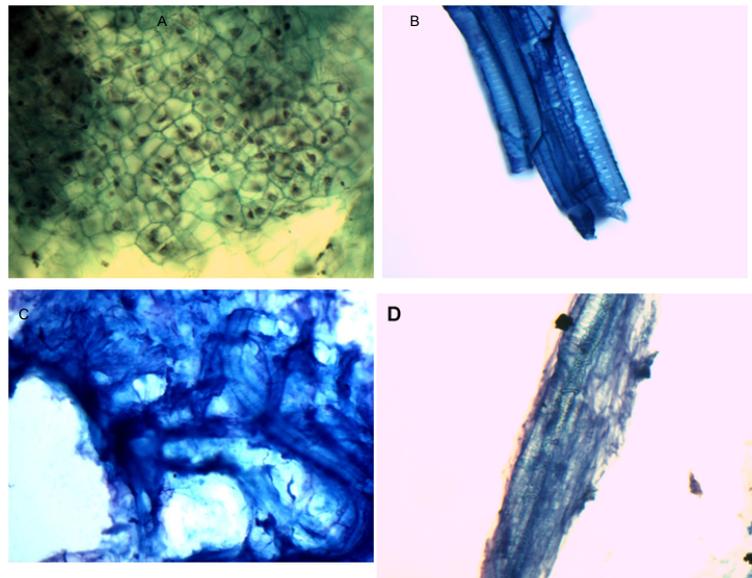
**Figure 4:** Brussels sprouts on the MGG stain show compactly arranged sheets of cells that are dense and polygonal in shape, resembling fish scale (A). Their cell walls are moderately thick. The Pap stain shows a nest of overlapping, plump round cells, which appears to bloom from a stalk-like portion (B). Compared to the rigid assembly of the cells in (A), these cells are delicate and translucent. The MGG smear of carrots shows rectangular cells stacked end-to-end, forming several orderly arranged tube-like column (C). The Pap stained image reveals a prismatic structure with polygonal-shaped surface and thick refractive edges (D).

A: Brussels sprouts, MGG stain, 40x magnification

B: Brussels sprouts, PAP stain, 60x magnification

C: Carrot, MGG stain, 40x magnification

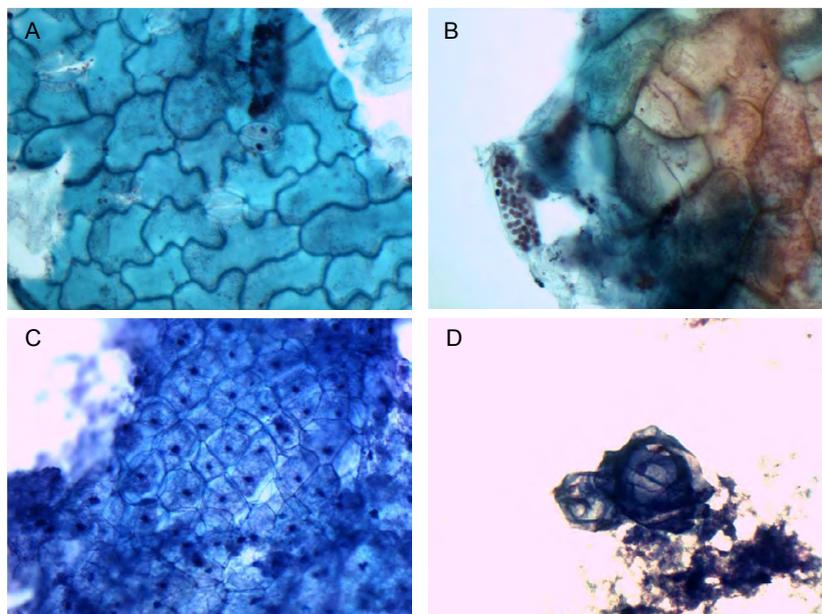
D: Carrot, PAP stain, 60x magnification



**Figure 5:** Pap smear of cauliflower reveals a tightly packed sheet of varied polygonal-shaped cells, each clearly separated by a prominent cell wall (A). At a low power, they resemble squamous cells in sheets. A microscopic feature of celery cells include long, narrow cylindrical and spiral tubes arranged side by side (B). The continuous tube contains elliptical pits distributed throughout its length and resembles a nematode larva.

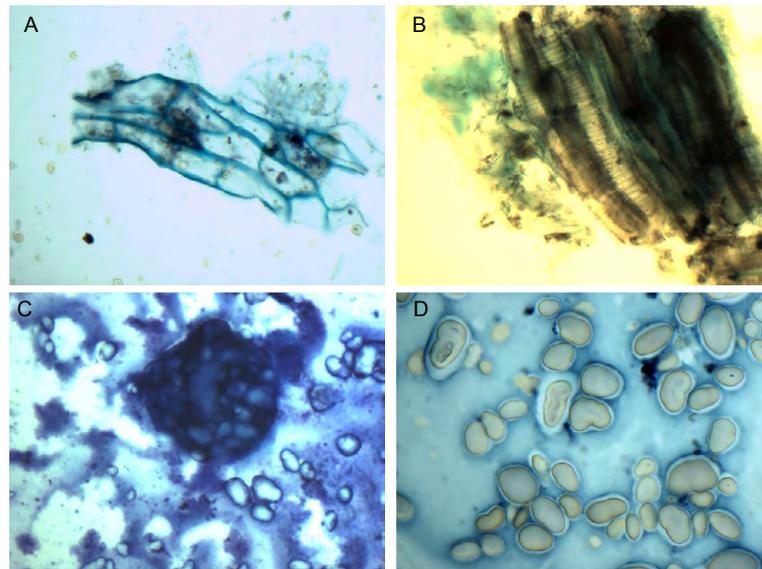
Smears of cucumber demonstrate a formless sheath encasing an elongated structure with ovoid shaped rings (C). The rings appear to form loose curvy spirals with central line in some section which can mimic a nematode. The Pap image shows a dark woven pattern that appears to be etched onto tissue fragment (D).

- A: Cauliflower, PAP stain, 60x magnification
- B: Celery, MGG stain, 40x magnification
- C: Cucumber, MGG stain, 60x magnification
- D: Cucumber, PAP stain, 100x oil magnification



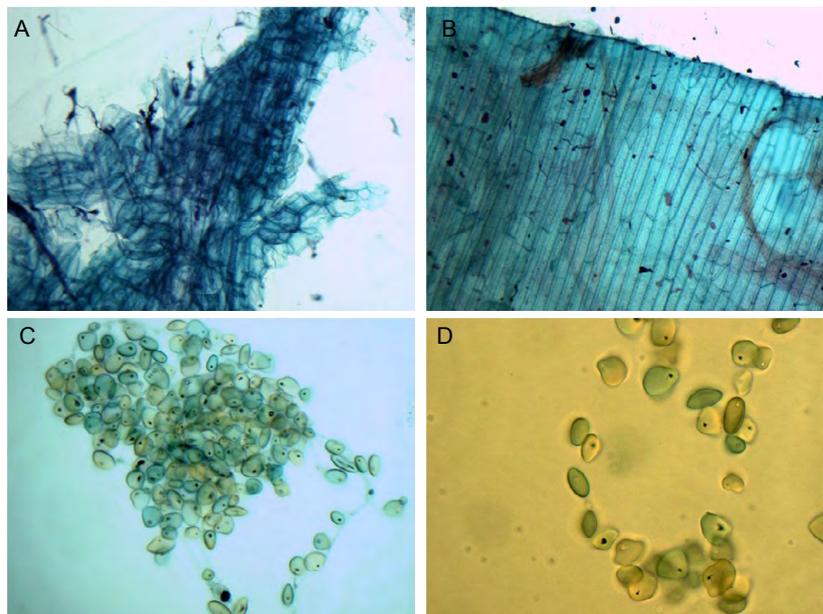
**Figure 6:** Cells of the cilantro have a wavy shaped outline and are closely linked in a jigsaw-like pattern. The thick cell wall appears rigid, and the cytoplasm appears mostly dense and homogenous with light flecks of reddish, pigmented granules. Sprouting from the tissue is a tubular structure packed with numerous, rounded beads (A). Notably, stomata are interspersed among the tissue fragments (B). The stomata appear as slit-like pores flanked by two reniform-shaped guard cells. Kernels of corn have plump polygonal cells with rounded edges on MGG stain (C,D). The fine cell wall surrounds the cell that has a foamy but granular cytoplasm. Centrally in each cell, there is a small, round nuclei. Thin balloon-shaped cells appear in a loose arrangement and resemble squamous cells in sheets and anucleated squamous cells singly (D).

- A: Cilantro, PAP stain, 60x magnification
- B: Cilantro, PAP stain, 60x magnification
- C: Corn, MGG stain, 60x magnification
- D: Corn, MGG stain, 60x magnification



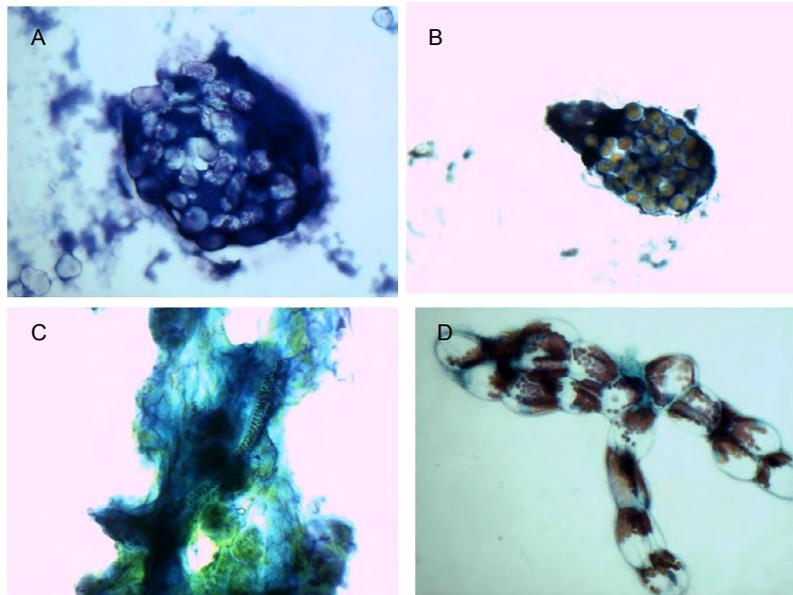
**Figure 7:** Eggplants display a diverse, multicolored morphology. The PAP smear of eggplant flesh shows several conducting tubes are bundled together with regularly spaced elliptical pits traversing through it (A). PAP smear of eggplant seeds contains several rows of oblong, quadrilateral cells, with thick refractile blue cell walls (B). Fava beans are smeared into bean-shaped fragments that are singly dispersed or loosely aggregated (D) with a thick cell wall that does not take up PAP staining. The MGG stain shows a dark staining, purple wall (C).

- A: Eggplant seeds, PAP stain, 60x magnification
- B: Eggplant, PAP stain, 60x magnification
- C: Fava beans, MGG stain, 60x magnification
- D: Fava beans, PAP stain, 60x magnification



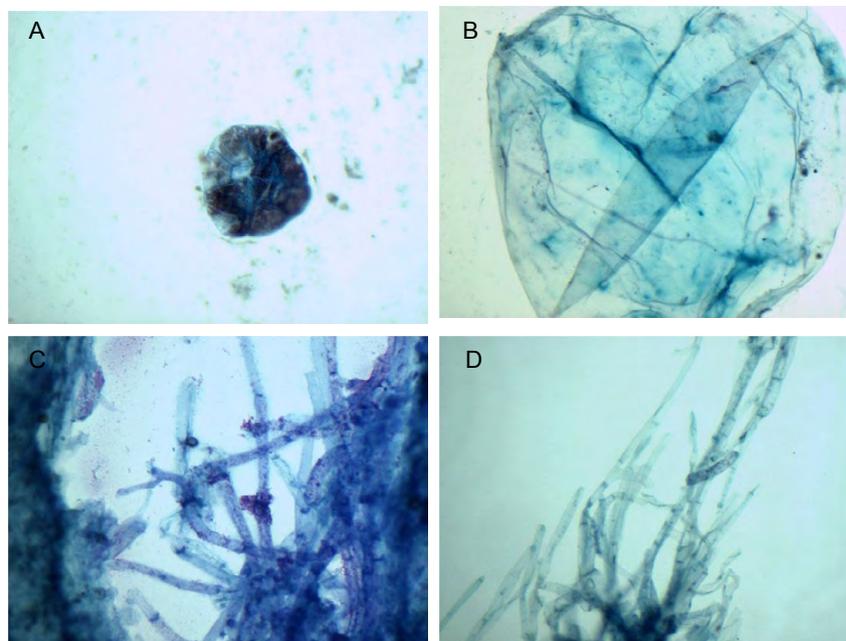
**Figure 8:** Garlic contains several broad, tubular vessels with elongated and polygonal cells linked together to form a long column (A). Strips of green onion have a lamellar pattern and even spacing (B), with quadrilateral-shaped cells. PAP stained smears from a ginger root yielded loose aggregate of oval to polygonal-shaped structures with distinctive glassy, refractive appearance with distinctive nuclei. They can mimic ova, if found in stool (C, D).

- A: Garlic, PAP stain, 20x magnification
- B: Green onion, MGG stain, 20x magnification
- C: Ginger, PAP stain, 100x oil magnification
- D: Ginger, PAP stain, 60x magnification



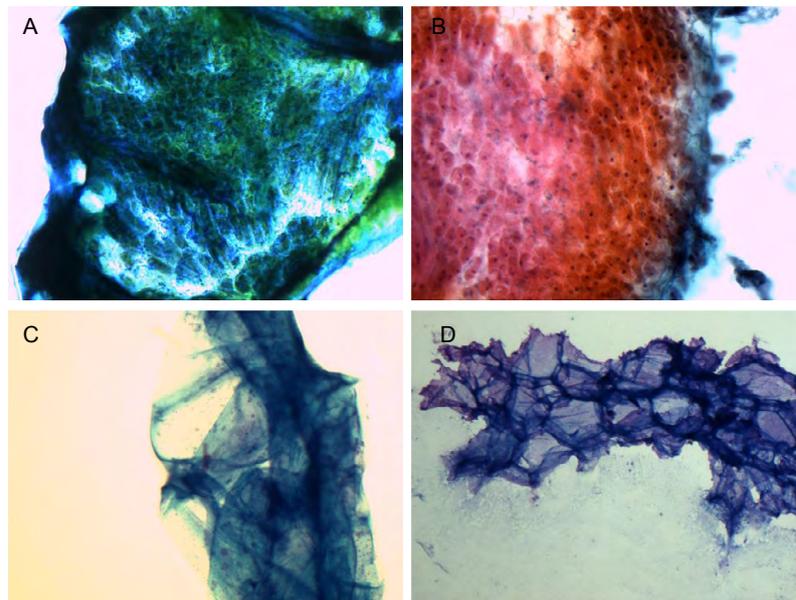
**Figure 9:** Green beans consist of small round cells packed together in aggregated clusters (A, B). In the Pap stain, the cell wall stains more prominently as a light blue color, and the cytoplasm takes up an orange color (B). Almost all green bean cells are clustered as shown, and resemble conidiophores from *Coccidiomycosis*. Leaves of lettuce (C, D) have display numerous papillary fronds branching from a thick stalk with helical spiral tubes on MGG stain (C). Many large, red-pigmented granules seem to accumulate at one pole of the cell, shown with PAP stain (D).

- A: Green beans, MGG stain, 60x magnification
- B: Green beans, PAP stain, 40x magnification
- C: Lettuce, MGG stain, 60x magnification
- D: Lettuce, PAP stain, 60x magnification



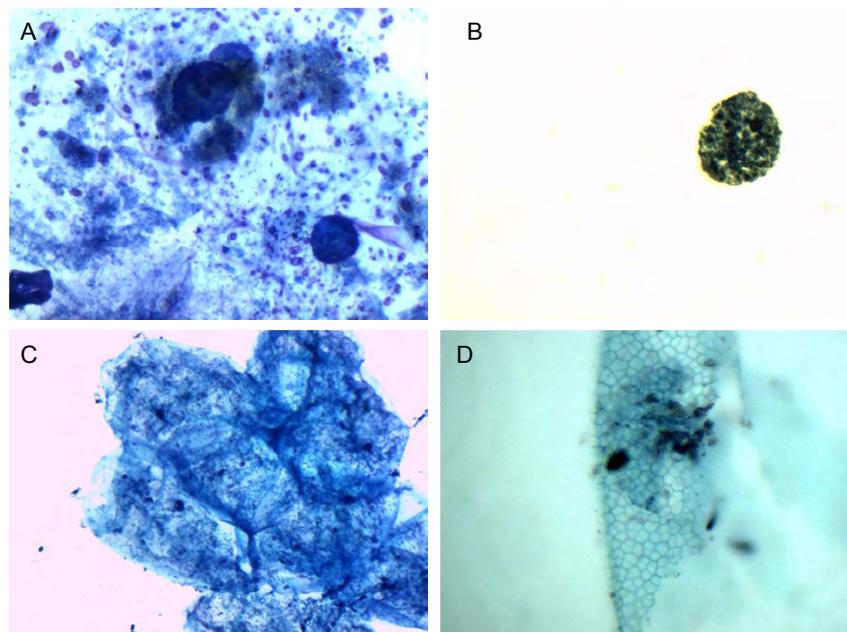
**Figure 10:** The PAP stained smear of mint leaves contains a multicellular round structure with central dots resembling *Mollescum contagiosum* (A). Onion cells are large and appear balloon-like and thin (B). Mushroom have tangles of filamentous hyphae (C, D). The hyphae appear long and broad, and can be difficult to distinguish from better known pathologic fungal elements such as *Aspergillus*. The intact ends of the strand appear to have a rounded, slightly convex contour. High power view shows acute angle branching (D).

- A: Mint leaves, PAP stain, 60x magnification
- B: Onion, MGG stain, 40x magnification
- C: Mushroom, MGG stain, 60x magnification
- D: Mushroom, PAP stain, 60x magnification



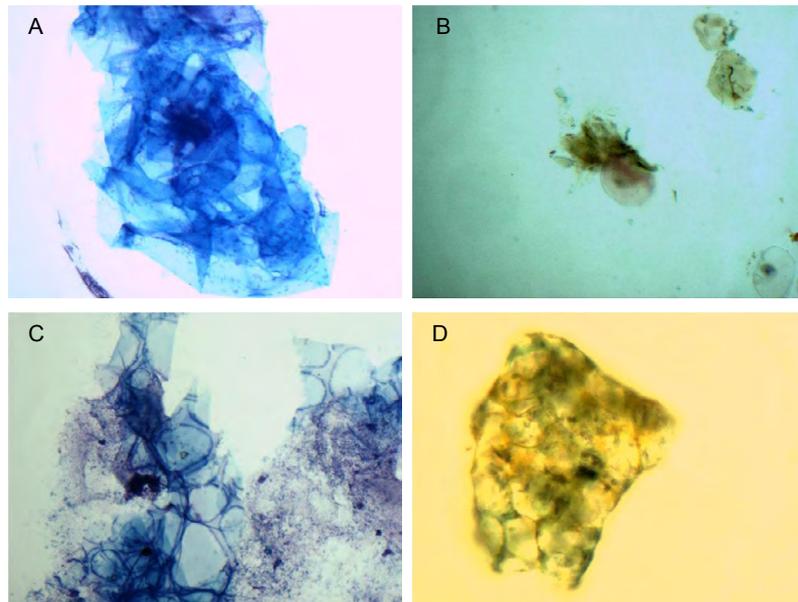
**Figure 11:** Parsley leaves in the MGG stain shows a densely green sheet of tissue colored by small chloroplasts (A). Parsley leaves with PAP smear have oblong, polygonal cells stained pink-red with tiny, dark nuclei (B). Potato cells are composed of large, irregularly shaped cells with a distinct crinkled appearance that resembles tissue paper (C). The sharp polygonal cells of radish are light purple and translucent in MGG stain (D). Its translucent protoplasm imparts a delicate quality resembling anucleated squamous cells.

A: Parsley, MGG stain, 40x magnification  
 B: Parsley, PAP stain, 40x magnification  
 C: Potato, MGG stain, 60x magnification  
 D: Radish, MGG stain, 60x magnification



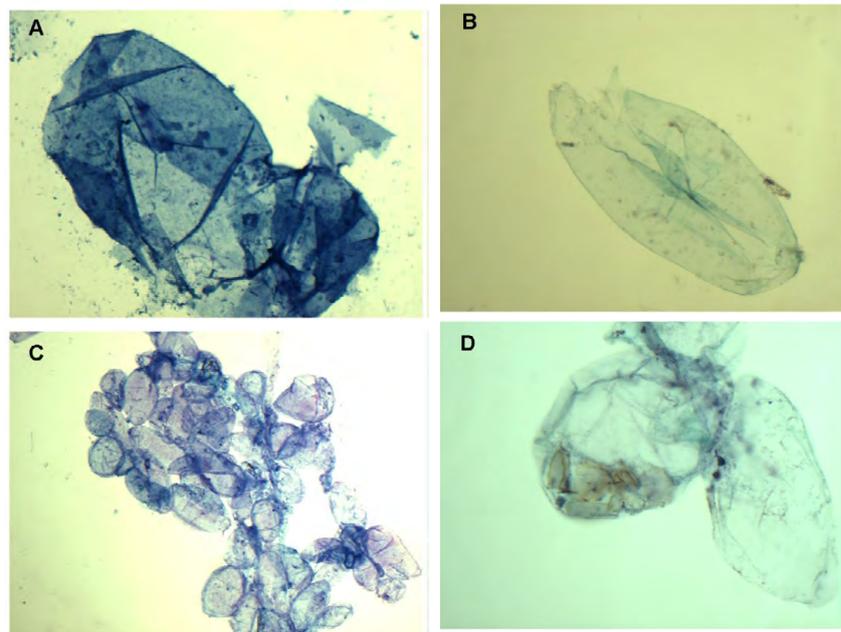
**Figure 12:** Red bell peppers are composed of round cells with conspicuous large granular material (A, B). The dark staining granules are blue and not very distinctive in the MGG stain (B), but are more readily appreciated on PAP stain (B), and can resemble Toxoplasmosis. The MGG smear of snowpeas (C) shows a small sheet consisting of slightly overlapping egg-shaped cells with slightly granular cytoplasm. The PAP smear reveals smaller, polygonal-shaped pattern of blue-gray cell walls (D).

A: Red bell pepper, MGG stain, 60x magnification  
 B: Red bell pepper, PAP stain, 100x oil magnification  
 C: Snowpea, MGG stain, 60x magnification  
 D: Snowpea, PAP stain, 60x magnification



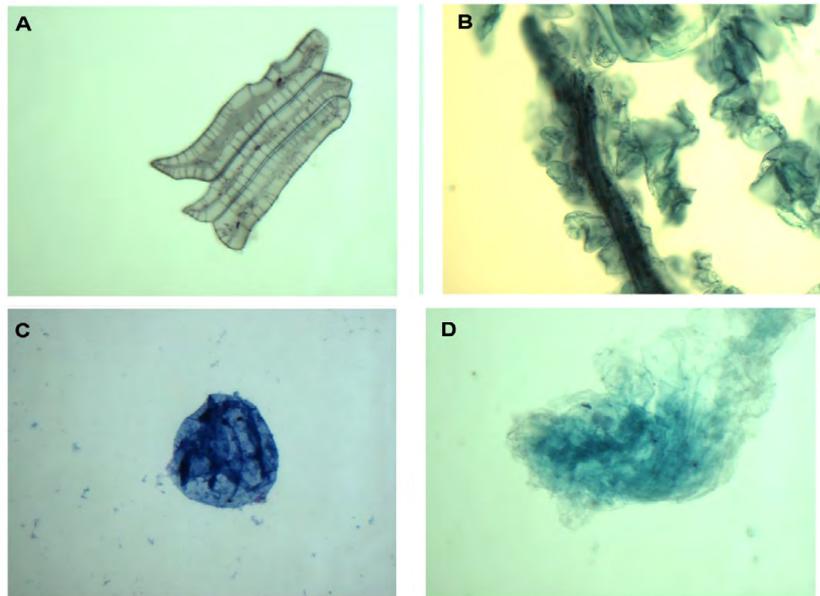
**Figure 13:** Cell of sweet potato are a conglomerate of flimsy balloon-shaped cells (A, B). The Pap stain shows brown cells that appear well-defined with marginally denser cytoplasm (B). Water chestnuts have thin, flat sheets with broad anastomosing cords (C). A PAP stained preparation of water chestnuts contains rounded cells and prominent intercellular space, which take on a green hue (D).

- A: Sweet potato, MGG stain, 60x magnification
- B: Sweet potato, PAP stain, 60x magnification
- C: Water chestnut, MGG stain, 60x magnification
- D: Water chestnut, PAP stain, 100x oil magnification



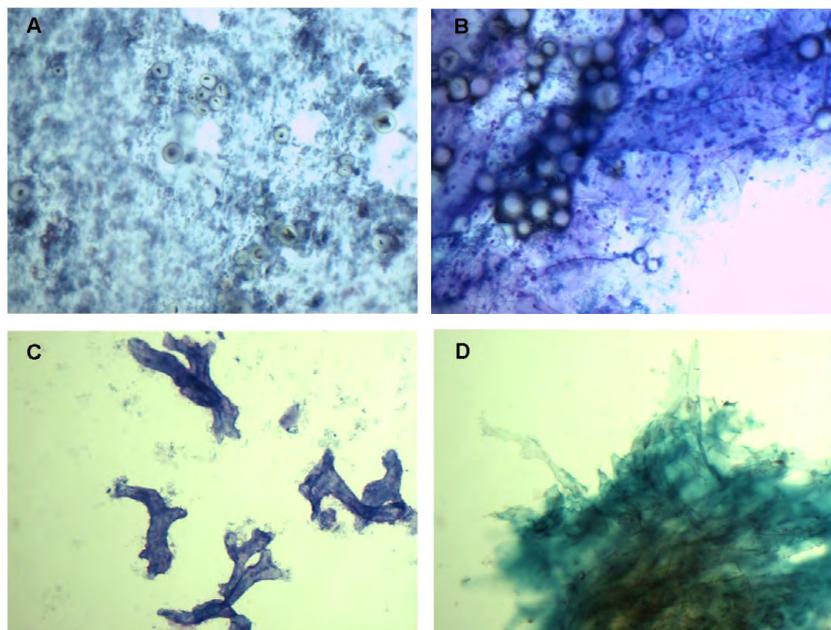
**Figure 14:** Apples (A, B) are relatively acellular, with smooth cell walls and a glassy sheet-like, or plastic bag appearance. Bananas break into smaller rounded clumps that have rounded edges and varying sizes. Under MGG staining (C), the small clumps have a crumpled quality with an almost tacky texture. With PAP staining (D), banana particles become clear and thin. The fibrous strands that surround the banana fruit (the phloem bundles) can appear as jagged, fractured pieces admixed with the edible fruit's thinner, smooth cells

- A: Apple, MGG stain, 40x magnification
- B: Apple, PAP stain, 40x magnification
- C: Banana, MGG stain, 20x magnification
- D: Banana, PAP stain, 40x magnification



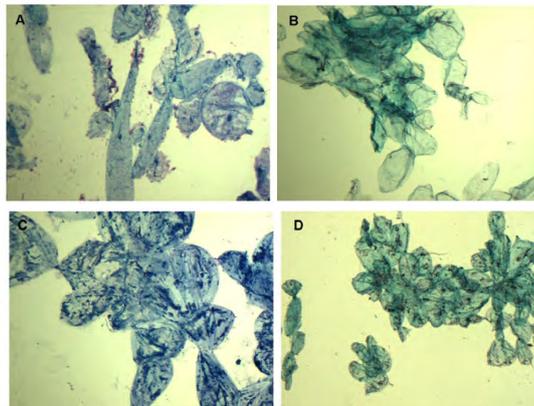
**Figure 15:** The blueberry (A) has cell walls that are regular and rectangular in shape. Under PAP staining, the exocarp loses its “blue” color but retains its rectangular organization. Dates have amorphous pulpy appearance attached to long fibers (B). The grape (C) is a type of berry, and as has amorphous faintly blue flesh with MGG stain. The grapefruit consists of vesicles filled with fluid, and fibrous endocarp. Seen under 40x, the macerated vesicles rupture to leave behind delicate tangles of fibrous endocarp (D).

- A: Blueberry, PAP stain, 40x magnification
- B: Date, PAP stain, 40x magnification
- C: Grape, MGG stain, 60x magnification
- D: Grapefruit, PAP stain, 40x magnification



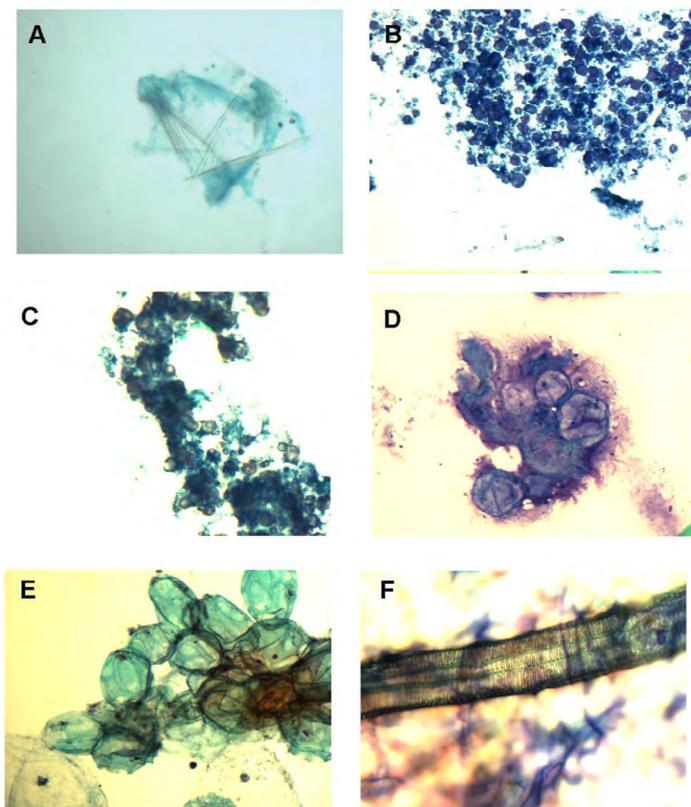
**Figure 16:** The mango is a stone fruit, with fibrous mesocarp fruit flesh. The fibrous material coalesces into a grungy background (A). What may be mistaken for infectious organisms are the rounded, thick-walled droplets that resemble fungal spores such as *Candida* or infectious parasites (B). The orange's color is lost in preparation, and the vesicles are ruptured, leaving behind thick, fibrous endocarp on MGG stain (C). The staining is more opaque under MGG, and a slightly more see-through under PAP stain (D).

- A: Mango, PAP stain, 60x magnification
- B: Mango, MGG stain, 60x magnification
- C: Orange, MGG stain, 20x magnification
- D: Orange, PAP stain, 20x magnification



**Figure 17:** The raspberry is a complex/composite fruit, with multiple berries attached together to form one raspberry unit. Stained with MGG (A), the flesh paucicellular and grungy shapes. With PAP stain (B), the cytoplasm is less viscous, and takes on a crumpled tissue paper-like quality. The strawberry is another composite fruit and the exterior seeds are consumed. The fragments of seeds are mixed into the fruit flesh, generating a granular background (C). At low magnification (D), the aggregate nature of the fruit is obvious, with cells attached onto a central core.

- A: Raspberry, MGG stain, 20x magnification
- B: Raspberry, PAP stain, 20x magnification
- C: Strawberry, MGG stain, 10x magnification
- D: Strawberry, PAP stain, 4x magnification



**Figure 18:** The pineapple recognizable under the microscope, with its criss-crossing sharp needle-like fibrous endocarp (A). This material, unlike gout crystals, is larger and not polarizable because it is made of cellulose. Pomegranate seeds are covered by endocarp that smears into vesicular shaped globules (B). The cytoplasm is dense, and nuclei are difficult to discern on light microscopy (C). At 200x magnification, the tomato's slimy interior endocarp is an acellular starch, which lends itself to the dense background seen on MGG staining (D). Under Pap staining, the tomato's intracellular vacuoles are ghostly pale lobules within each round cell (E). At high magnification, the orderly cellulose of tomato skin create rigid-appearing lines within the cell walls (F).

- A: Pineapple, PAP stain, 60x magnification
- B: Pomegranate, MGG stain, 40x magnification
- C: Pomegranate, MGG stain, 60x magnification
- D: Tomato, MGG stain, 20x magnification

cells (Figures 1C and 1D). Many vegetable cells from artichoke, carrot, cauliflower, corn, and radish, resemble anucleated to intermediate squamous cells. The cells of baby corn resemble respiratory columnar cells (Figures 2A and 2B). The enlarged cells and abundant mucinous-appearing juice of the tomato can look like mucinous adenocarcinoma.

Broccoli was found to have a vast repertoire of appearances: broccoli cells mimicked *Trichomonas vaginalis* (Figure 3A), the viral inclusions of cytomegalovirus (Figure 3B), and even the enlarged Reed-Sternberg cells of Hodgkin lymphoma (Figure 3C).

Vegetables frequently looked like parasitic organisms. Microscopic features of the spiral vessels in celery and cucumber cells were reminiscent of nematode larvae (Figures 5B-5D). Cells from ginger root and water chestnut looked similar to parasitic ova (Figures 8C, 8D, 13C and 13D). Cells from cilantro resemble cross-sections of strongyloides larvae (Figures 6A and 6B). Green beans have cell walls that break into shapes that look like *Coccidioides* fungal elements (Figures 9A and 9B). Cells from red bell pepper resemble toxoplasmosis (Figures 12A and 12B).

Not surprisingly, cells from mushrooms have a fungal appearance, particularly similar to *Aspergillus* (Figures 10C and 10D). Pineapple fibers do not look cellular or alive, but rather resemble gout or pseudogout crystals (Figure 18A).

## Discussion

Cells of fruits and vegetables can appear very similar to animal cells in that they contain nuclei, nucleic acids, and cytoplasm. In addition, vegetable cells have cell walls. Plant nuclei frequently stain as dark, homogeneous shapes without internal structures such as distinct nucleoli. Many of them could be mistaken for overly stained malignant nuclei or dysplastic cells. While some of vegetable and fruit cells appear similar to human cells or microorganisms, there are some overall differences in morphologic features. Certain biological components are found within only plant matter. Plastids are cytoplasmic structures that have limiting membranes, and contain pigments used in photosynthesis.

Starch can be seen as grains occupying the majority of a cell. Spiral vessels, also called tracheae, are structures most clearly seen in certain vegetables such as celery and cucumber. The distinctive morphologic patterns of vegetable cells such as spiral vessels, plastids, starch, and cell wall makes it possible to identify these mimickers of human pathologic processes.

The morphologic pattern for fruit cells includes the variable lack of cell wall, larger cells, amorphous cell shapes, and sometimes spiral vessels. These characteristics differentiate fruit and vegetable contaminants from human cells. Most of fruit cells such as tomatoes are much larger in size, incompatible with adjacent human cells.

This is the first comprehensive paper illustrating and describing fruits and vegetable cells based on cytological evaluation. We have described some basic identifying characteristics of plant matter, and illustrated the morphologic resemblance of some of these cells with various pathogenic microorganisms, viral changes, and benign and malignant cells. This comprehensive catalogue of food contaminants is intended to help decrease the diagnostic error in cytologic specimens.

## References

1. Weaver KM, Novak PM, Naylor B (1981) Vegetable cell contaminants in cytologic specimens: their resemblance to cells associated with various normal and pathologic states. *Acta Cytol* 25: 210-214.
2. Zhou J, Ferrer H, Cleveland R, Ganesan S (2009) Cytologic detection of *Strongyloides stercoralis* in a 55-year-old Hispanic man with routine rectal/anal pap smear. *Diagn Cytopathol* 37: 901-902.
3. Naryshkin S, Young NA (1993) Respiratory cytology: a review of non-neoplastic mimics of malignancy. *Diagn Cytopathol* 9: 89-97.
4. Naryshkin S, Bedrossian CW (1995) Selected mimics of malignancy in sputum and bronchoscopic cytology specimens. *Diagn Cytopathol* 13: 443-447.
5. Policarpo-Nicolas ML, Wick MR (2008) False-positive interpretations in respiratory cytopathology: exemplary cases and literature review. *Diagn Cytopathol* 36: 13-19.
6. Idowu MO, Powers CN (2010) Lung cancer cytology: potential pitfalls and mimics - a review. *Int J Clin Exp Pathol* 3: 367-385.