Morphological Characterizations of Selected Brown Rice Commercially Available in East Coast of Peninsular Malaysia

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ABSTRACT

Presently, the intake of brown rice becomes more popular for people who are very conscious about their health. The present study was conducted to examine the morphological characteristics of different sources of brown rice commercially available in Kelantan state of Peninsular Malaysia. Macroscopic observation was done on fresh brown samples and white rice sample. Longitudinal and horizontal section shows the present of both aleuron and bran layers obviously for all brown rice samples. Long grain and wholegrain mix brown rice had the longest and the thickest values compared to control (white rice). The brown rice samples consist of the pericarp, aleuron layer, endosperm, starch, parenchyma cells and parenchyma cells wall. All brown rice samples also had different thickness of aleuron layer. The cross sectional diameters of the brown rice samples were in the range from 847.2 to 1000 μm. These observations are vital in choosing the best cooking techniques for brown rice that give palatable for human consumption.

Keywords : Brown rice, Scanning Electron Microscope (SEM), morphological characterization

INTRODUCTION

Rice is among the most important staple food and staple for half of world population (Heinemann *et al.* 2005) including Malaysia. Approximately 97% of the Malaysian population consumed rice twice a day and on average, 2½ plates of rice per day Norimah *et al.* (2008). Rice can be consumed either in form of milled or non-milled. The earlier is commonly known as white rice whiles the latter known as brown rice. There are thousands of rice varities available around the world. Today, brown rice is suggested as whole grain rice to

provide more nutrients and health benefits than the more common white rice. Brown rice is the unmilled rice containing the pericarp, the seed coat and nucellus, the germ or embryo and the endosperm (Deepa *et al.* 2008). The difference between the brown rice and white rice is not only the color but also its bran layer, whereas white rice has had its bran layer removed by a polishing process.

Before white rice has been milled, brown rice is produce which its process only removes the outermost layer, the hull, of the rice kernel and is the least damaging to its nutritional value. The outer layer of rice grains was covered with oily layer of brown rice or also known as rice bran which composed of some botanical entities including sub layers within the pericarp and aleuron layer.

Brown rice is considered healthier than white rice as many nutrients are contained in the bran layer, however brown rice has a different taste and texture, takes longer time to cook, and does not store as well as white rice. Abas *et al.* (2011) stated that, rice bran has 20–30% total dietary fibre which most of it are insoluble fibre. The endosperm cells are thin-walled and packed with amyloplasts containing compound starch granules.

MATERIALS AND METHODS

Sample preparation

The brown rice samples were purchased from local hypermarket in Kota Bahru District, Kelantan state of Malaysia. There were three different commercially available brands of brown rice and one brand of white rice was purchased for control purpose. Three brown rice sample from each varities were selected, cleaned and one of them were cut into half for cross sectional view. The samples were subjected to morphological characterization.

Scanning Electron Microscopy

Scanning electron micrographs of the native brown rice samples were obtained by viewing with a scanning electron microscope (Quanta FEG 450, FEI Electron Microscopy). The brown rice samples was mounted on round aluminum stubs with the aid of double-sided adhesive tape. The samples were coated with gold (~22.7 μm) by means of a SCD 005 high vacuum evaporator and scanned. Cross-sections and longitudinal sections of brown rice samples were made and characteristics were studied using Scanning Electron Microscope (SEM). The selected regions were then captured for futher characterization of it morphological properties.

RESULTS AND DISCUSSION

The physical characteristics like grain length, width and thickness of grain varied significantly among commercially available different brown rice varieties used in this study. Table 1.1 shows physical characteristics of some selected brown rice commercially available in Kelantan state of Malaysia.

Generally, when brown rice freshly observed under SEM, it shows similar morphological characteristics to white rice with husk colour varying from golden yellow to brownish black. Each of the brown rice samples have different length, width and thickness which attributed to the biological origin of the rice (Babu *et al.* 2009). Long grain rice (S1) had the longest grain length and significantly longer than other unpolished rice samples. In other characteristic, S3 (wholegrain rice mix) had the widest and thickest values. The thickness of this brown rice could be due to the thicker pericarp and aleuron layer surrounding the endosperm of brown rice. The outer coating bran layer of brown rice caused it need longer time to cook compared to white rice.

Table 1.1: Tabulation of the physical characteristics of some selected brown rice commercially available in Kelantan state of Malaysia

Sample	Characteristics/ features			
	Rice length (mm)	Rice width (mm)	Rice thickness (mm)	Length to width ratio
S1	7.406 ± 0.081	2.069 ± 0.011	1.769 ± 0.032	3.570
S2	7.412 ± 0.085	2.076 ± 0.037	1.688 ± 0.053	3.570
S3	7.034 ± 0.199	2.245 ± 0.124	1.771 ± 0.021	3.130
S4	6.728 ± 0.184	2.156 ± 0.035	1.748 ± 0.028	3.070

Data are tabulated based on means of 10 grains rice ± standard error of brown rice from each sample. S1 = long grain rice; S2 = Unpolished Thai fragrant rice, S3 = Wholegrain rice mixture, S4 = White rice (control)

Figure 1.1a show the rough external surface of long grain rice (S1) under 100x magnification. The photomicrographs show some facture of layer present signify the long grain rice (S1), it have two distinct layer which the outermost layer known as pericarp (p) and aleuron layer. For determination of shape, length-width ratio for long grain rice (S1) is 3.57 which have same slender shape like Thai fragrant brown (S2). Close view photomicrographs to the uncovered layer under 1000x magnification in figure 1.1b show the present of aleuron grains (ag).

At higher magnification (5000x), the parenchyma cells (pc), aleuron grains (ag) and parenchyma cell wall were clearly shown in figure 1.1c. The clear globular shape of aleuron grains can be observed which slightly larger than Thai fragrant brown (S2) and the arrangement of aleuron grains (ag) is closely packed together with parenchyma cells (pc). The broad surface which covers aleuron grains is the parenchyma cells wall (wc).

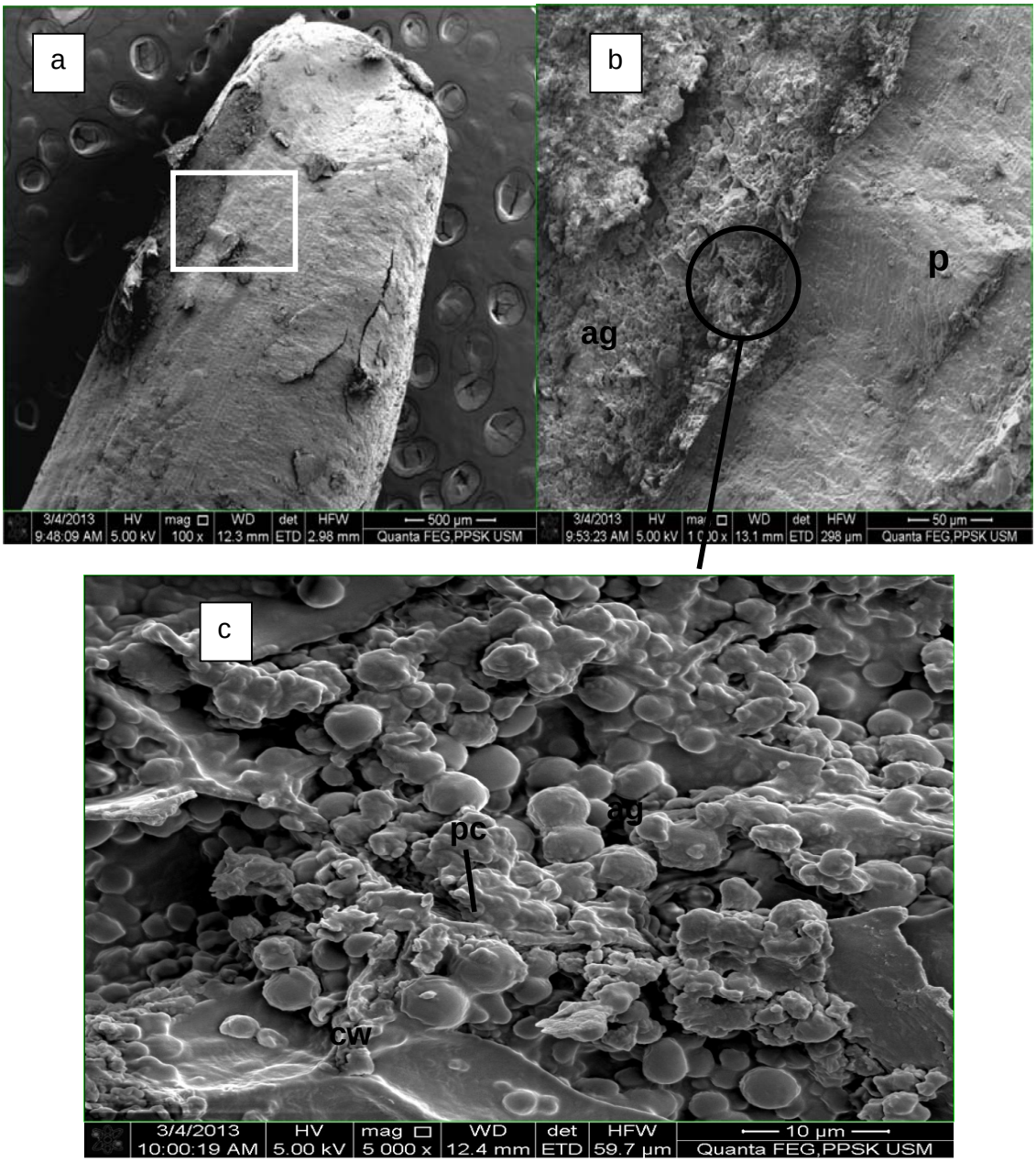

Figure 1.1 (a, b, c) shows scanning electron photomicrographs (100x-5000x magnification) of the long grain rice (S1). Photomicrograph 1.1a is the overall view structure of long grain rice (S1). Photomicrograph 1.1b shows the fissure between the two distinct layers of long grain rice (S1) which consist pericarp (p) as outer layer. Photograph 1.1c shows the presence of aleuron grains (ag), parenchyma cells (pc) and parenchyma cells wall under 5000x magnification.

Figure 1.1d shows scanning electron photomicrographs of representative transverse cross section under 100x magnification of sample 1 (long grain rice). From the

photomicrographs, two distinct layer was observed where it slightly intact with each other connecting between the pericarp (p) and endosperm (en). The diameter of the cross section is approximately 862.7 µm and endosperm (en) is located centrally right after the pericarp (p) layer which cover outermost layer of brown rice.

The space distance was observed in figure 1.1e between aleuron layer and endosperm (en) was lesser compared to Thai fragrant brown (S2). The thickness of aleuron layer of rice grains where aleuron grains (ag) and parenchyma cells (pc) present is approximately 20.2 µm. Compound of starch (c) was present on the endosperm (en) area in polygonal like-shape. Figure 1.1f show the aleuron grains (ag) and parenchyma cells wall (cw) under 5000x magnification with average diameter around 0.5 to 3.6 µm.

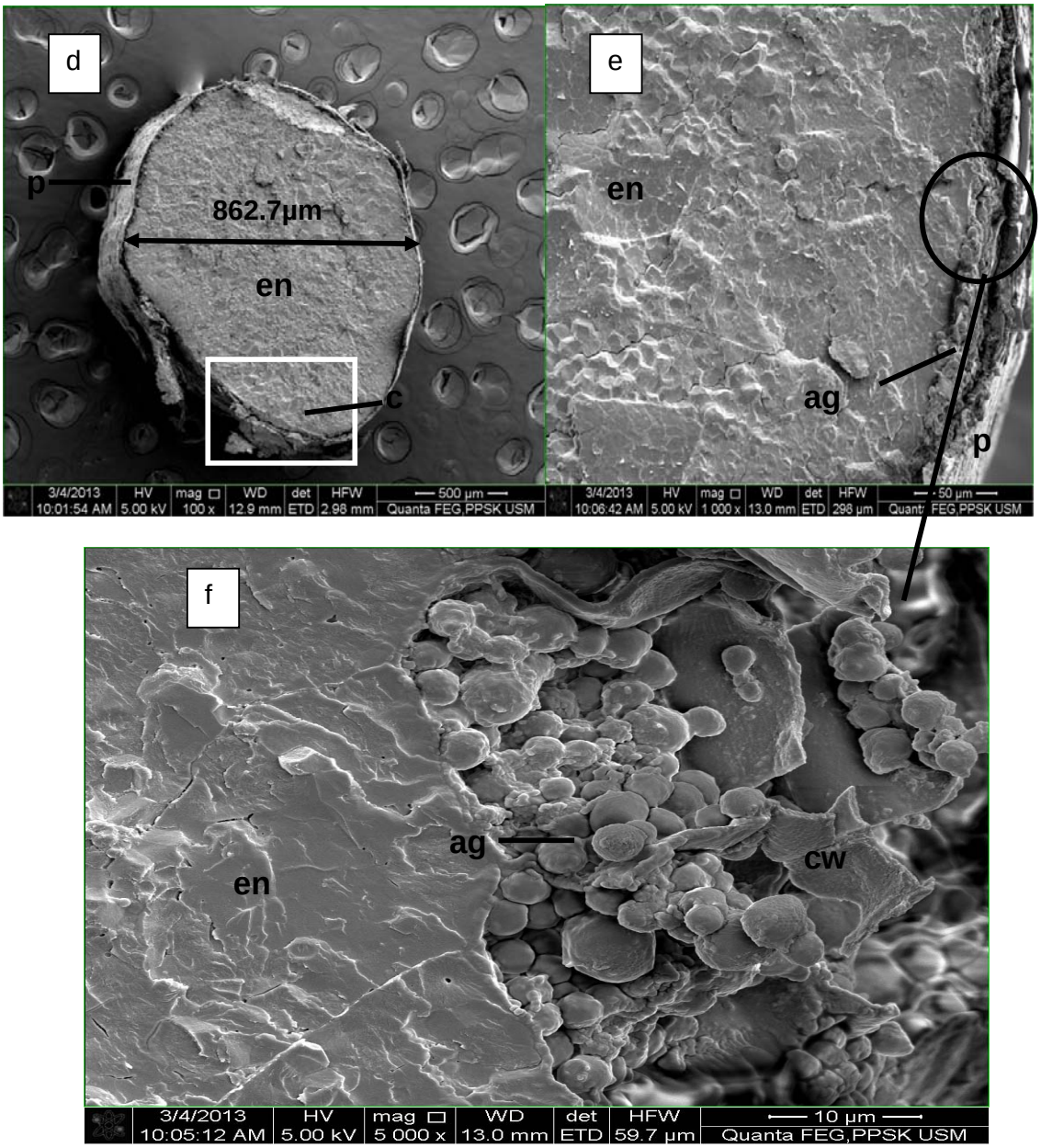

Figure 1.1 (d, e, f) are scanning electron photomicrographs (100x-5000x magnification) of transverse cross section of long grain rice (S1). Photomicrograph 1.1d is representative rice grain which has been cut to view the transverse cross section. Close view of the space between the pericarp (p) and aleuron layer with endosperm (en) in figure 1.1e under 1000x magnification. Scanning electron photomicrograph 1.1f shows the parenchyma cells (pc) which surrounded by aleuron grains (ag) under 5000x magnification.

Figure 1.2a show the whole external structure of the Thai fragrant brown (S2) rice. It shows rough surface and some fissure which reveal two distinct layers on the surface.

According to Rice Knowledge Bank, the shape of brown rice (BrS) depends on the length-width ratio which the ratio for Thai fragrant brown (S2) grains rice is 3.57, over 3.0 have a slender shape. The outer layer of brown is covered by pericarp layer (p) as shown in figure 1.2b and the present of aleuron grains (ag) as well as parenchyma cell (pc) underneath the pericarp layer.

The shape of aleuron grains (ag) under 5000 magnification (Figure 1.2c) shown the small globular like shape and the arrangement is slightly intact each other. Juliana (1972) stated that the aleuron grains (ag) in parenchyma cells (pc) contain protein richly surrounded by fat- staining substances.

Figure 1.2 (d, e, f) shows scanning electron photomicrographs of representative transverse cross section from the brown rice of Thai fragrant brown (S2) which consist loosely two distinct layer. The diameter of the cross section is approximately 847.2 μm and endosperm (en) is located centrally right after the pericarp (p) layer which cover outermost layer of brown rice.

In addition, figure 1.2e shows the present of space between aleuron layer and endosperm which in endosperm consisting compound of starch (c) in polygonal like-shape. The thickness of aleuron layer of rice grains depend on the number of parenchyma cells presents. The diameter of aleuron grains were estimated (0.25 - 3.5μm) under high magnification 5000x as shown in figure 1.2f.

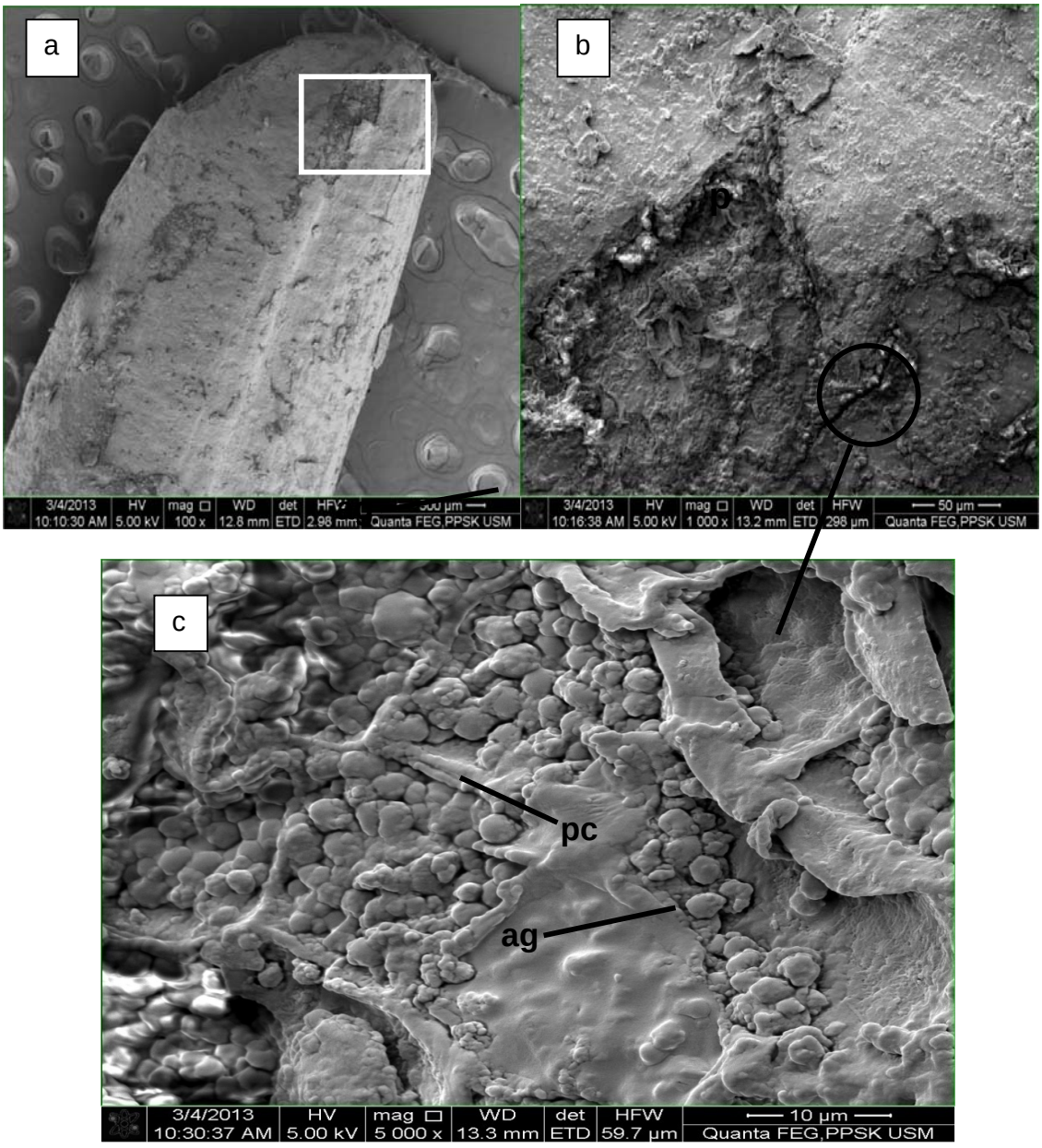

Figure 1.2 (a, b ,c) are the scanning electron photomicrographs in high magnification (100x-5000x) of the sample 2 (Thai fragrant brown). Photomicrograph 1.2a is the overall view structure of sample 2 (Thai fragrant brown). Photomicrograph 1.2b shows the fissure between the two distinct layer of

sample 2 (Thai fragrant brown) which consist pericarp (p) as outer layer. Photograph 1.2c showing the present of aleuron grains (ag) and parenchyma cells (pc) at 5000x magnification.

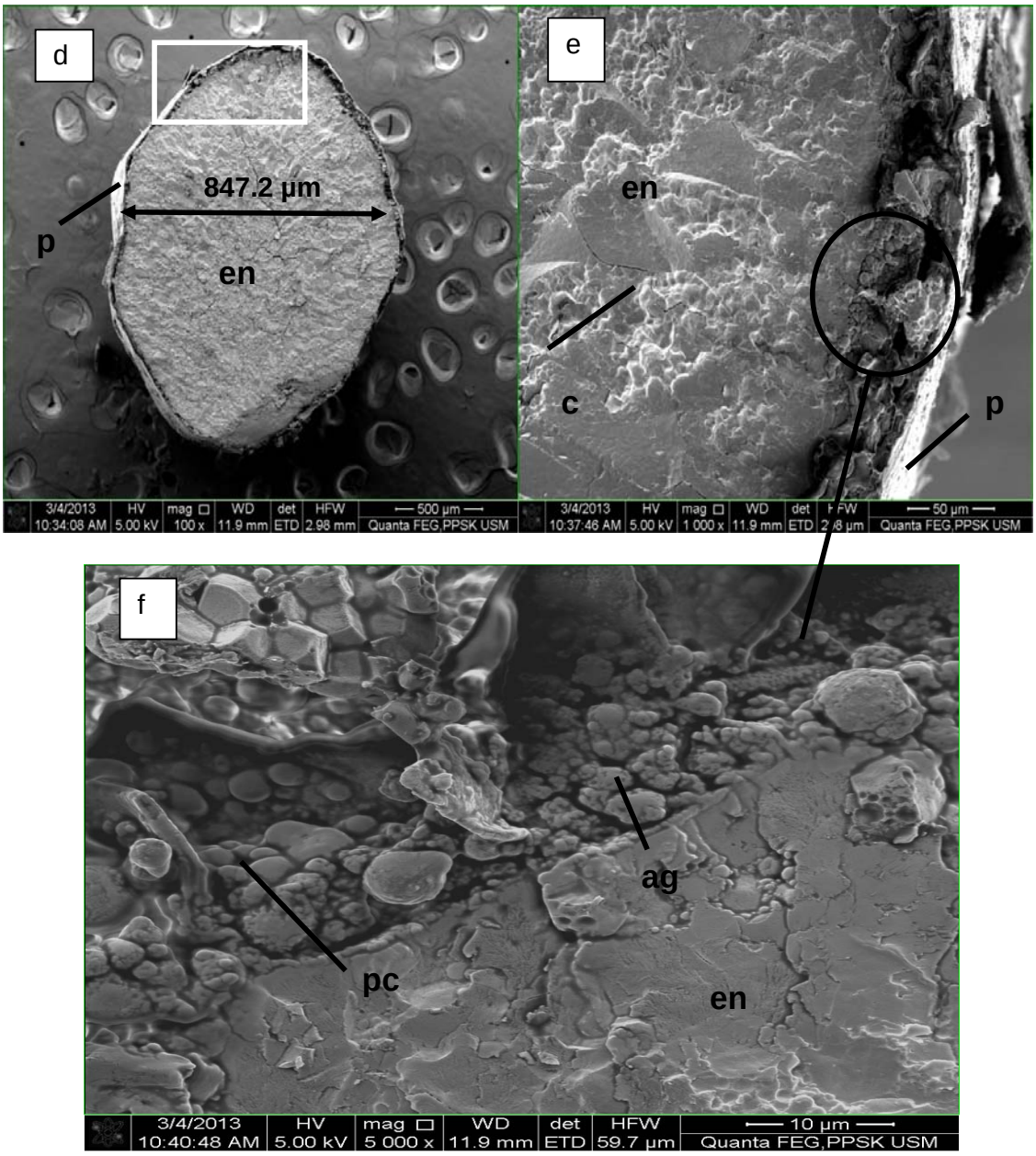

Figure 1.2 (d, e, f) are scanning electron photomicrographs in high magnification (100x-5000x) of transverse cross section of sample 2 (Thai fragrant brown). Photomicrograph 1.2d is a representative rice grain which has been cut to view the transverse cross section. Close view of the space between the pericarp (p) and aleuron layer with endosperm (en) in figure 1.2e under 1000x magnification. Scanning electron photomicrograph 1.2f show the parenchyma cells (pc) which surrounded by aleuron grains (ag) under 5000x magnification.

Figure 1.3a show the end part of brown rice to view the external morphology structure of wholegrain rice mix (S3) which have slightly smooth compared to the Thai fragrant brown (S2). The actual colour of this type of sample is dark brown compared to the other sample. The different in colour intensity may due to the degree of milling process of each sample. The present of fracture or fissure as indicator of two distinct layer is lesser. Watson and Dikeman (1977) stated that there are several polyhedral starch granules in a single amyloplast of rice sample.

Figure 1.3b show that compound starch granule (c) have a polygonal shape similar to the shape of other cereals as reported by Parengam *et al*. (2010). The shape of polyhedral of compound starch granule (c) might be due to the compression of starch granule during development (Juliana 1972). The shape of aleuron grains (ag) present is irregular globular shape compared to the long grain rice (S1) as show in figure 1.3c under 5000x magnification.

Figure 1.3d shows scanning electron photomicrographs of representative transverse cross section under 100x magnification of the wholegrain rice mix (S3). The two distinct layer was clearly observed where it tightly intact with each other. The diameter of the cross section is approximately 1000 µm and endosperm (en) is located centrally right after the pericarp (p) layer which cover outermost layer of brown rice. There is no space available between the pericarp (p) and endosperm (en) was observed in figure 1.3e.

The thickness of aleuron layer of rice grains where aleuron grains (ag) and parenchyma cells (pc) present is approximately 23.3 µm. Compound of starch (c) was present in small size on the endosperm (en) area in polygonal like-shape. Figure 1.3f show the close view of aleuron grains (ag) which has irregular globular shape and differ from other sample. The estimated diameter for aleuron grains (ag) is approximately 0.5 to 3.8 µm and parenchyma cells wall (cw) is surrounded around the aleuron grains (ag) at 5000x magnification.

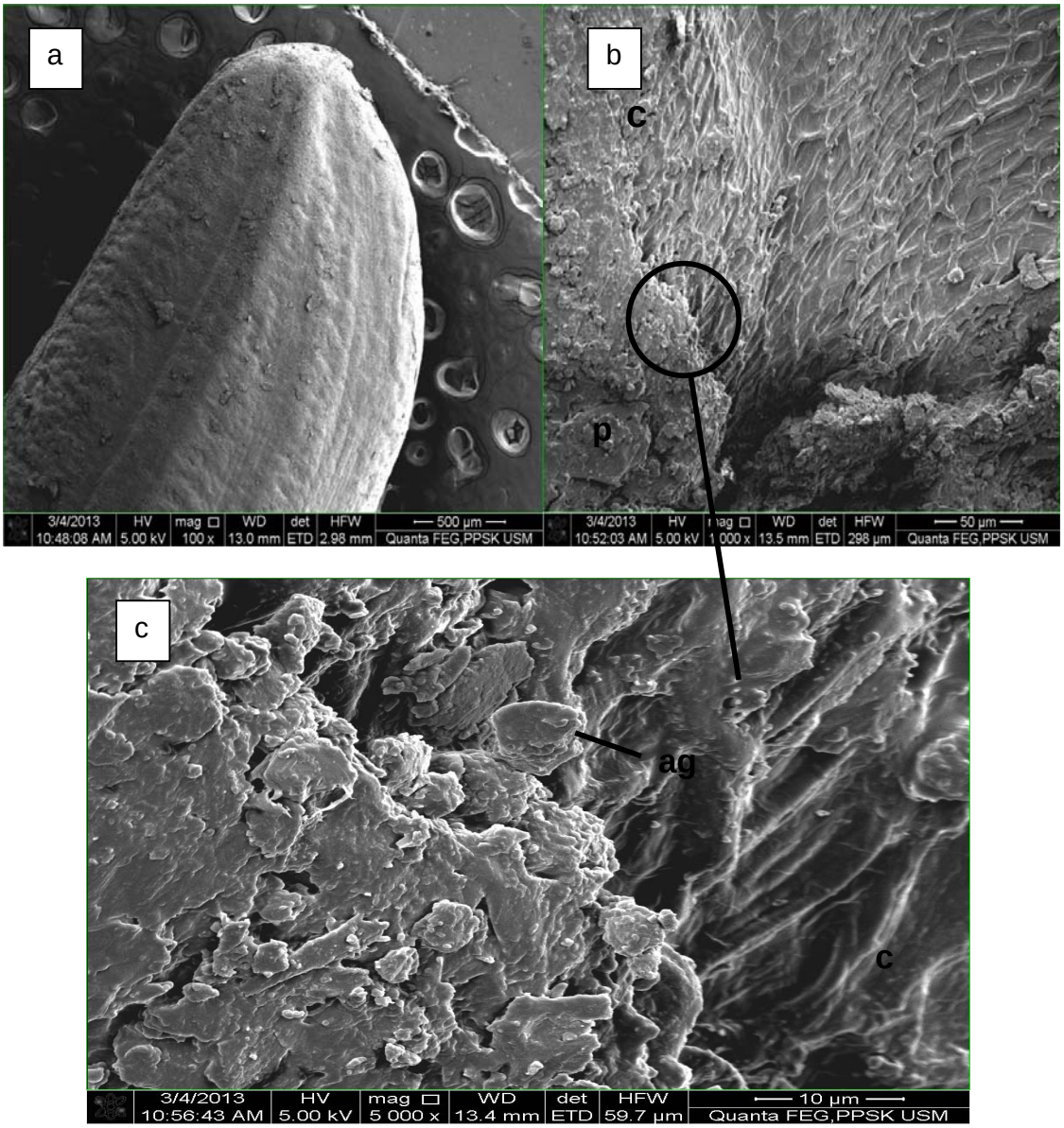

Figure 1.3 (a,b,c) are the scanning electron photomicrographs in high magnification (100x-5000x) of the wholegrain rice mix (S3). Photomicrograph 1.3a is the overall view structure of the wholegrain rice mix (S3). Photomicrograph 1.3b shows the fissure between the two distinct layer of the wholegrain rice mix (S3) which consist pericarp (p) as outer layer and the present of plygonal compound starch granule (c). Photomicrograph 1.3c showing the present of aleuron grains (ag) under 5000x magnification.

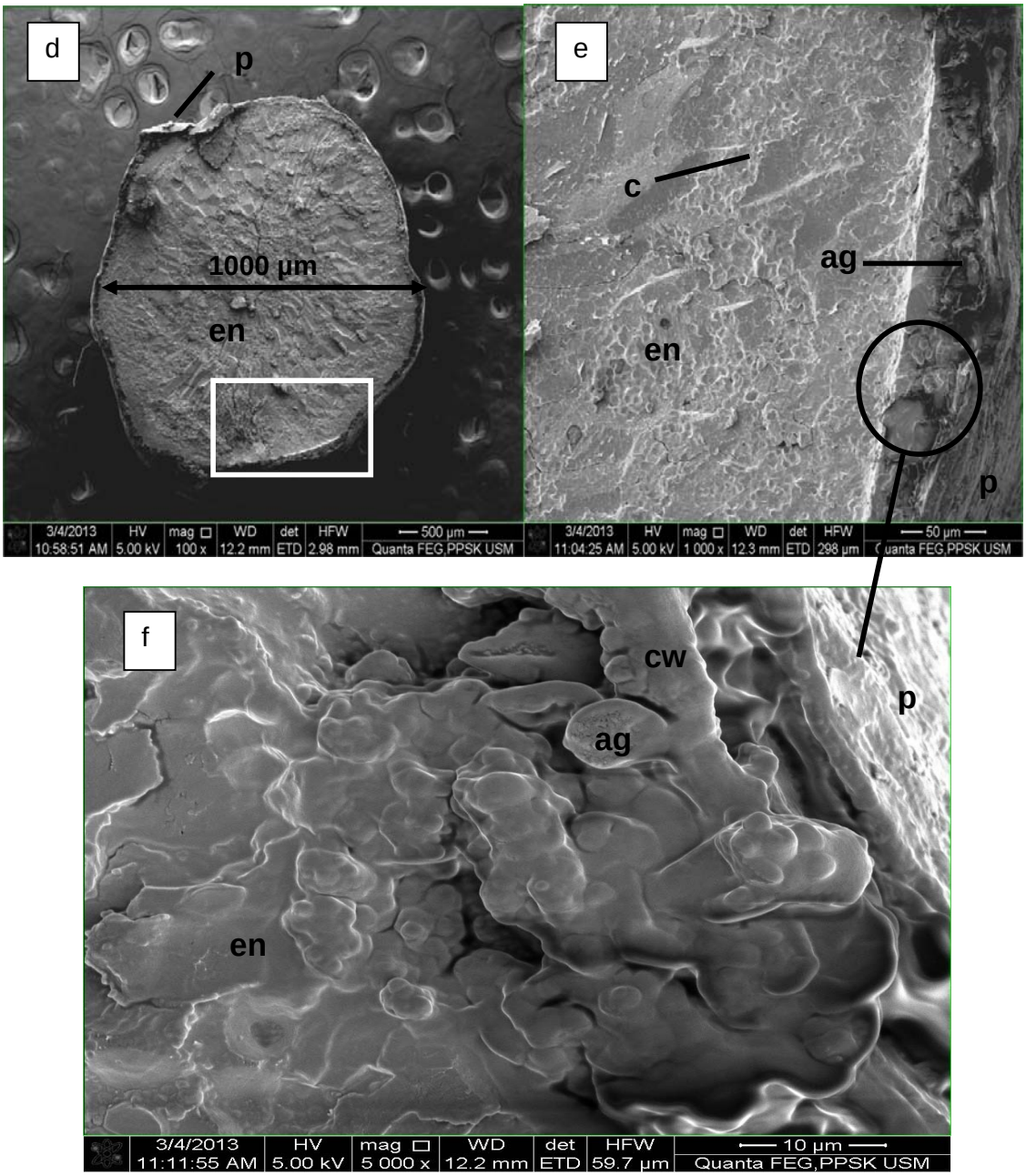

Figure 1.3(d, e, f) are scanning electron photomicrographs in high magnification (100x-5000x) of transverse cross section of the wholegrain rice mix (S3). Photomicrograph 1.3d is a representative rice grain which has been cut to view the transverse cross section. Close view of the space between the pericarp (p) and aleuron layer with endosperm (en) in figure 1.3e under 1000x magnification. Scanning electron photomicrograph 1.3f show the parenchyma cells wall (cw) which surrounded by aleuron grains (ag) under 5000x magnification.

Figure 1.4a show the end part of white rice (S4) as a control to view the external morphological surface structure which differs from all brown rice samples. The surface area of white rice is smooth without any fracture of layer. The colour of this type of sample is whitish because of milling process removes almost completely bran layer. The close view of the surface of white rice (S4) in figure 1.4b under 1000x magnification shows the surface cover with aleuron grains (ag) as outermost layer which totally differ from brown rice sample.

Figure 1.4c shows the aleuron grains (ag) with parenchyma cells (pc) under 5000x magnification. The shape of aleuron grains (ag) present is in irregular globular shape while parenchyma cells (pc) also present as shown in figure 1.4c under 5000x magnification. Figure 1.4 (d, e, f) shows photomicrographs of representative transverse cross section from the white rice of sample 4 which do not consist any aleuron layer covering the endosperm (en). The diameter of the cross sectional of white rice (S4) sample is approximately 826.6 µm. The endosperm (en) is located centrally and there is no pericarp (p) or bran layer observed at the outermost layer. Figure 1.4e shows the close view under 1000x magnification of peripheral side which the most outer layer of white rice contain only endosperm (en) with some of aleuron grains (ag).

The starch compound (c) also present and has polygonal like-shape at endosperm. The thickness between the aleuron grains and parenchyma cells presents as outer layer of white rice is approximately 8.97 µm. The diameter of aleuron grains were estimated (0.25 – 1.8 µm) under high magnification 5000x shown in figure 1.4f.

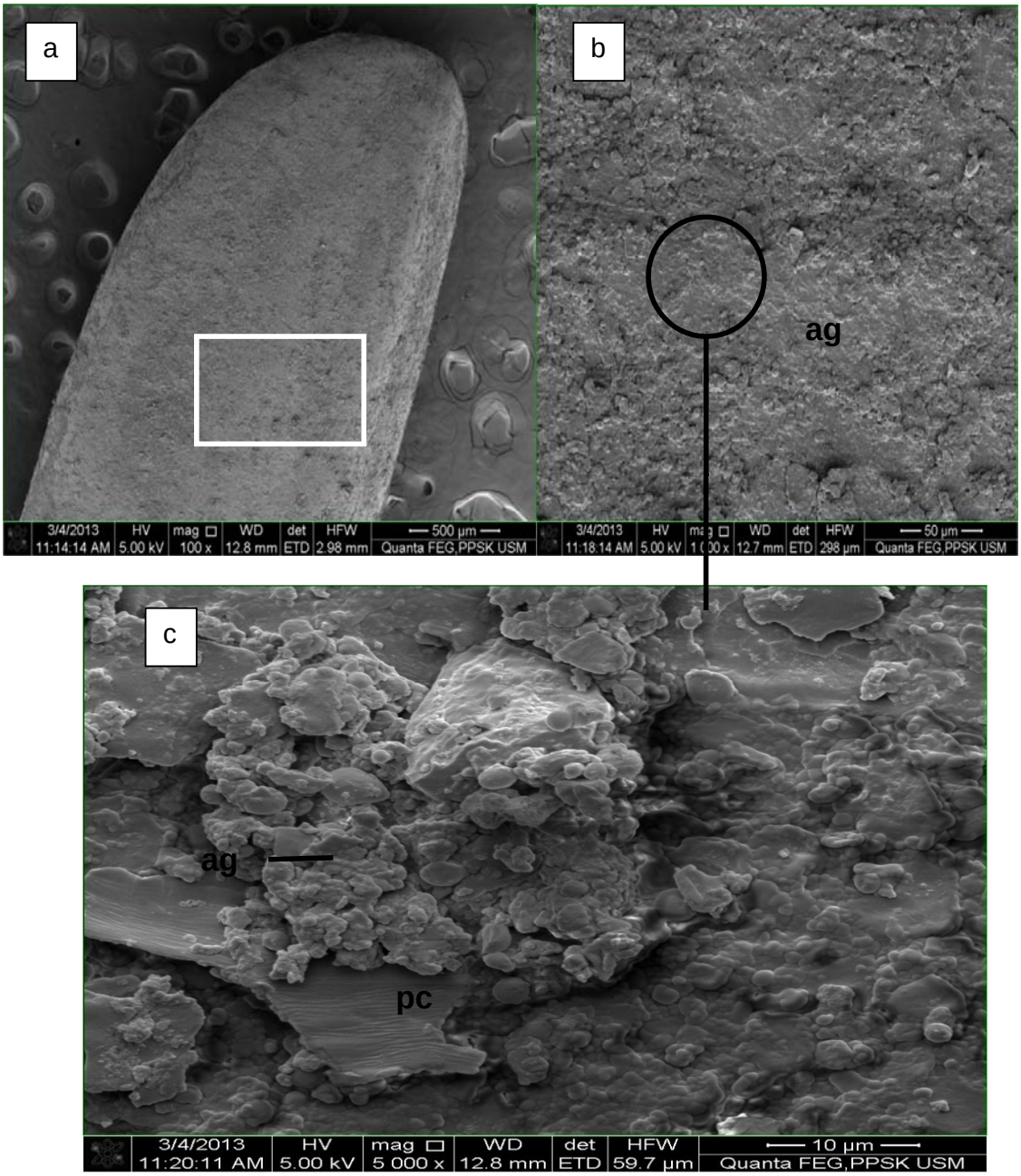

Figure 1.4 (a,b,c) are the scanning electron photomicrographs in high magnification (100x-5000x) of the white rice (S4) as a control. Photomicrograph 1.4a is the overall view structure of white rice (S4). Photomicrograph 1.4b shows the smooth surface without fracture which consist endosperm (en) with aleuron layer as outer layer. Photomicrograph 1.4c showing the present of aleuron grains (ag) and parenchyma cells (pc) at 5000x magnification.

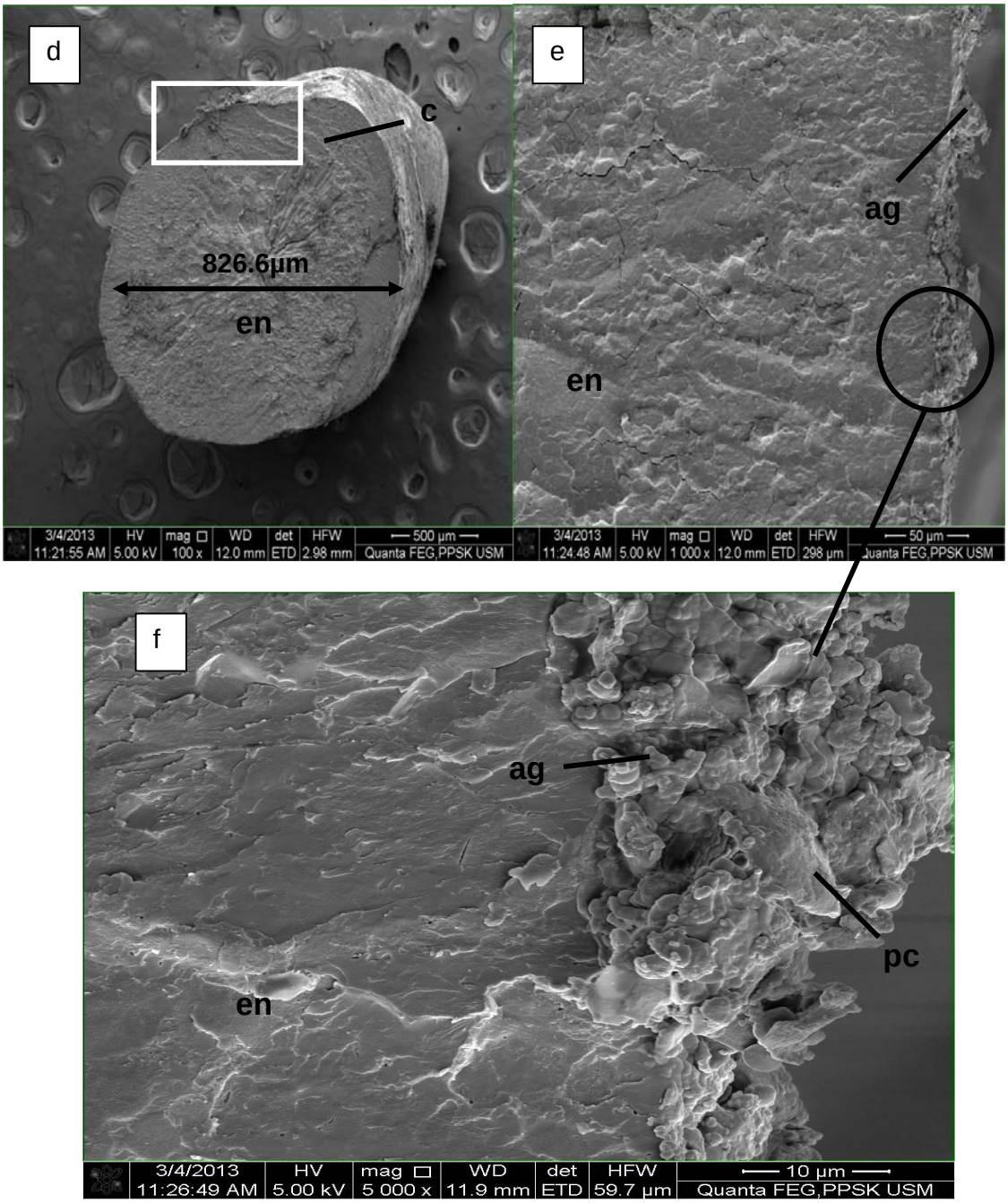

Figure 1.4 (d, e, f) are scanning electron photomicrographs in high magnification (100x-5000x) of transverse cross section of white rice (S4). Photomicrograph 1.4d is a representative rice grain which has been cut to view the transverse cross section. Close view of sample without any aleuron layer but only aleuron grains (ag) with endosperm (en) present in figure 1.4e under 1000x magnification. Scanning electron photomicrograph 1.4f shows the parenchyma cells (pc) which surrounded by aleuron grains (ag) under 5000x magnification.

CONCLUSION

The external morphology of brown rice is differ and depends on the degree of milling process. The brown rice has a layer which known as aleuron and bran layer which cover the outermost layer while it is absent in white rice sample. These layers are thought to store many essential nutrients such as minerals, essential oils and other functional phytochemicals that provide various health benefits to consumer.

AKNOWLEDGEMENTS

The authors acknowledge the Universiti Sains Malaysia's grant funding of this research undertaking.

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