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BIBLICAL CHRISTIAN WORLDVIEW ON POST-HARVEST PATHOGENIC FUNGI IN THE TRADITIONAL MARKET CORN SEEDS

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ABSTRACT

The post-harvest fungi is one of the greatest cause of various diseases. Particularly, in fungus that infects seeds, the toxic substance called aflatoxin is found. This has caused us to wonder: Has fungi been pathogenic fungi since the beginning of creation? The purpose of this research is to study: 1) The Place of Fungi in God's Original Creation and the Origin of Pathogenic Fungi, 2) Characterization of post-harvest fungus on corn seeds, 3) Aspergillus sp.'s Structure as Proof of God's Wonderful Original Creation and Providence, and 4) The factors that contribute to the growth of fungi in post-harvest corn seeds and our responsibility. We conclude that in the beginning, fungi were a part of God's originally good and perfect creation. These fungi were created by God with the structure and function to support its operation in fulfilling God's creative purpose. The complex structure of Aspergillus niger and Aspergillus flavus that infected the corn seeds showed God's providence after the Fall. Pathogenic fungi were the result of the Fall of man into sin. Their growth is caused by the failure to give proper care to the crops. But this should not discourage us since the Bible tells us that God is continually working to restore His creation. Therefore, we are called to be stewards of His creation, to develop and preserve whatever is entrusted in our hands, including the crops for God's glory and under His authority until He has fully renewed and restored everything.

Keywords: *Aspergillus sp.,* corn seeds, creation, fungi, pathogenic, post-harvest

ABSTRAK

Jamur pasca panen merupakan salah satu penyebab terbesar timbulnya berbagai penyakit, khususnya disebabkan oleh jamur yang menginfeksi biji-bijian dan menghasilkan substansi beracun disebut dengan aflatoksin. Keadaan ini menimbulkan pertanyaan apakah jamur patogenik ada sejak awal penciptaan? Penelitian ini bertujuan untuk mempelajari: 1) Posisi jamur patogenik di awal penciptaan dan asal mula jamur patogenik, 2) karakteristik jamur pasca panen pada biji jagung, 3) struktur *Aspergillus* sp sebagai bukti dari providensi Allah akan ciptaanNya yang sangat luar biasa, 4) faktor-faktor yang berkontribusi terhadap pertumbuhan jamur pasca panen biji jagung dan Tanggung jawab kita. Dari hasil penelitian ini disimpulkan bahwa pada mulanya, jamur merupakan bagian ciptaan Allah yang sungguh amat baik dan sempurna. Struktur yang kompleks dari *Aspergillus niger* dan *Aspergillus flavus* yang menginfeksi biji jagung menunjukkan providensi Allah setelah kejatuhan dosa. Pertumbuhan jamur patogenik merupakan gambaran kejatuhan manusia ke dalam dosa yaitu kegagalan manusia untuk memberikan pemeliharaan yang memadahi pada biji-bijian pasca panen. Namun demikian, keadaan ini tidak mematahkan semangat kita karena Alkitab mengatakan bahwa Allah masih terus bekerja untuk memulihkan ciptaanNya. Oleh karena itu, diharapkan kita semua menjadi pelayan atas ciptaanNya untuk mengembangkan dan menjaga apa yang dipercayakan kepada kita di bawah otoritasNya termasuk biji-bijian untuk memuliakan Allah hingga Dia secara penuh memperbaharui dan memulihkan segala sesuatu.

Kata Kunci: *Aspergillus sp.,* biji jagung, jamur, pasca panen, patogenik, penciptaan

INTRODUCTION

Have you ever thought of the quality of the post-harvest commodity sold in the supermarket or in the traditional market which we often use daily, or even consume as food? Generally, harvested crops can be stored for a long period after harvest. But after harvest, there are some problems that can decrease the quality of the harvested crops. Harvested crops are usually daily supplies for domestic consumption, but the post-harvest disease reduces the yields either qualitatively or quantitatively (Singh, Yadav and Verma 2017).

Several fungi that are often found in post-harvest fruits and vegetables are Alternaria solani, Aspergillus niger, Aspergillus fumigatus, Fusarium sp., Mucor sp., Penicillum sp. and, Rhizopus sp. These fungi were found to be the causes of the main post-harvest diseases which degrades the yields' quality (Pallavi et al. 2014). Consuming food infected by fungi can cause various diseases. Aspergillus sp is the fungus that produces aflatoxin with the widest spread. The aflatoxin found in the yields is usually caused by the post-harvest condition, e.g. exposure to heat and humidity (Kinyungu, et al. 2019). Aspergillus Spp is pathogenic since it can cause allergenic effects on humans (Paulussen, et al. 2016).

The type of fungi that infects the yields can be identified through observation based on the morphology of the spore's character, the structure of the spore's bearing, the color of the mycelium, and microscopic observation (Pallavi et al. 2014). The handling of the yields commodity sold in traditional markets and supermarkets might be different. How the yields are stored before they are sold in the market will determine the growth of the fungus. The explanation above has led us to think that fungi are harmful since the beginning of creation? This question leads to another question: Are there other factors that influence the growth of pathogenic fungi? The specific answer to these two questions will be found in the analysis and the result of the research discussed in this paper.

Therefore, the purpose of this research is to study: 1) the place of fungi in God's original creation and the origin of pathogenic fungi, 2) the characterization of post-harvest fungus in corn seeds, 3) Aspergillus sp.'s structure as proof of God's wonderful original creation and His providence after the Fall, and 4) the factors that contribute to the growth of pathogenic fungi in post-harvest corn seeds and our responsibility. Hopefully, this research will encourage us to be aware of and to diligently carry out our responsibilities to preserve and to develop other creatures, and to recognize God's glory through all existing creatures. This research becomes the initial research that can serve as the basis for obtaining solutions for the post-harvest fungus problem that destroys the post-harvest commodity result.

RESEARCH METHODOLOGY

The medium of growth used to grow the post-harvest fungus is *Potatoes Dextrose Agar* (PDA), which ontains granulated sugar (2%), agar (2%), sliced potato with the skin (25%), and chloramphenicol 50%. The composition is mixed in aquadest and sterilized using autoclave for 15 minutes with 15 atmospheres pressure. The harvested seeds to be examined

is corns purchased from the traditional market. The seeds are soaked in NaClO 1% disinfectant solution for 1-2 minutes and then inoculated aseptically on a PDA medium with the amount of 10 seeds/dish using sterilized tweezers. The seeds-containing dish is incubated under room temperature of 25˚C-27˚C for 5-7 days.

DISCUSSION AND ANALYSIS

The Place of Fungi in God's Original Creation and the Origin of Pathogenic Fungi

The fact that fungi can cause various diseases for animals, plants, and even impacting human lives, including the yields commodity for daily consumption (Kinyungu, et al. 2019) and bring loss for humans has made us wonder whether fungi has been parasitic and pathogenic since the beginning of creation. This is clearly not the view of the Bible. The book of Genesis clearly proclaims that in the beginning, God has created the heaven and the earth and everything in it, and called them "good" even "very good" (Genesis 1:1, 11-12, 31). Loucks (2009), taking his stand from Genesis quoted Marsh dan Gillen who said that fungi were created during the Creation Week about 6,000 years ago as "a variety of different reproductively isolated kinds or baramin (bara = created, min = kind; Marsh 1941) He then quoted Buckley to further affirm that fungi had crucial role in recycling organic material, therefore fungi are very important in the recycling process of nutrients in nature. So, how do we explain the existence of pathogenic fungi?

Loucks (2009) concludes that the pathogenic symbiosis between microbes and vascular plants is the result of the Fall, which resulted in the degeneration of God's created world in various degrees. He wrote,"... in ... the biblical creation worldview, ... plant diseases are the result of the Curse by God on the whole of creation due to man's sin (Genesis 3:17–18). In this worldview, pathogenicity is the result of the corruption of the originally designed commensal and symbiotic interactions between plants and microorganisms (such as fungi)". We can find a similar view in Hoekema's analysis (1986), "nature suffers along with humanity; it must share with humankind the results of sin" (By referring to Genesis 3:18, Hoekema (1986) further explains, "Undesirable types of plants will now begin to spring up, and weeds will multiply, making the task of tilling the soil much more difficult than before".

From the explanation above, we can conclude that in the beginning, fungi were a part of God's originally good and perfect creation, created with a good intention and purpose, and were not originally destructive or pathogenic. Pathogenic fungi existed as the result of the Fall of man which also resulted in the cursing of the ground or nature.

Characterization of post-harvest fungus on corn seeds

Initially, this research uses a few samples of the yields found in traditional markets. The characterization result of the post-harvest fungi in the traditional market corn seeds found two types of fungi, identified as *Aspegillus niger* and *Aspergillus flavus* with the percentage of 60% and 40%, respectively (Table 1).

Table 1. The Characterization Result of the Post-Harvest Fungi in the Traditional Market Corn Seeds

Fungus	Spore Colour	Percentage of Infected Seeds (%)
Aspergillus niger	Black	60
Aspergillus flavus	Green	40

The characterization result of post-harvest fungus on table 1 shows that the fungus has black mycelium and green spore. The identification result shows that the black spores are produced by *Aspergillus niger* fungus, while the green spores are produced by *Aspergillus flavus* fungus. Figure 1 shows the growth of *Aspergillus niger* and *Aspergillus flavus* in the traditional market corn seeds day 14. The fungus consists of interlacing strands with multiple branches called hypha. The total mass of the filament is called mycelium. The macroscopic characterization shows that the fungus colonizing the corn seeds in the medium is *Aspergillus sp* (Paica, Ene and Stefan 2013; Zulkifli and Zakaria 2017). Pallavi et al (2014) state that seeds are suitable substrate for the growth and development of various fungi, such as the genus of *Aspergillus. Aspergillus* is a eucaryote microorganism which has the widest spectrum and is abundantly available in nature, while also being the general contaminant in various substrate in tropical and sub-tropical areas (Taniwaki, Pitt and Magan 2018). *Aspergillus* also often contaminates seeds, nuts, and their processed products (Mimoune, et al. 2016).

Based on the observation, *Aspergillus niger* has a round black colony. The black part in *Aspergillus* is found in the conidia head and is round (Vashishta et al. 2016). The green spore is caused by *Aspergillus flavus* fungus. The mold character of *Aspergillus flavus* based on macroscopic observation shows the round green colony. This is in line with the opinion of Afzal, Shazad, and Nisa (2013) which says that the *Aspergillus flavus* colony is greenish-yellow. The growth of *Aspergillus flavus* is seen from the colony with filament which looks like cotton and velvet that initially has a light green color (Gautam and Bhadauria 2012).

The figure 1 reveals how different handling during the storage period will affect the quality of the commodity sold. According to Pallavi et al (2014), The factors influencing the growth of fungus are water quantity, temperature, oxygen quantity, pH, media, and inhibiting component. The growth of the pathogenic fungus is caused by several factors, such as the less optimal post-harvest processing for the corns in the traditional market, which includes cleansing, storing, and packing so that the fungus can easily colonize the medium which contains the corn seeds. Observation result shows the growth of the fungus signified by the enlarging diameter of the fungus colony. The result of the research can serve as one of the proof that inappropriate handling can cause the growth of the post-harvest pathogenic fungus on food commodities. This shows that humans are responsible for preserving the post-harvest commodity to prevent the growth of pathogenic fungus.

Aspergillus sp.'s Structure as Proof of God's Wonderful Original Creation and Providence

Figure 2 shows that the post-harvest fungi grown on the corn seeds from the traditional market are *Aspergillus niger*, *Aspergillus chevalieri*, and *Mucor* sp. The fungus which dominates the corn seeds is *Aspergillus niger*. *Aspergillus niger* has a head that carries the big, solid, round, black, and brown conidia. This fungus has some peculiar characteristics: the hypha with septa, the growing sexual spores which stretch out on the stigma base, is aerobic and therefore needs enough oxygen (Vashishta et al., 2016).

Figure 1. Characterization of the Post Harvest Pathogenic Fungi in the Traditional Market Corn Seeds Day 14. The red arrows show fungi spore. a. *Aspergillus flavus*, b. *Mucor* sp., c. *Aspergillus niger*, d. *Aspergillus chevalieri*

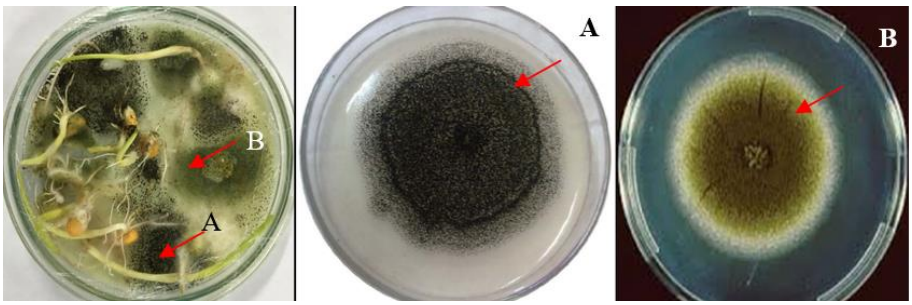
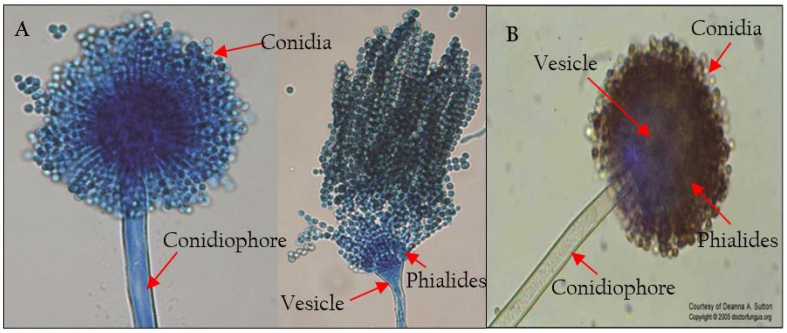


Figure 2. Microscopic characteristics of fungi which grows in the corn seeds from the traditional market. 1. *Aspergillus niger*, 2. *Aspergillus chevalieri,* 3. *Mucor sp*, 4. *Aspergillus niger*. It was observed by phase contrast microscopy at 400 times of magnification



Garcia-Rubio, et al. (2020) states that *Aspergillus* is part of the *Ascomycetes* division since it has a bag structure and contains spores. *Aspergillus niger* is classified in the *Eurotiales* order since it has the conidia shape which stands out more than its ascus. The older *A. niger* colony's color is black and dark brown. The microscopic characteristic of *A. niger* is having the vertically straight soft conidiophore. *A. niger*'s chain conidia spread across the vesicle surface and form a rough perfect black circle (Silva, et al. 2011). *Aspergillus niger* is dangerous for causing aspergillosis (Richardson and Rautemaa-Richardson 2019).

The structure of the fungi morphology displayed in this research findings above shows that each part of the fungi mutually supports its survival and function. This reminds us of the fact that in the beginning, all that God created was good and perfect (Genesis 1:31). Each creation, including fungus, is created with the structure and function to support its operation in fulfilling God's creative purposes. Loucks, in quoting Carrol (1988), even affirms that fungi can live as endophytes without causing any negative effect let alone disease in its host, "Within the last hundred years, endophytic fungi have been described that reside in plant tissues yet do not cause disease". Also, we cannot forget that fungi have important roles in the ecosystem balance and can be used as the source for medicines and biotechnological applications (Abdel-Azeem, et al. 2019; Paulussen, et al. 2016).

And so we can see that even though the consequences of sin have caused some fungi to be pathogenic, including *Aspergillus niger*, we can still see that they have not totally lost its original structure and capacity to perform their basic functions. Here we see God's providence

in this fallen and sinful world. This finding confirms the fact that sin has not brought total destruction nor devastation to the good and perfect order of God's creation. Quoting Calvin, Hoekema asserts, "The cursing of the ground means that there is a sense in which God will withdraw his favor from the earth – though, as Calvin reminds us, this will not be a total withdrawal". At the same time, Hoekema (1986) assures us from the passages of Scripture that the earth is full of the goodness of the Lord (Psalm 33:5, King James Version), and that the Lord's tender mercies are over all His works (Psalm 145:9, New International Version). This is evident i.e. in the fact that only slightly above 10,000 fungi (< 1%) from the whole 1,5 million fungi cause disease on plants and animals according to Agrios and Deacon, as quoted by Loucks (2009). What's even more wonderful is the fact that by His providence, He has provided a way for us to prevent the growth of these pathogenic fungi in our crops through the exercise of our God-given responsibilities as His image, even in our fallen state, i.e. through better handling, packing and storing of the post-harvest crops.

The factors that contribute to their growth of fungi in post-harvest corn seeds and our responsibility

The result of the post-harvest fungi characterization gives a strong proof that confirmed the previous explanation that fungi were originally created in diversity to maintain balance in the ecosystem. However, man's sin has brought some serious consequences to the ecosystem, including the fungi. As explained earlier, the sin of man has brought a curse to the ground and one of the consequences is the existence of pathogenic fungi. And in their sinfulness, humans also fail to carry out their God-given responsibility to handle God's creation, particularly the food commodity. This has caused pathogenic fungi to grow in unappropriate places and cause disadvantages, e.g. the post-harvest pathogenic fungi. This is supported by (Zhang, et al. 2019), who helps us see another factor that influenced the growth of pathogenic fungi in the crop, i.e. the handling and storage. This shows that humans play a crucial role and have specific responsibilities in the process. The failure to give proper care to the crop which includes cleaning, storing, and packing apparently results in harmful consequences, both for the crop itself and for us humans who should have benefited from it.

This failure reminds us of the failure of the first man that God created in His own image to carry out the God-given mandate to develop naturally. The Bible tells us that at Creation, God gave Adam and Eve, our first parents the responsibility to work the garden and to take care of it (Genesis 2:15; Psalm 8:6). This means that they are responsible for all the natural resources that God has created, as God's representatives. This command echoes God's great mandate for the first mankind, which He made in His own image and likeness (Genesis 1:26) to exercise dominion over nature and to multiply, the mandate known as the "Cultural Mandate" (Genesis 1:28-30). Man is to be totally dependent on God and responsible to Him as he obeys God's command to develop all potentialities found in nature and in humankind as a whole to build a God-glorifying culture (Hoekema 1994) This means that Adam, in exercising dominion over nature should not act in autonomy for his own selfish purposes but instead, as God's representative, he should submit to God's authority, and then teach his descendants to do the same as together with Eve they multiply and fill and subdue the earth. But sadly, Adam and Eve disobeyed God and so brought themselves and all their

descendants into sin. Man now stands in enmity with God, their fellowmen, and nature (Genesis 3), exploiting everything for his own selfish purposes. Sin undoubtedly has corrupted our whole being, which includes our capacity, capability, and integrity. We also no longer carry out the task for the perfect and good purpose that God has set in the beginning, when He first created everything. Instead, we misuse our authority and exploit nature for our own selfish gain. No wonder we find so many damages caused by humans in nature (Genesis 6:5; Romans 1: 18-32).

But the Fall is not the end of the story. The initially perfect and good world that God created is not left to destructio n. God never abandons the work of His hand, and neither can sin destroy God's original purposes for His creation. Genesis 9:1 once again confirms the continuation of man's responsibility in Creation (Genesis 1:28). Manahan's dissertation on the Cultural Mandate also affirmed, "The dominion given man in Genesis 1:26-28 refers to shaping activity, a duty to be practiced with respect to the cosmos in which man lives. Genesis 9:1-7 being post-fall, pay attention to the alteration in man's relation to the cosmos, but in no sense is that formative activity which should be done to the glory of the Creator negated" (Manahan, 1982). As Hoekema declares, "This earth is still God's earth. He created it, maintains it, and directs it in such a way that sin is to some extent restrained, civilization is still possible, and human culture is significant" (Hoekema, 1986, p. 201).

Not only that God's mandate for Adam and Eve retained after the Fall. even in their fallen state (Genesis 9:1), the Bible also promises redemption (Genesis 3:15). Wilkinson (1993), in response to those who think that "creation is irreparably fallen so that we are saved out of this fallen creation to live eternally with God while creation itself is consigned to destruction" states, "A far more biblical view is that creation is fallen *through* human sin and will be redeemed *through* human redemption (Carson & Woodbridge, eds. 1993, p. 317)

So, how should we see this responsibility that we have over nature in light of our fallen condition as God's image in this fallen world? Wilkinson (1993) asserts, "Through the restoration accomplished in Christ, our creative, dangerous, but God-given powers of dominion can become restoring, healing powers, leading to an enhancement of what God has made, to an unfolding of the Creator's purpose". (Carson & Woodbridge, eds. 1993, p. 318). And so we see that Christ's redeeming work will bring complete restoration not only to His chosen people, but extends to the whole universe, to the whole creation. As Paul said in Romans 8, the whole creation and us has been groaning together in the pains of childbirth until now as we wait for the redemption of our bodies (Romans 8:22-23, ESV). Therefore, God is working through His Spirit to apply the finished work of Christ's redemption, renewing and restoring all creation to reach its final consummation in the new heaven and the new earth. As His redeemed people, we are once again called to develop and preserve nature as His stewards for His glory while we look forward to the realization of this final consummation.

The damage in the yields commodity shows our failure to carry out our responsibilities toward the harvested crops which causes the growth of fungi that destroy the commodity. Moreover, through the growth of fungi in the post-harvest commodity, we can see God's glory and order in creating fungi through the conducted research. This shows that even though sin

has corrupted God's creation, it has not been able to destroy God's glory which is evident throughout all His creation, including the fungi. God is continually restoring His people to His image and at the same time, He is continually restoring His created world. The redemption of God's people does not deliver mankind from their attachment to other creation but is the redemption for the creation (Wilkinson in Carson p. 381, 2002). And therefore, each one of us is called to take part in His redeeming work over nature, the restoring of His created world by doing our best in whatever is entrusted into our hands, including the crops.

CONCLUSION

This study has shown us that fungi were part of God's good and perfect original creation, created with a good intention and purpose, and were not originally destructive or pathogenic. Fungi had crucial role in recycling organic material, therefore fungi are very important in the recycling process of nutrients in nature. However, after the Fall of man into sin, degeneration occurred in various degrees in God's created world. Nature suffers the consequences along with humanity, and one of the results is the existence of pathogenic fungi. But even after the Fall, God did not take away the responsibility of mankind to develop and to preserve nature. We clearly see this in this research that even though the existence of post-harvest pathogenic fungi cannot be denied, their growth can be prevented and controlled with better handling. Through this research, it is confirmed that the growth of pathogenic fungus in the yields is caused by the mishandling of the crops, which results in the reduced quality of the crops. This shows that the growth of pathogenic fungus in yields has to do with human negligence in handling them, and that we can prevent its growth by better handling. This is one proof of His providence over His fallen world. Another proof of His providence is seen clearly as we study *Aspergillus niger* as the pathogenic post-harvest fungus that dominates the corn seeds and also fungi in general. Through their intricate design and amazing structure that enable them to perform their basic functions, we are reminded of God's wonderful creation and glory in the beginning.

And above all this, the Bible also tells us that this is not the final state of God's creation. God is continually working to renew and to restore His creation, including mankind. Therefore, we are called to become His stewards, doing our best to care for and develop all the natural resources to fulfill His purposes for His glory until we see the full restoration of all things in the new heaven and the new earth.

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