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Fungal infection to wheat bran pellet: Root case analysis

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Abstract
Mostly bran is removed during wheat flour processing and bran is by-product of flour processing that is rich in nutrition. Removed wheat bran commonly uses to produce animal feed formulas such as bran pellets. Fungal infection was identified in the exported wheat bran pellets manufactured in Sri Lanka, therefore, this study was conducted to investigate root cause for fungal infection in wheat bran pellet. Critical points that can be coursed for fungal infection in bran pellet during manufacturing, storage, container loading and export disinfection points were examined and analysed. Identified critical points are; in processing i.e. soaking of wheat, separation bran and germ, mixing and making of pellet mixture, pellet manufacturing, pellet cooling, packing, in storage i.e. warehouse conditions (relative humidity and temperature), loading to container and in export disinfection process i.e. application of Methyl Bromide. Pallets samples were analysed for fungal infection all these critical points. Results revealed that Methyl Bromide was applied for export disinfection, this application caused to accumulate water in the container cargo and it was evaporated during day time and moisture condensation processes were taken place inside the pallet container during night at sea transportation. Therefore, moisture accumulation should be minimized during application of Methyl Bromide. As well it was required to maintain the water activity below 0.63 of pellet after Methyl Bromide disinfection process.

Keywords: Wheat bran pallets, manufacturing, critical points, fungal infection

Introduction
Wheat (*Triticum* spp.) is the third most important cereal crop after maize and rice and believe origin from the Ethiopian Highlands, now cultivated worldwide. Wheat flour based food products such as bread, biscuits, cookies, cakes breakfast cereal, pasta and noodles are highly popular around the world. In 2016, world production of wheat was 652 million tons, making it the third most-produced cereal. This grain is grown on more land area than any other commercial food. World trade in wheat is greater than for all other crops combined. Globally, wheat is the leading source of vegetable protein in human food, having a higher protein content than other major cereals, maize or rice. Wheat is also use more extensive for animal feeds (Olli-Pekka 2012; Richard 2016) [5, [5]].

Wheat is mostly consuming as flour therefore, wheat flour milling common in the wheat industry. The first wheat flour milling steps involve equipment that separates wheat from seeds and other grains, eliminates foreign materials such as metal, sticks, stones and straw; and scours each kernel of wheat. Other steps are; conditioned for milling, removing of outer husks, crease dirt and polish the outer surface with an intense scouring action. Milling process is a gradual reduction of the wheat kernels to produce particles of endosperm which are then graded & separated from the bran by sieves & purifiers. One pass through the corrugated "first break" rolls begins the separation of bran, endosperm and germ (Carson, and Nancy 2009) [2].

The whole grain can be milled to leave the endosperm for white flour. The wheat germ and bran especially are concentrated source of vitamins, minerals, fat, oil and protein, while the refined grain is mostly starch. Mostly bran is removed during wheat flour milling. Wheat bran (course & fine bran) and germ are the major by-product of the wheat flour processing that is rich in nutrition. Therefore, removed wheat bran commonly uses to produce animal feed formulas such as bran pellets (Antoine, *et al* 2003) [1].

Wheat flour mills in Sri Lanka produce different types of wheat flour and wheat bran pallets. Wheat bran pallets are mostly export by these companies.

However, these flour mills had been reported fungal infection of their exported bran pallets after they reached to the overseas. Accordingly, these companies requested investigation to identify, the root case for this fungal Infection. Therefore, this study was conducted to investigate, analysis and for identification root cause for fungal infection in exported wheat bran pellets.

Methodology

Wheat Bran Pellets are manufactured from the by-product of wheat flour processing. It was made mixing of major by-products of wheat milling i.e. course bran, fine bran, germ, grind stalks & organic Impurities with high pressure steam by process flow chart mention in figure 1. Pellets (compressed small piece of mixture of bran, germ and other organic materials) are main product manufactured to utilize by – products in these flour mills. Pallets are mainly used for animal feed, especially for feeding of cows. Pellets contained all nutritional component such as protein, fat (oil), minerals and vitamins, therefore it is highly nutritious and it can be easily infected by microbes. This study was analysis and investigate all critical points (Table 1) from manufacturing to export i.e. raw material, manufacturing, storage, disinfection and transportations that can be vulnerable for fungal infection.

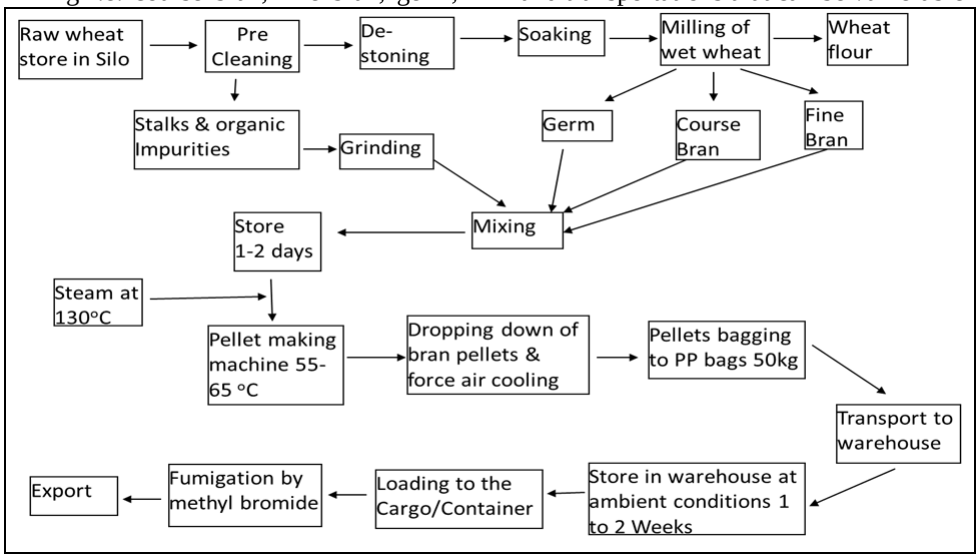

Fig 1: Identified process flow-chart from manufacturing to export for bran pallets

Processing points of wheat milling and bran pallet manufacturing mentioned in table 1 were analyzed. The critical points were identified according to the vulnerable forms or process that can be create favorable conditions such as high moisture and temperature suitable to fungal growth.

After manufacturing pellets packed in 50kg poly propylene bags under air conditioned environment (temperature 20 -23 ^{o}C and relative humidity (RH) 55 – 60%). After that 50kg bags directly loaded on to Lorries through conveyor belts and transport to warehouse. 50kg bags were stored directly on warehouse floor and stock height about 15bags. Warehouse has not been provided enough rooms for ventilation. The storage period of product was maximum two weeks' prior shipment. After warehouse storage 50kg pallets bags packed to large containers for export shipping. Containers were selected form container yards and pallets directly loaded into it containers. However, containers need to be clean before loading for product hygiene and safety. Some of containers were observed with water and wet floors which can be caused for fungal growth.

Table 1: Identified critical points vulnerable to fungal infection and analysis

Identified critical points	Analyses conditions
Silo stored raw wheat	for moisture and its quality (impurities)
Soaking of wheat	Biological quality of soaking water, Moisture content after soaking
Separation of bran and germ (Milling)	Moisture content of germ, moisture content of, course bran and fine bran
Mixing and making of pellet mixture	Moisture content of pellet mixture (course bran, fine bran, germ, grind stalks & organic Impurities)
Just after pellet making	Moisture content & temperature of hot pellet before cooling and water activity of pellets
After cooling of pellet at stored bin	Moisture content & temperature of pellet after cooling and water activity of pellets
During packing of pallets to PP bags	Moisture content, water activity & temperature of pellet
During storage of warehouse	Moisture content, water activity & temperature inside pellet. Warehouse temperature
After fumigation of cargo and before sending to the ship	Moisture content, water activity & temperature of pellet

Pallets loading to containers and fumigations (disinfection)

The empty container was dressed/underlined with Kraft papers, and 12 absorb bags are hanged on either inside of container. The 25kg of silica gel were put inside the container sporadically as 500g bags during loading. 50kg pallet bags loaded into containers through conveyor belts, close the container and send for fumigation. Fumigation was compulsory disinfects process need to be done during export of biological products. It was performed by Methyl Bromide ($C_2 H_5 Br$) at the warehouse premises with 7 canisters which is equal to a concentration of 96g per cubic meter through a small tube inserted into the container thought the door beading. Then the container transferred to shipping yard and then on board of the ship and send to overseas

Results and discussion

The initial quality analysis of the raw wheat sample, used in these flour mills was reported; moisture content (MC) 9.8% and impurities percentage of wheat sample 2.192%. Initially raw wheat was soaking before sending to flour milling, soaking was initial pre-treatment for grain before milling (Gunathilake 2018) [3]. After soaking of raw wheat MC was increased to 13.8%. During flour milling, course bran, fine bran and germ was separated. Moisture percentage of separated germ was reported 15.1% and moisture content of pellet mixture (course bran + fine bran + germ + grind stalks & organic Impurities) was reported 14.31%. Pellets were made by the pellet machine. This was high temperature process and heated pressurized steam was used therefore after making pellet, its temperature was reported 55°C and moisture percentage of the just after manufacturing of pellets was 16.24%. The water activity of pellets in this point was observed 0.75. Table 2 is shown moisture content, water activity and temperature of pellets of different points till packing to the container

Table 2: Moisture content, water activity and temperature in pellets at different manufacturing points

Identified manufacturing points	Moisture percentage	Water Activity	Temperature
Pellets after force air cooling	13.51	0.72	33.1
Before packing to the pp bags under ambient condition	13.47	0.69	31.6
During packing of pellets to the pp bags under air conditioning	13.81	0.66	28.1
After 02 days storage of pellets in warehouse	14.1	0.69	34.6

Generally, suitable conditions for fugal growth are; high environment relative humidity (it cause to accumulate water droplets around food materials), high stored temperature, high water activity (if water activity is less than 0.6, 99% fungal growth inhibit and less than 0.65, 80% fungal growth inhibit (Rosane, *et al* 2008; Millls 1989) [7, 4], high nutrient content in the foods and high oil content in the foods. During packaging of pellets to PP bags in air condition room at flour mill, water activity was observed 0.66. However, water activity of pellets was increased up to 0.69 after two days at warehouse as explain above, these water activities and environmental conditions were suitable for microbial incubation initiation. The results in table 2 showed that pellet get cooled under air conditioning and when it opened to normal atmospheric conditions (high temperature and RH), it caused to absorbed moisture and increased the water activity.

Figure 03 is shown warehouse temperature and inside temperature of the pellets bags stored in warehouse. The temperature inside the pellets bags was significantly high in comparison to the warehouse environment temperature. As well, warehouse environment temperature was fluctuated according to the day and night time. However, inside temperature of the pellet bags reported higher temperature in comparison to warehouse temperature. This higher temperature in pallets was suitable for incubation spores of microbes.

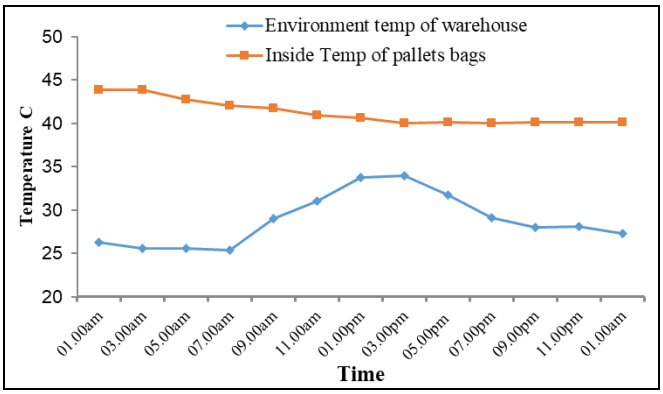

Fig 3: warehouse environment temperature and inside temperature of the pellets bags

As identified above, water activity of the pellets was increased and pallet temperature was also high during the warehouse storage. Therefore, those conditions in warehouse were favourable for initiation of fungal growth.

Fumigation of pallets stored containers (before export)

Fumigation was compulsory disinfects process need to be done before exporting of biological products. Methyl Bromide (C_2H_5Br) was used to performed fumigation. It was identified that under laboratory control conditions, methyl bromide dose requirement to kill fungus was 32 g/m³. However, practically this dose may not be enough for killing of microbes. In professional fumigation, 96g/m^3 was applied i.e. 3168g of C_2H_5Br applied to 33 m^3 volume container (20ft container). After applying chemicals, 24 hours' incubation period required for good killing of microbes. In addition, hot air was also injected to container to induce reactions. This hot air injection can be caused to water accumulation inside the container. The existing method of fumigation was; pallets loaded into the container and fumigate with Methyl Bromide dose 96g /m^3 and closed container vents. However, it was required to open the vents of the container at least for 4 hours after 24 hours' incubation period for de-gassing and brining to the atmospheric condition prior the shipment. It was observed that it was not practiced in this pallet transportation that caused to condensation water in the container.

Water condensation in the container during sea transportation

During sea transportation, condensation occurs when moisture laden air releases its water vapour on to the surrounding surfaces in the form of water droplets. As well, condensation can be too occurred due to temperature gradient during day and night time. If water vapour remains inside the container during fumigation, vapour condensation to water inside container that triggered to increase water activity of pallets.

Identified root case for fungal infection and preventive measures

Results showed that, pallet manufacturing process conditions in the wheat mill were not favorable for fugal growth as well, pellets were not kept long time in the mill under unfavorable conditions. Hence, it can be concluded that minimum chance for fungal infection under manufacturing process in mill. However, it was identified that can be chance to initiate fungal growth in warehouse because high pellet temperature reported day and night time, high temperature caused to absorbed more moisture from the environment. The fungal growth was enhanced by the high temperature and moisture that conditions could be observed inside the pallet loaded and closed container after C_2H_5Br fumigation, which is further enhanced during the sea transportation by the wrong

fumigation procedures followed by the absence of degassing. Therefore, fumigation need to be practiced separately to the pellet bags in the warehouse, after 48 hours' pallet bags required to open for de-gassing and then load the in to the fumigated container after opening the vents and close the container. Cargo container should be underline by Kraft papers before loading. It must be kept the water activity of pellets below 0.63 before loading.

Conclusion

Pallet manufacturing process in the mill was not favourable for fugal growth and it could be initiated in warehouse due to high pallet temperature. However, it can be concluded that the fungal growth was enhanced by the high temperature and moisture conditions inside the pallet loaded container due to wrong C_2H_5Br fumigation, which is further enhanced during the sea voyage that condensation occurs when moisture laden air releases due to day and night temperature differences. Therefore, it was required to maintain the water activity of pallet below 0.63 before sea transportation.

Reference

1. Antoine C, Peyron S, Mabille F, Lapierre C, Bouchet B, Abecassis J, Rouau X. Individual contribution of grain outer layers and their cell wall structure to the mechanical properties of wheat bran. Journal of Agricultural and Food Chemistry. 2003; 51:2026-2033.
2. Carson G, Nancy E, Criteria of wheat and flour quality, In. Khan, K. and Shewry P. (Eds.) Wheat Chemistry and Technology. 4th edition. St. Paul, Minnesota, USA: AACC International, Inc, 2009.
3. Champathi Gunathilake DMC. Application of two temperatures hot water soaking for improving of paddy parboiling process. Agricultural Engineering International: CIGR Journal. 2018; 20(4):164-168.
4. Millls JT, Spoilage and heating of stored agricultural products; Prevention, detection and control, Canadian Government Publishing Centre, Supply and Services Canada Ottawa, Canada, 1989.
5. Olli-Pekka L. Modifying Wheat Bran for Food Applications - Effect of Wet Milling and Enzymatic Treatment, Honour's thesis, Metropolia University of Applied Sciences, Helsinki, Pinelands, 2012.
6. Richard D. Taylor Outlook of the U.S. and World Wheat Industries, 2016-2025, Center for Agricultural Policy and Trade Studies North Dakota State University Fargo, North Dakota, USA, 2016.
7. Rosane SC, Lima HLS, Pinto GAS, Gava CAT, Rodrigues S. Effect of Moisture on Trichoderma Conidia Production on Corn and Wheat Bran by Solid State Fermentation, Journal of Food Bioprocess Technology. 2008. 1:100–104 DOI 10.1007/s11947-007-0034-x