

**DEVELOPING A GENERIC HAZARD  
ANALYSIS CRITICAL CONTROL POINT  
(HACCP) SYSTEM FOR THE FLOUR  
MILLING INDUSTRY**

by

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In the Department of Biotechnology

Faculty of Science

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## DECLARATION

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I, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not previously in its entirety or in part submitted it at any other university for a degree.

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Lauren Gillion

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Date



## SUMMARY

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Worldwide food borne disease is of major concern to food handling enterprises, researchers and public health officials especially because consumers expect only the best with regard to food safety and quality. If however consumers are unsatisfied with the purchased product, the food manufacturer can suffer major economic losses. Therefore we are of the opinion that all food handling enterprises should produce food products that meet the in-house specifications as well as conform to the local health regulations. An increase in international trade also occurred over the last couple of years and as a requirement it has to be proved that food safety of the specific product is managed. The Hazard Analysis Critical Control Point (HACCP) System has been proved in various industries to be the food safety tool that successfully manages the hazards associated with the production of food products from farm to table.

In South Africa, HACCP has become a requirement because of customers' demands as well as government's demands in cases where the product is exported to countries such as the European Union or the United States of America. In the near future however, HACCP will become mandatory in terms of the law. Therefore there was a need within the flour milling industry for a generic HACCP model which could afterwards be adopted for the specific needs of several mills in South Africa.

The study included eight key generic pre-requisite programs that have to be in place before the HACCP study can be attempted. It included elements such as premises; purchasing, transport and storage; equipment; personnel; sanitation and pest control; recall; quality assurance and management. These pre-requisites are regarded as the basis of a HACCP system. A generic flow diagram has also been developed. The HACCP plan contained the hazard analysis, the critical control points, critical limits, procedures for the monitoring of the CCPs as well as verification procedures to ensure its effectiveness. The critical control points identified were the rebolt sifter, metal detector and impactor system before packaging as well as the mix-back system.

The study also included the microbial safety of the wheat as well as the microbial safety of the final flour products. It was evident from the results achieved that the Good Agricultural Practices at the farms were merely non-existent which meant that intensive cleaning of the wheat had to take place before milling. Although various cleaning processes took place, most of them responsible for only removing physical impurities, the microbial load of the end product was more or less the same as on the raw product. In order to reduce the microbial load on the final flour product, the pre-requisite programs such as cleaning, general housekeeping and personal hygiene of the food handlers should be in place.

The results obtained from the analyses of the packaged product verified those from previous studies that most of the micro-organisms are found in the outer bran layers of the wheat kernel, since those products that contained bran or part thereof had far higher microbial counts than the plain flour where the bran layers were removed.

This study will be used by the wheat milling industry as a guideline to implement HACCP within their mills. In order to achieve this, resources such as time and money is needed. It is also important that the staff should be well trained; committed and enthusiastic - the same goes for top management for they should lead by example. It cannot be emphasized enough, that HACCP is not a stand alone but needs to be backed up by pre-requisite programs in order to be efficient.

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## GLOSSARY OF TERMS

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For the purpose of these guidelines, the following definitions apply:

- acceptable - satisfactory to the administering authority
- adequate - enough to achieve the intended purpose of these guidelines
- administering authority - a certified organisation that has the jurisdiction, for example: a government department, local authority or a body accredited by the South African National Accreditation Services
- animal - any vertebrate or invertebrate part of the animal kingdom not planned to be used as food
- appropriate - acceptable to, or necessary by, the administering authority
- approved - permitted by the administering authority
- available - includes available somewhere else than on the food premises in question
- cleaning - removal of dirt, impurities, soil, food residues or other objectionable matter
- container or food container - anything in which or with which food is served


- contamination - incidence of any undesirable matter in the product so that it does not meet a standard or requirement determined by law, does not meet satisfactory food hygiene standards or is unfit for human consumption
  
- control - all the essential measures to ensure and maintain conformity with the criteria established in the HACCP plan
  
- control measure - action used to avoid, eliminate or decrease a food safety hazard to an acceptable level
  
- corrective action - action taken to eliminate the cause (s) of an existing non-conformity, shortcoming or unwanted situation in order to prevent it from re-occurring
  
- critical control point - a point, step or procedure at which control can be applied and a food safety or suitability hazard prevented, eliminated or reduced to an acceptable level
  
- critical limit - a value separating the acceptable from the unacceptable
  
- decision tree - a series of questions that are applied to each step in the process in respect of an identified hazard to identify which steps are CCPs
  
- defect action point (DAP) - a point, step or procedure at which control can be applied to prevent non-compliance with mandatory but non-safety requirements that are regulated nationally or


internationally (or both) and that are aimed at protecting consumer interest

- deviation - the failure to meet a critical limit
- disinfection - use of approved chemical agents, physical methods or both to reduce the number of micro-organisms to a level that will not lead to harmful contamination of the food, without adversely affecting the food
- establishment - any structure (s) or area (s) in which food is handled and the environment under the control of the same management
- executive officer - the representative designated under section 2(1) of the Act
- facility - any apparatus, appliance, equipment, implement, storage space, working surface or object used in association with the handling of food
- flow diagram - a methodical illustration of the sequence of steps or operations used in the production or manufacture of a particular food item
- food - foodstuffs as defined in Section 1 of the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act 54 of 1972) and intended for human consumption
- food business - any public or private undertaking whether lucrative or not that carries out any or all of the stages from primary production through to the export of the product

- food business operator - dependable person or persons that ensure that requirements of the regulations are met within the food company under his or her control and include the management as well as the person with the overall power on site or in the exact organization
  
- food chain - all the stages through which food is handled from primary production to processing, manufacturing, distribution and retail to the point of consumption
  
- food handler - a person who in the course of his or her normal duties comes into contact with food not planned for his or her own use
  
- food handling - any process in the growing, harvesting, preparation, processing, packaging, storage, transportation, distribution and sale of food
  
- food handling enterprise - a business which for the period of its operations produces, processes, manufactures, stores, transports, distributes or sells foodstuffs or is busy in any activity which may impact on the safety of such foodstuffs
  
- food hygiene - all conditions and actions necessary to ensure the safety, soundness and wholesomeness of food at all stages, from its production or manufacture through until its final consumption



- food premises - a building, structure, stall or other similar structure including a caravan, vehicle, stand or place used for or in association with the handling of food
  - food safety - the guarantee that a particular food product will not cause injury to the consumer when it is prepared and / or eaten according to its proposed use
  - food suitability - the guarantee that a food is suitable for human consumption according to its intended use
  - food spoilage - any microbiological food deterioration
  - Good Manufacturing Practice (GMP) - the combination of manufacturing and quality measures aimed at ensuring that a product is always manufactured to its specification
- 
- HACCP certification - the issuing of documentary proof by a certifying body accredited to do so by the South African National Accreditation System (SANAS), a non-profit institute registered in terms of section 21 of the Companies Act, 1973 (Act No. 61 of 1973) registration No. 199600354108 based on the results of an external HACCP auditing, or in the case of imported foodstuffs, a certifying body accredited for the purpose by a worldwide recognized accreditation authority

- HACCP Plan - a document prepared in accordance with the principles of HACCP, aimed at ensuring the control of hazards that could influence the food safety in the segment of the food chain under consideration
- HACCP Study- the process of applying the stages used to design the HACCP system
- HACCP System - the hazard analysis and critical control point system that identifies, evaluates and controls hazards which are important for food safety
- handle - manufacture, process, produce, pack, prepare, keep, offer, store, transport or display for sale or for serving
- hands - includes the forearm or the part of the arm extending from the wrist to the elbow 
- hazard - a biological, chemical or physical agent with the potential to cause harm to or affect the safety of the consumer
- hazard analysis - process of collecting and evaluating information on hazards and on conditions leading to be included in the HACCP system
- Hazard Analysis and Critical Control Point (HACCP) system - a system that identifies, evaluates and controls hazards that are significant to food safety
- hazard characterization - the qualitative assessment of the nature of

any adverse result associated with any biological, chemical or physical agents or a combination of these that might be present in food

- monitor - to perform a planned series of observations or measurements of critical limits to assess whether a CCP is under control
- non-conformity - non-fulfillment of a particular requirement
- packaging material - any containers such as cans, bottles, cartons, boxes, cases and sacks, or wrapping and covering material, such as foil, film, metal, paper, wax-paper, plastics and cloth
- pest - any animal competent of contaminating food directly or indirectly
- person in charge - someone who is accountable for the food premises and/or the owner of such food premises, as the case may be
- potable water - water that complies with the requirements of SABS 241
- preventive action - any action taken to eliminate the cause (s) of a potential non-conformity, shortcoming or other unwanted situation in order to avoid its occurrence
- record - a document that provides objective proof of measures undertaken or results achieved

- representative body - a group of persons or an organisation mandated to represent persons in a specific sector or specific food handling enterprise responsible for handling 60% or more of the foodstuffs under consideration
- risk - an approximation of the probability of the occurrence of a hazard or other non-conformity
- safe - containing no substances likely to cause injury to the end user
- sensitive production areas - areas where the product is particularly vulnerable to contamination
- step - a point, procedure, operation or stage in the food processing / production chain, from primary production to final consumption
- suitable - deemed by the administering authority to be suitable for the purpose
- total quality management - a management approach that is centered on quality, based on the partaking of all members of the association and aimed at long-term achievement through customer satisfaction and through benefits to all member of the organization and of society
- toxic - harmful to human, animal or plant health
- validation - obtaining the confirmation that the particular requirements of the HACCP plan are efficient

- vehicle - means a train, trolley, wagon, cart, bicycle, sled, truck, boat, ship or aeroplane and includes any other craft, vehicle or conveyance used in the handling or transport of food
- verification - the application of methods, procedures, tests and other evaluations, in addition to monitoring, to verify compliance with the HACCP Plan
- waste materials - unused materials, or used materials subsequently disposed of, including cleaning materials disinfectants and hazardous materials
- water - means water that complies with the requirements set out in SABS 241: water for domestic supplies
- wholesome - beneficial to physical health



**References:** Codex Alimentarius  
 R 918 & R 908 from Department of Health  
 R 1313 from Department of Agriculture  
 SABS 049 – Food hygiene management  
 SABS 0330:1999 – The implementation and management of  
 Hazard Analysis and Critical Control Point  
 (HACCP) system

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Language and style used in this thesis are in accordance with the requirements of the *Journal of Applied Microbiology*. This thesis is a representation of a compilation of manuscripts but each chapter is an individual entity, repetition between chapters however has been unavoidable.

# CHAPTER 1

## INTRODUCTION

Food poisoning although not frequently recorded, is a very common phenomenon in South Africa. Food poisoning symptoms in the mild stages go unnoticed because the sufferer gets treated for the symptoms that include diarrhea (sometimes bloody), vomiting, nausea or stomach cramps but rarely samples are drawn to identify the cause of the illness. Unless a few people suffer from the same symptoms at once and a trend is found that they consumed food from the same source, only then investigations will identify the pathogen within the food and what the source could be. The immunocompromised such as pregnant women, the elderly and the very young are particularly very susceptible to food borne illness (Bas *et al.* 2004). Outbreaks such as those in Johannesburg at the All African Games in 1999 due to contaminated fruit juices or the botulism deaths from fish in 2002 increased the consumer's awareness regarding safe food. The power of the media plays an important role and can make or break a food handling enterprise. Major economic losses are also faced due to a food safety failure (Todd 1989).

First world countries such as the United States of America and the United Kingdom have more concrete evidence and statistics that can trace the micro-organism involved, the mortality rate or hospitalization cases due to contaminated food. In the US 76 million illnesses per annum are food related of which 5000 lead to death and 325 000 lead to hospitalization (Mead *et al.* 1999; Billy 2002; Youn and Sneed 2003). Of these cases most were children or the elderly. In the UK, 9.4 million people suffer food related illness per year (DeWaal 2003; Walker *et al.* 2003; Sun and Ockerman 2005).

Foods that are most likely linked to food poisoning outbreaks are seafood, eggs, beef, produce, poultry, dairy products, pork, game, juices, luncheon meats and foods with multiple ingredients such as salads, baked goods and soup (DeWaal 2003). If the statistics are evaluated carefully, it is clear that there is a lot of room for improvement in

South Africa within the food production chain, if countries such as the US and UK could have such high food poisoning statistics.

The overall picture is that food safety receives very little attention although it has been suggested that the food should be safe from farm through till fork (Sun and Ockerman 2005). Therefore it is advised that food safety should be controlled by having a total quality management system in place. Such a system includes the pre-requisite programs and a HACCP plan that would be able to ensure that all factors that could affect the quality of the product are under control (NACMCF 1998).

In terms of the regulations in South Africa, HACCP is only mandatory at present for specific sectors listed. It is compulsory in the seafood industry especially if they want to export to European Union countries since December 1995 and to the United States of America since December 1997. In a sense, HACCP is used as a political tool as trade barrier since it has become a requirement for export (Uys 2000). More and more customers are also aware of HACCP and therefore it is becoming a customer requirement. Because HACCP aims on identifying hazards and controlling them, time is saved and the consumer's perception of safe food is met. The HACCP concept is also based on prevention rather than detection. End product testing has always been the method of ensuring that a product is safe but can be very time consuming because by the time results are obtained the food had been served and consumed and it could sometimes be very difficult to recall (Sun and Ockerman 2005).

Therefore HACCP should be implemented. For some people HACCP is some sort of magic that is capable of solving all food safety problems. However it is important to notice that it does not provide zero risks but aims to minimize the risks. In most cases the main reasons for HACCP failure are incomplete hazard analysis as well as a complete reliance on HACCP only, resulting in the negligence of the general hygiene management. HACCP is excellent to use in focusing the attention on food safety issues but does not guarantee against ignorance or mishaps of any kind (Heggum 2001).

HACCP was first introduced by the Pillsbury Company, NASA and the US army laboratories at Natick to ensure that the food of astronauts was safe for consumption in space more than 30 years ago (Trujillo 2000; Sperber 2005). HACCP focuses on controlling problems before they happen mainly during processing or serving (Sun and Ockerman 2005). The Codex Alimentarius Commission has identified seven principles for HACCP that are mainly structured into three main elements. Element 1 refers to the hazard analysis (principle 1), element 2 refers to the measures for hazard control (principles 2 – 5) and element 3 to the documentation and verification of the HACCP system (principles 6 – 7) (Untermann 1998).

Before HACCP can be implemented it is important to have the pre-requisite programs in place first. These programs are also described as the HACCP support network (Mortimore and Wallace 1995). These programs refer to “the universal steps or procedures that control the operational conditions within a food establishment allowing for environmental conditions that is favourable for the production of safe food” and include elements such as the Good Agricultural Practices (GAP), Good Manufacturing Practices (GMP), Good Laboratory Practices (GLP) and Good Hygiene Practices (GHP) (Wallace and Williams 2001). The pre-requisite programs are the backbone to the HACCP system and can only simplify the HACCP plan. It eliminates so called “critical control points” that in fact are not true CCPs and that can be covered under the pre-requisite programs as control points. In the end the HACCP plan is simplified and easier managed.

The flour milling industry is considered a low risk area within the food handling enterprises since the flour is mainly used for baking purposes. However there are pathogens that produce toxins that can be heat stable and can cause illness even after the product has been baked such as *Bacillus* and *Staphylococcus* species. In some cases the flour does not undergo heat treatment (cooking or baking) for example, flour used for candy coatings and in such cases consumers are at risk of contracting food poisoning. In other cases where the flour are used in sauces, the heat treatment sometimes are not at the extreme and the chance that the micro-organisms are not killed off completely, exist.

There was a need within the milling industry for controlling food safety especially due to customer's demands and government's regulations. The best way to ensure food safety was with the implementation of a HACCP based food safety system. Therefore the principal aim of this study was to develop a generic HACCP model for the flour milling industry. Afterwards this generic model could then be adapted for each specific mill and its needs. The specific project objectives were:

- To develop pre-requisite programs for the flour milling industry;
- To develop a generic flow diagram;
- To conduct a hazard analysis;
- To identify the critical control point/s;
- To identify the critical limits;
- To identify monitoring and verification procedures;
- To investigate the microbial safety of wheat and flour.

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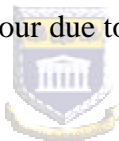
## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 WHEAT AND THE MICROBIAL LOAD ON WHEAT

##### 2.1.1 Wheat

Wheat originated in the Middle East thousands of years ago in the areas now known as Israel, Egypt, Syria and Jordania (Anon. 1993). The wheat plant is adaptable to various types of climates and geographical areas therefore it can be found in India with its extreme heat conditions as well as very close to the Pole regions (Anon. 1993). When a seed is planted and it warms, it takes up moisture and certain metabolic processes that initiates growth, occurs. This includes the development of shoot and root and if conditions are favourable, the plant continues to grow into a wheat plant. Inside the stem of the wheat plant, a head of wheat starts to develop. Wheat is ready for harvesting once it has ripened and takes on an amber colour due to the loss of water.



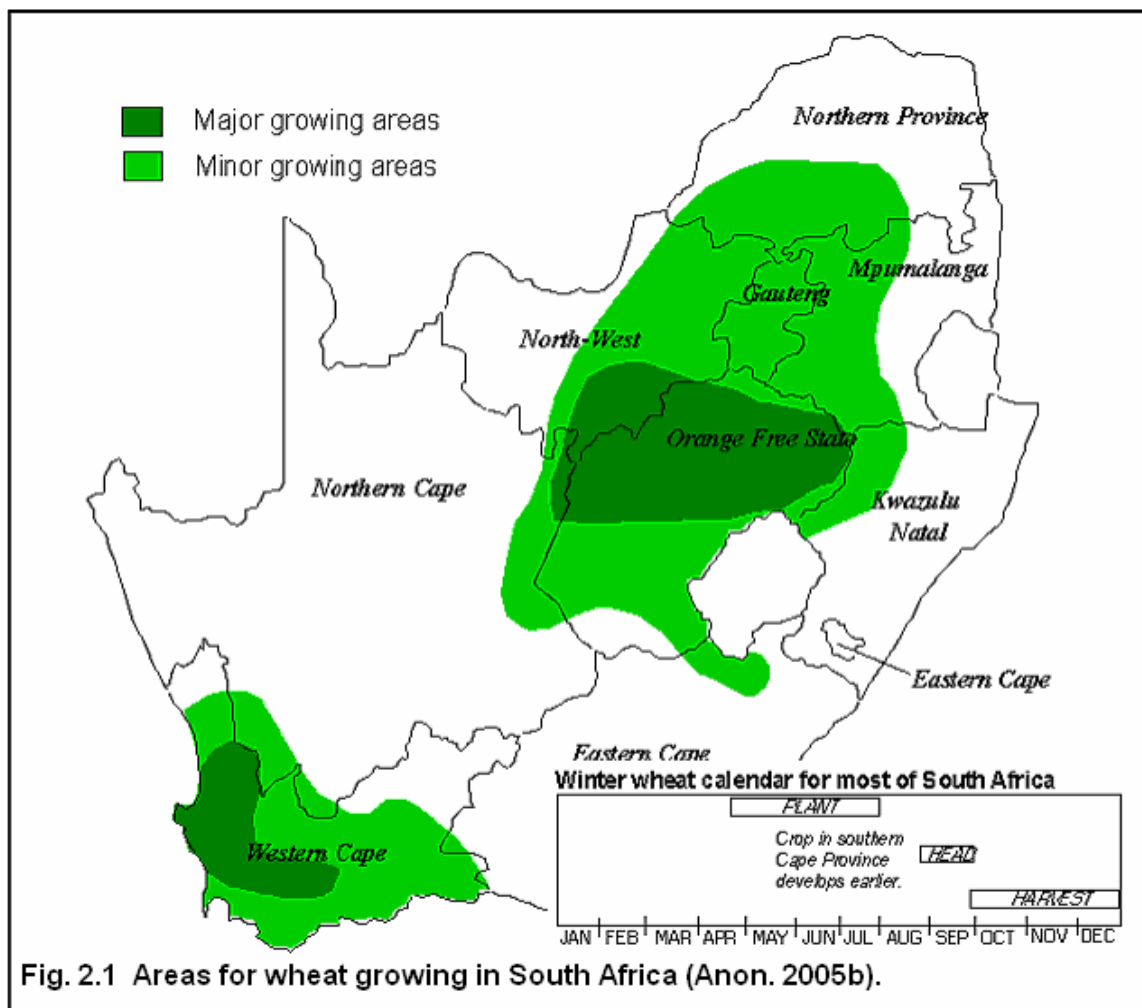
##### 2.1.1.1 *Wheat types*

Three species of wheat are commonly grown. *Triticum aestivum* are responsible for the formation of the classes hard red winter, hard red spring, soft red winter, hard white and soft white. *T. compactum* forms all club wheats and *T. durum* includes the durum and red durum wheat cultivars (Atwell 2001). Several terms are used to describe the qualities of wheat. Soft and hard refers to the hardness of the kernel. Hard wheat requires more energy to mill than soft wheat since more force is needed to crush the kernel. Red and white refers to the presence of a reddish pigment in the outer layers of the wheat kernel which is visually possible. Winter and spring on the other hand describes the growth habit of the wheat. Winter wheat is planted in autumn because it requires cold temperatures in order to form heads (also commonly known as vernalization) and is harvested in summer. Spring wheat requires no cold weather and is planted in spring and harvested in late summer or autumn. The kernels of durum wheat are far harder than other classes of wheat and do not require vernalization. Club wheats on the other hand are usually soft and usually have low protein contents. A large number of varieties exist

within these wheat classes and is differentiated from each other by certain characteristics such as physical features, yield potential, disease and drought resistance. New varieties are also developed by cross breeding or biotechnology.

### 2.1.1.2 Growth regions

In South Africa, the major growing areas for wheat are as indicated on the map below, in the Western Cape and Orange Free State. Other minor growth areas are the Eastern Cape, Gauteng and KwaZulu Natal regions as can be seen in figure 2.1 (Anon. 2005b). The “Swartland” north of the Cape Peninsula and “Rûens” parallel to the South Coast, are the most popular regions for production. During a normal season, the harvest of wheat in South Africa is around about 2.5 million tons that is used locally but a small percentage can also be exported (Anon. 1993).

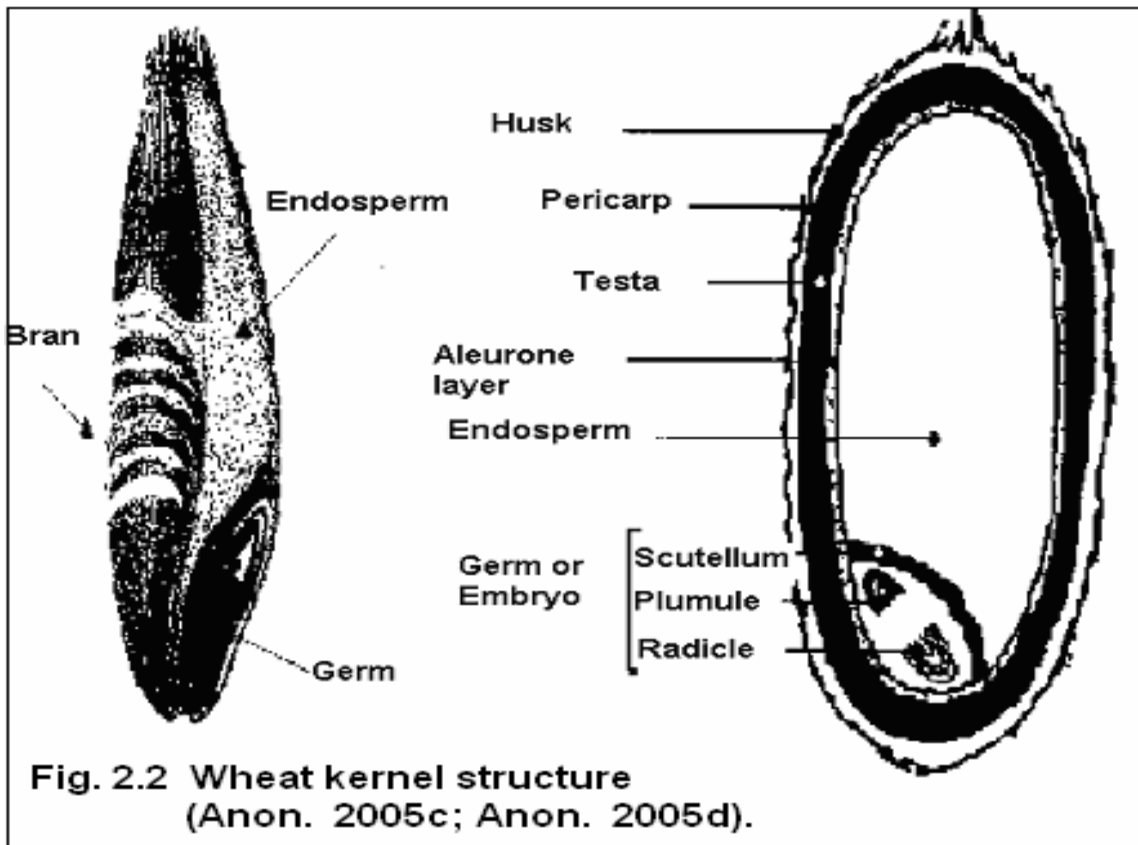


#### 2.1.1.3 *General uses of wheat*

Wheat when grounded into flour, are used for a variety of products of which bread is worldwide the most common. Bread is regarded as the staple food of a lot of cultures in South Africa. HRW, HW and HRS are used in bread production because hard wheat contains a lot of gluten whereas SRW and SW are used for the making of cakes, crackers and cookies. Durum wheat is used for standard pasta products such as noodles (Atwell 2001). Alternative uses of wheat are for the production of whisky and beer. The rest of the wheat plant as well as the residues from the milling operation are used in animal feeds.

#### 2.1.1.4 *Structure of the wheat kernel*

A wheat kernel consists of three very essential constituents namely the endosperm, germ and bran (Atwell 2001). The germ consists of the embryo and scutellum and comprises about 3% of the wheat kernel. Most of the lipids and other essential nutrients are concentrated in the germ (Atwell 2001). The outer protective layers of the wheat namely the bran, is divided mainly into the pericarp, testa and nucellar epidermis. The latter are subdivided into a number of layers (Mousia and Pandiella 2004). About 14% of the wheat kernel consist of the bran which is very rich in fiber and ash content (Atwell 2001). The essential part of the kernel that is mainly used in the milling process is the starchy endosperm which is a source of energy and protein for the developing wheat plant (Atwell 2001). The biggest part of the kernel is made up of the endosperm which is the primary constituent of flour because of its high starch and moderately high protein content. Between the bran and the endosperm, a layer of highly specialized endosperm cells the aleurone layer is found. This layer is considered to contain a high enzyme activity and therefore making it much more biologically active. This layer is generally removed during milling operations as part of the bran.



### 2.1.2 Microbial load on wheat

Wheat just after it has been harvested, are contaminated by micro-organisms from various sources including dust, water, soil, fertilizers, animal feces, human handling and other sources. The bacteria that can be found on the grains belong mainly to the *Pseudomonadaceae*, *Micrococcaceae*, *Lactobacillaceae* and *Bacillaceae* families and the moulds mostly to the *Alternaria*, *Fusarium*, *Helminthosporium* and *Cladosporium* families (D’Mello *et al* 1993; Mousia *et al.* 2004; Anon. 2005f). Although others might also be present, these are the most commonly found. The wheat should be stored under appropriate conditions to prevent these micro-organisms from flourishing and alter the properties of the product. Therefore in South Africa, a list of grading rules that is updated on a regular basis by the department of Agriculture is available to the wheat grader in order to accept or reject a load of wheat on arrival at the mill. The maximum value for the moisture levels of wheat when stored is 13%. Moisture levels higher than

13% result in optimum conditions for micro-organisms to grow and the properties of the product being altered. Other conditions that could also lead to alteration of the product are temperature and the oxygen concentration.

## **2.2 WHEAT MILLING PROCESS**

### **2.2.1 Traditional wheat milling**

The traditional wheat milling process will be discussed in four steps starting with the receipt and storage of the wheat, the cleaning house, milling and the final product. A schematic representation of the wheat milling process is found in Figure 2.3.



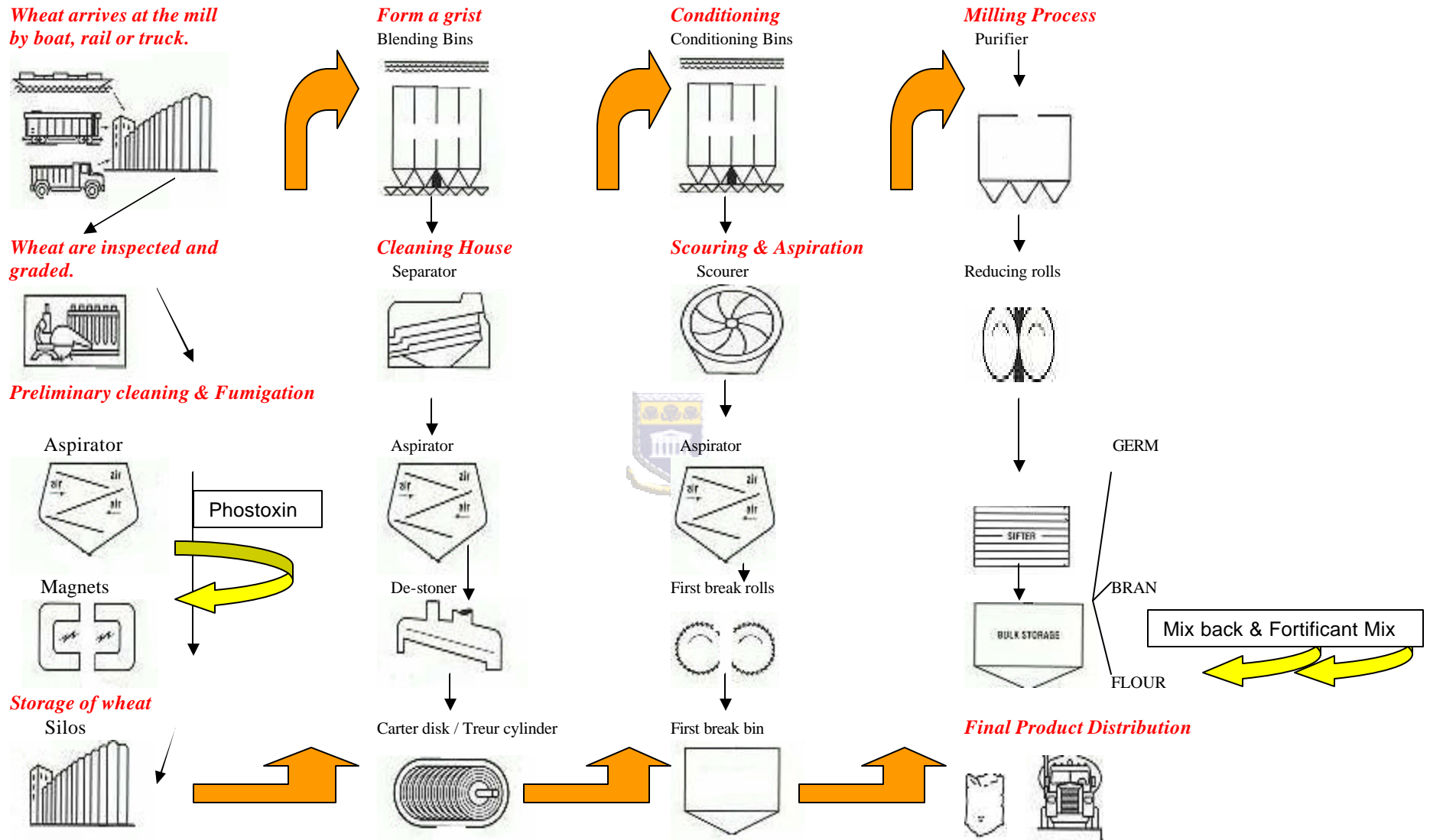


Fig. 2.3 Wheat milling process (Anon. 2005a).



### 2.2.1.1 *Wheat receiving and storage*

Wheat is usually received at the mill by truck or rail. A well trained and experienced wheat grader with the relevant qualification on site then takes a representative sample of the whole load of wheat and does grading according to the latest national grading rules (Anon. 1993). The sample is inspected and tested for impurities, moisture content, protein content, hectoliter mass, cultivar, insect infestation and sprout damage (Anon. 1993; Anon. 2004b). The maximum moisture content of the grain is 16.7% whereas the minimum is 11.5%. The optimum moisture content of grains before storage should be +/- 13 % (Anon. 1977). In the rare cases where high moisture wheat are stored for long periods, it is important that drying or aeration of the wheat should take place in order to minimize the risks of sweating, sprouting, heat damage and spontaneous combustion (Anon. 1977). If it is found that the quality is acceptable as is stated on the grading certificate received, the wheat can be unloaded. If however the quality of the wheat differs from the grading certificate, the wheat grader has the authority to reject or re-grade the wheat. The accepted wheat is unloaded at the weigh bridge and on its way to the silos, undergoes the first cleaning phase where it passes through magnets to get rid of ferrous materials. Excess dust is also removed by aspiration. Before storage the wheat gets fumigated in order to get rid of all forms of live insects (Anon. 1993). The wheat now gets stored in the silos for an uncertain time period. Because wheat while it is stored is still respirating, it is important that the moisture content of the wheat should be no more than 14% and the temperature kept at no more than 20 °C (Anon. 1993). If these conditions are not maintained, it can cause enzyme activity that activate the break down of starch into sugars and fermentation can take place that results in an unpleasant odour (Anon. 1993).

### 2.2.1.2 *Cleaning house*

Before cleaning can take place, a process called gristing takes place where different types of wheat is mixed in different proportions in order to produce the right quality flour. Now the wheat undergoes a cleaning process in order to get rid of foreign materials and impurities. These various steps in cleaning are referred to as the cleaning house and involve a number of cleaning machinery. Aspirators, de-stoners, combi-cleaners, seed

removers, treur cylinders and carter disks are used at various places and in different combinations varying from mill to mill, to get rid of foreign materials. After cleaning, the wheat is transferred to tempering bins for extensive conditioning when water is added in order to facilitate the efficient separation of the endosperm from the bran (Anon. 1993). Depending on the moisture content of the wheat kernel, water is added to bring the moisture within the kernel to about 15.5% (Anon. 1993). This conditioning phase usually takes place in two stages where 60% of the water is added during the first conditioning and 40% during the second conditioning phase (Anon. 1993). The lying time for hard wheat is at least 12 hours and for soft wheat 7 hours at ambient water temperatures. Advantages of proper conditioning are a better flour product at the end of the day, less stress on the reduction rolls due to the mellowed endosperm and consistent milling performance.

#### *2.2.1.3 Milling*

After the wheat was tempered for a couple of hours in the tempering bins, the wheat passes through a scourer and aspirator in order to remove any mud formed (Anon. 2004b). After this last cleaning section, the wheat goes through to the first break roller and first break scale. During the milling process, the endosperm is separated from the bran and the germ by breaking the kernel into smaller fragments (Mousia and Pandiella 2004). This break rolls are fluted rolls that was designed to break each grain into three parts known as the endosperm, germ and bran. A continuous process of grinding, conveying and sifting takes place whilst the endosperm is sent through reduction rolls, scales and sifters in order to produce the final product, flour (Fig. 2.3). The bran and wheat germ were also sifted into different streams and separated by sieves so that when the milling process is complete, these products are also separated.

#### *2.2.1.4 Finished flour*

The result of the milling process is the flour produced. The different types of flour depend on the variety of wheat as well as the percentage of bran removed before the milling process. When whole wheat flour is produced, the whole grain is used. White bread flour on the other hand is more refined because the bran is separated from the rest

of the grain. Brown bread flour on the other hand has a higher extraction rate than white bread flour since it contains more bran thus giving the flour a darker colour and a stronger flavour and odour (Anon. 2004a; Anon. 2005e).



**Fig. 2.4** Final product samples (Top left to right: White bread flour; crushed wheat, bran rich self raising flour. Bottom left to right: cake flour; digestive wheaten bran; whole wheat flour.)

### **2.2.2 Debranning or Pearling of wheat**

Until recently the aleurone layer which is considered the most nutritious part of the cereal grain since it is rich in vitamins, minerals and other nutrients, was removed with the bran layers because it is very difficult to separate it with conventional milling processes. The aleurone layer refers to the most inner part of the bran layers closest to the endosperm as can be seen in Fig. 2.2. Debranning however, opened new doors in the milling industry

since it removes the layers from the cereal grain from the outside inwards which means that the aleurone layer can remain attached to the endosperm (Mousia and Pandiella 2004). Other advantages of the debranning system are: improvements to the ash and colour results, improved flour quality, more value-added food and non-food products since the aleurone is used, removal of microbial contaminants, reduced stress on the milling process resulting in an increased yield and reduced bran that improves the bread making performance (Mousia and Pandiella 2004). The debranning system has proved that it efficiently removes the bran from the wheat kernel therefore improving the flour quality since bran has a negative effect in the baking industry due to its particle size and content. The bread quality is affected in terms of colour, volume and texture (Mousia and Pandiella 2004). Bran particles also disrupt the gluten-starch network and restrict the gas cell expansion within the matrix; it absorbs water, restricting the hydration and development of gluten (Mousia and Pandiella 2004). The presence of bran in the final product therefore can have a negative effect on the flour stability during storage.

### **2.3 FOOD SAFETY MANAGEMENT SYSTEMS**



Food borne diseases is of major concern worldwide to every food manufacturer, health official, researcher and many others. Customers expect only the best quality when purchasing a product and when unsatisfied, can cause the downfall of even the greatest food handling enterprises. Food that do not cause harm to the consumer when prepared or eaten according to its intended use, is regarded as safe for human consumption. Therefore it is very important that every food manufacturer produce safe food that meets the in house specifications and also conform to local health regulations. This is then also why there is a definite need for Food Safety Management Systems within the food industries. Most of the quality assurance programs however are designed to discover the problems once it has already occurred whereas HACCP is a food safety tool that is based on prevention rather than detection (Bauman 1991). With traditional inspection it is possible to evaluate current sanitation and food safety conditions but it is not possible to see that plants are operating under conditions that continuously prevent problems before

occurring (Trujillo 2000). Other food safety management systems include the ISO series and others less known.

### **2.3.1 Pre-requisite programs**

The actions that take place prior to the layout of a HACCP plan and that can have an effect on the hygiene; quality and safety of the food under production are referred to as the pre-requisite programs. Concepts such as cleaning, hygiene, design of the plant and building as well as preventative maintenance are very well-developed and is known to the food industry as Good Manufacturing Practices and therefore is not new to most of the food handling enterprises (Wallace and Williams 2001). It is of utmost importance that these pre-requisite programs such as the Good Manufacturing Practices (GMP), Good Agricultural Practices (GAP), Good Hygiene Practices (GHP) and Good Laboratory Practices (GLP) should be in place before an attempt can be made to implement HACCP. Therefore to formalize the pre-requisite programs alongside HACCP in order to control the identified hazards are a new concept (Wallace and Williams 2001). With the implementation of the pre-requisite programs all the critical areas are covered. If HACCP however is implemented before the pre-requisite programs are in place, it could lead to a complicated HACCP system with too much critical control points (Mitchell 1992).

Of all these pre-requisite programs the Good Manufacturing Practices (GMP) and Good Hygiene Practices (GHP) are the most important and should be documented, monitored, confirmed and reviewed frequently. If these practices are well-developed and frequent auditing shows consistency, the food safety plan (in this case the HACCP plan), is noticeably simplified.

The Codex Alimentarius Commission's basic texts on food hygiene (CAC 1997) which is a joint food standards program by the Food and Agriculture Organisation (FAO) of the United Nations World Health Organisation (WHO), is a very good guideline to use in identifying Good Manufacturing Practices for a specific food industry. On home ground,

the South African Association for Food Science and Technology has issued minimum standards for Good Manufacturing Practice in the food industry (Anon. 2004c). On the other hand, the South African Bureau of Standards also published a code of practice for food hygiene management (SABS 049) that could be used in identifying and developing these practices within the food industry (SABS 2001).

Overlapping programs in these documents are: Establishment design & facilities; equipment; control of operation; storage, packaging, distribution and transportation; maintenance, cleaning and sanitation; pest control; personal hygiene; training etc. and are discussed in more detail and examples given further on in the text.

### **Key generic pre-requisite programs**

#### *2.3.1.1 Establishment design and facilities*

##### 2.3.1.1.1 Design

2.3.1.1.1.1 Food establishments should be located away from: polluted areas and activities that could contaminate the food source, areas that are subject to flooding, areas prone to the infestation of pests and away from areas where wastes cannot be removed effectively (CAC 1997; SABS 2001; Anon. 2004c).

2.3.1.1.1.2 The internal design and layout of food establishments should permit good food hygiene practices and it should be protected from cross-contamination at all times (CAC 1997).

2.3.1.1.1.3 Surfaces of walls, partitions and floors should be constructed of impervious materials with no toxic effect in the intended use (CAC 1997; SABS 2001; Anon. 2004c).

2.3.1.1.1.4 Walls and partitions should have a smooth surface and should be easily cleaned (CAC 1997; SABS 2001; Anon. 2004c).

2.3.1.1.1.5 Floors should be constructed to allow adequate drainage and cleaning, should be free from cracks and smooth in order to facilitate good cleaning (CAC 1997; SABS 2001; Anon. 2004c).

- 2.3.1.1.1.6 Ceilings and other overhead fixtures should be constructed and finished to minimize dirt build-up and the shedding of particles and where applicable fitted with insect-proof screens (CAC 1997; SABS 2001; Anon. 2004c).
- 2.3.1.1.1.7 Doors should have smooth, non-absorbent surfaces, be easily cleaned and disinfected and have automatic closing devices (CAC 1997; SABS 2001; Anon. 2004c).
- 2.3.1.1.2 Facilities
- 2.3.1.1.2.1 Potable water that complies with the requirements of SABS 241 should be used for manufacturing purposes and adequate facilities for its storage, distribution and temperature control should be available whenever necessary to ensure the safety and suitability of the food (CAC 1997; SABS 2001; SABS 2001c).
- 2.3.1.1.2.2 Drainage and waste removal facilities should be provided and should be adequate. It should also be designed and constructed in a way that it does not become a health risk by contaminating the food product (CAC 1997; SABS 2001).
- 2.3.1.1.2.3 Personnel hygiene facilities and toilets should be provided and should be appropriately designed and located in order to prevent contamination of the food product produced. A supply of hot and cold water, soap dispensers and an appropriate means of drying the hands should be available (CAC 1997; SABS 200; Anon. 2004c).
- 2.3.1.1.2.4 An adequate means of natural or artificial ventilation should be provided to minimize airborne contamination, to control ambient temperatures, odours and humidity where necessary to ensure the safety and suitability of the food (CAC 1997).
- 2.3.1.1.2.5 Lighting should be natural or artificial in order to operate in a hygienic manner. Lighting fixtures should be protected to ensure that the food is not contaminated by breakages (CAC 1997; SABS 2001; Anon. 2004c).
- 2.3.1.1.2.6 Provision should be made for suitable removal and storage of waste materials (CAC 1997; SABS 2001; Anon. 2004c).



2.3.1.2 *Equipment*

2.3.1.2.1 Location

2.3.1.2.1.1 Equipment should be located in a manner that adequate maintenance and cleaning is permitted, that it functions in accordance with its intended use and that it facilitates good hygiene practices (CAC 1997).

2.3.1.2.2 General

2.3.1.2.2.1 Equipment should be designed in a way so that they can be easily cleaned, disinfected and maintained in a good working order and appearance to avoid the contamination of the product (CAC 1997; SABS 2001; Anon. 2004c).

2.3.1.2.2.2 Equipment should be made of inert materials or stainless steel with no toxic effect on the food product produced (CAC 1997; SABS 2001; Anon. 2004c).

2.3.1.3 *Control of operation*



2.3.1.3.1 Where temperature and time is critical to the safety of the food, systems should be in place to ensure that these factors are controlled effectively. Limits for time and temperature variations should be set and temperature recording devices should be checked at regular intervals (CAC 1997).

2.3.1.3.2 Microbiological specifications should be based on scientific principles and should state the monitoring procedures, analytical methods and action limits (CAC 1997).

2.3.1.3.3 In order to prevent microbiological cross-contamination it is important that processing areas should be controlled, raw materials and finished product separated, high risk areas accessed only via a changing facility and surfaces, utensils, equipment etc. properly cleaned and where necessary disinfected after handling of the product (CAC 1997; SABS 2001; Anon. 2004c).



- 2.3.1.3.4 Foreign bodies such as glass or metal should be controlled by suitable detection or screening devices such as metal detectors (CAC 1997; SABS 2001; Anon. 2004c).
- 2.3.1.3.5 Specifications for raw materials should exist. The raw material should be inspected and where necessary laboratory tests should be performed in order to establish fitness of use. Proper stock rotation of raw materials should also take place (CAC 1997; SABS 2001; Anon. 2004c).
- 2.3.1.3.6 Records and documentation should be kept of all processes including production, processing and distribution. These records should be kept for at least the shelf life of the product (CAC 1997; SABS 2001; Anon. 2004c).
- 2.3.1.3.7 Recall procedures should be in place. Recalled products should be kept under quarantine until destroyed or reprocessed (CAC 1997; SABS 2001; Anon. 2004c).

2.3.1.4 *Storage, packaging, distribution and transportation*

2.3.1.4.1 Storage



- 2.3.1.4.1.1 Adequate facilities for the storage of food, raw materials and chemicals should be provided and should be constructed in order to permit proper maintenance and cleaning, to avoid pest infestation and protect the food produced from contamination (CAC 1997; SABS 2001; Anon. 2004c).
- 2.3.1.4.1.2 The food produced, chemicals and packaging should be stored separately on pallets covered with a cardboard layer in order to prevent splinter contamination (CAC 1997; SABS 2001; Anon. 2004c).
- 2.3.1.4.1.3 Broken or contaminated pallets should not be used for transportation (SABS 2001; Anon. 2004c).
- 2.3.1.4.1.4 Storage areas should be maintained in a dry, clean and well ventilated condition (CAC 1997; SABS 2001; Anon. 2004c).
- 2.3.1.4.1.5 The finished product should be rotated on a first in first out basis (SABS 2001; Anon. 2004c).

#### 2.3.1.4.2 Packaging

2.3.1.4.2.1 Packaging should be of the kind that protect the final product from contamination and prevent damage at least during its expected shelf life under normal conditions. It should also accommodate proper labeling (CAC 1997; SABS 2001; Anon. 2004c).

2.3.1.4.2.2 The packaging should not be toxic or have any negative health effect on the consumer of the product (CAC 1997; SABS 2001).

2.3.1.4.2.3 Reusable packaging should be durable, easily cleanable and disinfected where necessary (CAC 1997; SABS 2001).

2.3.1.4.2.4 Ingredient lists on the product should identify the presence of allergens (Anon. 2004c).

#### 2.3.1.4.3 Distribution and Transportation

2.3.1.4.3.1 The type of transportation depends on the type of food and the conditions under which the food should be transported. It is of utmost importance that the food should be adequately protected during transportation (CAC 1997; SABS 2001; Anon. 2004c).

2.3.1.4.3.2 Transport should be inspected before use in order to identify foreign odours, pests, humidity and dirt (CAC 1997; SABS 2001; Anon. 2004c).

2.3.1.4.3.3 Bulk transport, containers and conveyances should be suitable for food use (CAC 1997; Anon. 2004c).

2.3.1.4.3.4 No products such as chemicals or other hazardous substances should be transported together with the food produced (SABS 2001; Anon. 2004c).

2.3.1.4.3.5 The containers and conveyances used for transportation of the foodstuff should be kept in good condition and in a clean state in order to protect the food from possible contamination (SABS 2001; Anon. 2004c).

2.3.1.4.3.6 The loading or unloading of foods or other materials that could come into contact with the food shall not take place under conditions that could cause deterioration, contamination or damage to the product (SABS 2001).

2.3.1.5 *Maintenance, cleaning and sanitation*

2.3.1.5.1 Scheduled cleaning operations should take place and should depend on the nature of the food premises. It should remove food residues and dirt which could be a source of contamination from the equipment and all parts of the establishment. Disinfections might also be necessary after cleaning (CAC 1997; SABS 2001; Anon. 2004c).

2.3.1.5.2 Chemicals for cleaning purposes should be used in accordance with instructions of the manufacturers and should be stored separately (CAC 1997; SABS 2001; Anon. 2004c).

2.3.1.5.3 Written cleaning programs should specify the areas of cleaning, utensils used, method and frequency of cleaning, responsible persons and the monitoring procedures (CAC 1997; SABS 2001; Anon. 2004c).

2.3.1.5.4 Sanitation systems should be monitored for the effectiveness and verified periodically by means of inspections, swabs, audits etc. (CAC 1997).

2.3.1.6 *Pest Control*

2.3.1.6.1 A pest control program should exist in order to minimize pest infestation and harbourage. The interior and exterior of the building should be examined on a regular basis for pest infestation. Potential food sources should be minimized and stored in pest proof containers on elevated racks and away from walls (CAC 1997; SABS 2001).

2.3.1.6.2 The establishment should be kept in good condition and maintained that way to eliminate breeding sites for pests i.e. holes and drains should be sealed, animals should be precluded and doors and windows that are able to open should be covered with wire mesh screens (CAC 1997; SABS, 2001; Anon. 2004c).

2.3.1.6.3 Pest control whether chemical, biological or physical should take place without affecting the safety of the food product produced (CAC 1997; SABS 2001; Anon. 2004c).



### 2.3.1.7 *Personal Hygiene*

2.3.1.7.1 Employees that are known to suffer or suspected to suffer from a disease that could be transmitted through food or that could still be a carrier of the disease, should not be allowed to enter a food handling area. Illness or symptoms should be reported to management immediately (CAC 1997; SABS 2001; Anon. 2004c).

2.3.1.7.2 Medical examinations should be carried out if food handlers have symptoms such as diarrhea, vomiting, fever, discharges from the ear, eye or nose and visibly infected skin lesions such as boils or cuts. (CAC 1997; SABS 2001; Anon. 2004c).

2.3.1.7.3 Employees should wear protective clothing and should always maintain a high degree of personal cleanliness. Hand washing should take place regularly and wounds or cuts should be covered with suitable waterproof dressings (CAC 1997; SABS 2001; Anon. 2004c).

2.3.1.7.4 Employees should refrain from smoking, spitting, chewing, eating, sneezing or coughing over unprotected food products (CAC 1997; SABS 2001; Anon. 2004c).

2.3.1.7.5 Jewellery, watches, pins, earrings and other items that could be a health risk should not be worn by food handlers (CAC 1997; SABS 2001; Anon. 2004c).

2.3.1.7.6 Visitors to food manufacturing, processing or handling areas should wear the protective clothing provided by the company in order to adhere to the company's personal hygiene rules (CAC 1997; SABS 2001; Anon. 2004c).

### 2.3.1.8 *Training*

2.3.1.8.1 All personnel should be trained in food handling and should have the knowledge that enables them to protect food from contamination (CAC 1997; Anon. 2004c).

2.3.1.8.2 Training programs for personnel should comprise the following: the nature of the food, the handling and packaging of the food, the ability to sustain

growth of pathogenic micro-organisms, processing before final consumption, storage conditions, expected length before consumption, basic personal hygiene and sanitary requirements of the equipment (CAC 1997; Anon. 2004c).

2.3.1.8.3 The effectiveness of the training should be checked by periodic assessments and routine supervision (CAC 1997; Anon. 2004c).

2.3.1.8.4 Systems to ensure that food handlers are aware of all procedures necessary to maintain the safety and suitability of the food should be in place (CAC 1997; Anon. 2004c).

## **2.4 HAZARD ANALYSIS CRITICAL CONTROL POINT**

### **2.4.1 The history of HACCP**

The HACCP concept was first introduced to the food industry by the Pillsbury Company, NASA and the US army laboratories at Natick in the 1960's (Efstratiadis and Arvanitoyannis 2000; Trujillo 2000; Sperber 2005). At first it was developed to ensure the safety of foods for astronauts in the NASA space program. The food products that were being produced for space use had to be free from pathogens and at that stage quality systems were mainly based on end product testing which obviously wouldn't have worked for such a mission because by the time results were received for product tested on earth, the possibility that the product would've been used up in space already, existed. In order to find an answer for their problem, they decided to take control over the process, raw materials, environment and people as early as possible in the food production system (Mortimore and Wallace 1995). A preventive system with a high level of food safety guarantee namely the HACCP system was born. HACCP concepts were used during the seventies in the production of low acid canned foods after the FDA published a mandatory regulation because botulism became a major problem in canned mushrooms (Trujillo 2000; Sperber 2005). Thereafter, the use of HACCP concepts was not visible till the 1990's when the seafood industry voiced concerns regarding microbiological, chemical and physical hazards (Trujillo 2000). The National Academy of Sciences (NAS)

recommended in 1991 that HACCP should be used to ensure food safety. In 1994, the FDA after numerous consultations with the seafood industry, the public and academics, issued a mandatory regulation requiring all seafood processors in the USA as well as those exporting to the USA, to implement HACCP (Trujillo 2000). During 1992, the National Advisory Committee on Microbiological Criteria for Foods (NACMCF) in the USA, issued guidelines for the use of HACCP based on the draft prepared by the HACCP working group of the Codex Committee (Trujillo 2000). These guidelines were re-issued in 1997 with a detailed explanation of the HACCP principles (Trujillo 2000).

The Codex Alimentarius Commission that was established in 1962 by the Food and Agricultural Organization (FAO) and the World Health Organization (WHO) should ensure fair international trade in food (Trujillo 2000). Codex adapted seven principles for the HACCP system in 1997 (CAC 1997). This is a step for step procedure on how to develop a HACCP plan. The seven principles of HACCP can be found in table 2.1 and discussed in more detail in the twelve step procedure in section 2.4.5.



## **2.4.2 HACCP**

HACCP or in long, Hazard Analysis Critical Control Point System identifies hazards within the food production system and implements control and management systems to ensure the safety of the product (Mortimore and Wallace 1995). The HACCP system is based on the principle that food safety issues can be prevented or minimized by prevention rather than detection in the final product (Vail 1994). It is an internationally recognized food safety system and can be applied effectively to all types of food businesses from production through to the end-product or even the final stage, consumption (Forsythe 2000). By developing, implementing and effectively managing the hazard control program, HACCP assures food safety (Vail 1994). Benefits of a HACCP system are the maximization of product safety as well as consistent food safety, cost-effectiveness, better use of resources and well-timed reaction to problems (Mortimore and Wallace 1995). HACCP also has a few downfalls including that it is an

expensive, technically complex and time-consuming process (Unnevehr and Jensen 1999).

### 2.4.3 Total Quality Management

Total Quality Management (TQM) is the organisation's cultural approach towards quality which is based on all members within the organisation participating to continually improve the quality of the product manufactured in the long run (Forsythe 2000). It is also said that a food safety plan such as a HACCP plan is just as good as the commitment of the personnel implementing and managing the program (Vail 1994). In order to maximize quality, productivity and food safety, a combination of HACCP, quality management systems (e.g. ISO 9000), TQM, food safety management systems and business excellence is needed (Forsythe 2000). Therefore the generic requirements for the food safety management systems such as the pre-requisite programs should be in place before the food safety assurance plan or HACCP plan can be developed.



### 2.4.4 Principles of HACCP

The following seven principles are the Codex guidelines and outline specifically how to implement a HACCP study.

**Table 2.1** The principles of HACCP (CAC 1997; NACMCF 1998; Unnevehr 1999; Efstratiadis and Arvanitoyannis 2000; Boccas *et al.* 2001)

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Principle 1 Conduct a hazard analysis.

Principle 2 Determine the Critical Control Points (CCPs).

Principle 3 Establish critical limit(s).

Principle 4 Establish a system to monitor control of the Critical Control Point/s.

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Principle 5 Establish the corrective action to be taken when monitoring indicates that a particular Critical Control Point is not under control.

Principle 6 Establish procedures for verification to confirm that the HACCP system is working effectively.

Principle 7 Establish documentation and record-keeping procedures.

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#### **2.4.5 The 12-step procedure for a HACCP system set up**

HACCP can also be approached as a twelve step procedure (CAC 1997; NACMCF 1998; SABS 1999; Trujillo 2000; Boccas *et al.* 2001; Sjöberg *et al.* 2002). The twelve steps include the seven principles for HACCP according to Codex Alimentarius but before these steps can be applied, more information regarding the process should be available as is set out in the following steps.



##### *Step 1: Assemble a HACCP team.*

In order to develop a HACCP plan, it is of utmost importance that the HACCP team should be a multidisciplinary group with the relevant knowledge and expertise on the product and process (NACMCF 1998; Forsythe 2000; Higuara-Ciapara and Noriega-Orozco 2000; Trujillo 2000). In cases where such specialists are not available on site, other external sources may be used considering that they have the relevant experience and expertise. It is advised that the HACCP team should at least consist of experts from the production, quality assurance and maintenance departments (Vail 1994; Mortimore and Wallace 1995). Other specialists that could be used from within the company or from external sources are from: purchasing, distribution, research and development, marketing and sales, supplier quality assurance, microbiologist, toxicologist, HACCP experts and others (Vail 1994; Mortimore and Wallace 1995; NACMCF 1998; SABS 1999). A team leader should be appointed within the HACCP team. This person should have very good



knowledge and experience of the HACCP system; he should be well trained and should have natural leadership qualities (Mortimore and Wallace 1995). The facilitator should be appointed from the core team to act as convener, assist in the organisation of meetings and to organise training for the members. The HACCP team would be responsible for developing, implementing and maintaining of the HACCP plan (Trujillo 2000).

*Step 2: Obtain information regarding the product and process.*

Describe the product and process in full (NACMCF 1998; SABS 1999). The composition, ingredients and processing methods should be discussed (Trujillo 2000). Microbiological, chemical and physical properties of the final product and if necessary the intermediate product should be discussed (NACMCF 1998; SABS 1999). The related legislation, packaging, storage and distribution details as well as the shelf life under prescribed conditions should be discussed (NACMCF 1998; SABS 1999).

*Step 3: Identify the intended use.*

The final product should be described and its intended use and distribution (NACMCF 1998; SABS 1999; Forsythe 2000; Trujillo 2000) discussed. The composition, physical and chemical structure including the water activity and acidity should be described. The packaging type, durability and storage conditions should be described as well as the method of distribution (Forsythe 2000). The expected uses of the product by the consumer should be described and the target groups such as infants, adults and the immunocompromised should be identified.

*Step 4: Draw up a process flow diagram and a floor plan.*

The process flow diagram should cover all the steps in the process from raw materials to final product in detail and should be constructed by the HACCP team (NACMCF 1998; SABS 1999; Forsythe 2000). The inputs, outputs and rework should be indicated and a hazard analysis should be done at each step. A block-type flow diagram is sufficient (NACMCF 1998). The floor plan should cover all the equipment in use or not, all the walkways, entrances, exits and should also be constructed by the HACCP team.

*Step 5: Verification of flow diagram and floor plan.*

The flow diagram and floor plan should be verified by the entire HACCP team on site. The flow diagram and floor plan should be confirmed during production at all times during the process and amendments to them should be made where needed (NACMCF 1998; Forsythe 2000; Trujillo 2000).

*Step 6: Conduct a hazard analysis.*

Identify the potential hazards that could occur at all steps in the process (NACMCF 1998; Trujillo 2000; Casani and Knochel 2002) and describe what could be done in order to prevent them (Forsythe 2000). A hazard is defined as a biological, chemical or physical agent in food, or condition of a food, with the potential to cause an adverse health effect (NACMCF 1998; Forsythe 2000). It can cause harm to the consumer through injury or illness. The four sources of hazards are: people, equipment, environment and the product (Von Holy 2003). Biological hazards are considered dangerous to the consumer since it causes almost immediate food poisoning (Mortimore and Wallace 1995) and include micro-organisms, bacteria, viruses, fungi and parasites (Forsythe 2000). Chemical hazards can be found in two categories namely the toxins and poisons that are found naturally in the product such as aflatoxins as well as chemicals that are added to the process whether intentionally or unintentionally such as lubricants, pesticides, fungicides, cleaning materials (Forsythe 2000), allergens, toxic metals, nitrites, nitrates, N-nitroso compounds, polychlorinated biphenyls (PCBs), plasticizers, veterinary residues, chemical additives (Mortimore and Wallace 1995). Physical hazards are the physical material not normally associated with the product such as glass, metal, stones, wood, plastic, parts of pests, bone, fruit pits etc. (Forsythe 2000; Mortimore and Wallace 1995; SABS 1999).

*Step 7: Determine the critical control points (CCPs).*

A critical control point is defined as a point, step or procedure at which control can be applied and a safety hazard can be prevented, eliminated or reduced to acceptable levels (Mortimore and Wallace 1995; NACMCF 1998). Critical control points are identified by using the decision trees such as those provided by the Codex Alimentarius Commission

(CAC 1997). With these decision trees, a sequence of questions should be answered in order to lead the user into making the decision whether a specific step in the process should be considered a critical control point or not (NACMCF 1998; Forsythe 2000). If any doubt arises as to whether a specific point, step or procedure within the process can be regarded as a critical control point, the question whether a consumer could get ill or hurt if there is a lapse at this specific point in the process and consumption of the product do take place. When answering yes, it is most likely that the point can be a CCP within the specific HACCP study (Wallace and Williams 2001).

*Step 8: Establish critical limits.*

Establish critical limits for preventative measures associated with every critical control point (Forsythe 2000; SABS 1999, Trujillo 2000; Casani and Knochel 2002). A critical limit is defined as “the maximum and/or minimum value to which a biological, chemical or physical parameter must be controlled at a CCP to prevent, eliminate, or reduce to an acceptable level the occurrence of a food safety hazard” (NACMCF 1998). It is the absolute tolerance for safety (Mortimore and Wallace 1995) and differentiates acceptability from unacceptability. A quantifiable parameter should describe the difference between a safe and an unsafe product such as temperature, time, pH, moisture, water activity, salt concentration or available chlorine (Forsythe 2000).

*Step 9: Establish monitoring procedures.*

Physical and chemical measurements are the preferred monitoring procedures since it can be done regularly and rapidly. Monitoring procedures include visual observations and the measurement of temperature, time, pH or moisture level. It should however be able to detect the loss of control at the critical control point in order to rectify a problem in cases where deviations occur and the process can get out of control (NACMCF 1998; Forsythe 2000; Casani and Knochel 2002).

*Step 10: Establish corrective actions.*

Establish corrective actions for each critical control point to deal with deviations from critical limits (NACMCF 1998; SABS 1999; Trujillo 2000; Casani and Knochel 2002).

Corrective actions should include an investigation and correction to the cause of the non-compliance, the disposition of the noncompliant product and records of the corrective action taken (NACMCF 1998). Product produced while a certain critical control point was out of control should be recycled or destroyed (Forsythe 2000).

*Step 11: Establish verification procedures.*

Verification is defined as the activities other than the monitoring procedures that determine that the HACCP plan is working effectively (CAC 1997; NACMCF 1998; Scott 2005). Therefore in order to make sure that the HACCP system is effective, verification, auditing methods, procedures and tests, as well as random sampling and analysis should be established (NACMCF 1998; Forsythe 2000; Trujillo 2000; Casani and Knochel 2002). Validation is defined by the NACMCF (1998) as the element of verification that focuses on collecting scientific and technical information to determine whether the HACCP plan when implemented will be able to control the identified hazards. This includes the use of scientific publications, historical knowledge, regulatory documents, experimental trials, scientific models and operational data and surveys (Scott 2005).



*Step 12: Establish documentation and record-keeping procedures.*

All procedures should be documented and all records kept in order demonstrating that while the product was being manufactured, the facility adhered to all relevant regulations in order to produce a safe product. Also that appropriate action was taken in cases where deviations occurred from critical limits (NACMCF 1998; Forsythe 2000; Trujillo 2000). Examples of documentation that should be kept are: summary of hazard analysis; HACCP plan; HACCP team listing and its assigned tasks; food's description, distribution, intended use and intended consumers; flow diagram; HACCP plan summary table; supporting documentation and all other records generated during the operation of the plan (NACMCF 1998).

The totality of all the above steps becomes the HACCP plan (Trujillo 2000). In order to implement a HACCP plan it is important that personnel are properly trained. The system

should be validated by collecting technical and scientific information to ensure that when properly implemented, it will effectively control the hazard. Maintenance of the plan is also very important therefore verification of the HACCP plan should take place to ensure that the system is operating according to plan (Trujillo 2000).

#### **2.4.6 Auditing**

The HACCP study must be maintained at all times (Mortimore and Wallace 1995). An audit is a verification procedure that is an essential part of any quality and safety management system. Auditing is the tool used to make sure that the system complies with the requirements. An audit is defined as a systematic and independent examination to determine whether activities and results comply with the documented procedures; also whether these procedures are implemented effectively and are suitable to achieve the objectives (Mortimore and Wallace 1995). The auditor is the person that exercise judgement based on the estimation of the facts obtained in the audit. Three types of audits are identified namely first party, second party and third party audits. A first party audit is where a food handling enterprise relies on its own staff to verify its own system internally. Second party audits are carried out by employees from a government agency when food safety auditing is required by government and provides a more focused, in-depth inspection of the operation. The third party audit is carried out by an independent, external individual or organisation and usually investigates a specific problem area (Souness 2000). Such an audit is frequently used when a critical control point regularly goes out of control (Mortimore and Wallace 1995). During the implementation and maintenance of a HACCP plan, all three types of audits may be used either in combination of each other or alone. The auditor should present a true and fair view of the efficiency, status and implementation of the HACCP plan.

Benefits of auditing a HACCP system would include the following: evidence of suitable thoroughness in the management of food safety, independent and objective reviews of the effectiveness of the HACCP system, confidence in the HACCP system can be maintained by verifying the effectiveness of the controls, areas for improvement can be identified,

awareness of food safety management is continually being reinforced and obsolete control mechanisms removed (Mortimore and Wallace 1995).

#### **2.4.7 Advantages of HACCP**

The most important advantage of HACCP above other food safety plans is that HACCP focuses on the prevention of food safety hazards rather than the detection of them (Trujillo 2000). Since HACCP concentrates on the identification of physical, chemical and biological hazards, it prevents those hazards from contaminating the food source (Anon. 2001). By the implementation of HACCP, the government gets to oversee the process regularly. Investigators will be able to see how well a manufacturer is complying with food safety legislation over a period of time because of regular record keeping since all records and documentation should be kept for a certain time period (Anon. 2001).

The responsibility for ensuring food safety is placed directly on the manufacturer or distributor when using HACCP as food safety tool (Anon. 2001). HACCP is internationally recognized and therefore food companies can compete more effectively in the world market (Anon. 2001). For the same reason as abovementioned, HACCP reduces barriers to international trade whether exporting or importing occurs and HACCP benefits food companies (Trujillo 2000; Anon. 2001). When HACCP is implemented effectively, it results in an increase in confidence by consumers and customers as well as the company saves on resources (Trujillo 2000). HACCP is based on sound science (Anon. 2001).

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## CHAPTER 3

### PRE-REQUISITE PROGRAMS

Pre-requisite programs are defined by the World Health Organisation as “practices and conditions needed prior to and during the implementation of HACCP and which are essential for food safety” (Wallace and Williams 2001). It includes the good hygiene practices (GHP), good manufacturing practices (GMP), good agricultural practices (GAP) and good laboratory practices (GLP).

#### 3A. PREMISES

Premises refer to the actual property and building as well as its surroundings where production takes place. The condition of the premises such as the outside property and building, the design, construction and maintenance, lighting, ventilation, air quality and compressed air, waste disposal, inedible areas, sanitary facilities, water quality and supply can have a major impact on the quality of the product. Therefore it is important that specifications for these factors should exist.

#### 3A.1 Building Exterior

3A.1.1 *Outside property and building* (Mills and Pedersen 1992; CAC 1997; SABS 2001a; Anon. 2004; Du Toit 2004; Fisher 2004)

3A.1.1.1 The mill should be located away from: environmentally polluted areas and industrial activities that can contaminate the food source (i.e. odours, dust or aerosols); areas subjected to flooding unless sufficient safeguards are provided; areas where wastes, either solid or liquid cannot be effectively removed, the air should be clean and free from excessive levels of bacteria, yeast and moulds as well as areas which are prone to the infestation of pests. The neighbouring roadways should be free from

debris and refuse, adequately drained and maintained to minimize environmental health hazards.

- 3A.1.1.2 The mill should be designed, sized, constructed and maintained to prevent the entry of contaminants and pests (e.g. no unprotected openings, air intake should be properly located and the roof, walls and foundation should be maintained to prevent leakages) as well as to allow proper cleaning. The building materials used, shall be of such as to permit easy cleaning and disinfecting. In order to satisfy performance of all operations, adequate working space shall be provided.
- 3A.1.1.3 The building should conform in all respects to Regulation 918 of the Department of Health and SABS 049 regulations.
- 3A.1.1.4 Raw material reception areas and distribution areas should be isolated from the other process steps. These more and less sensitive areas in terms of raw materials, products and personnel should be separated. Within a milling environment the less sensitive areas could be defined as the reception, processing and distribution areas whereas the more sensitive areas could be the packing areas.
- 3A.1.1.5 The raw product storage area and packing area should also be separated physically.
- 3A.1.1.6 Smoking and eating / drinking areas should be segregated from the production and storage areas. The organisation should have a smoking policy in place.
- 3A.1.1.7 An external facility for the disposal of waste should be located well away from the production areas and where possible in its own enclosed building.

- 3A.1.1.8 Suitable containers that can be cleaned thoroughly shall be used for the storage of litter, waste and refuse. If these containers cannot be stored in an enclosed waste room, they should be fitted with tight-fitting lids.
- 3A.1.1.9 Appropriate facilities approved by the local authority should be available for the disposing of sewage and waste water. It should remove all waste water and sewage from the premises and it should be constructed so that there would be no contamination of the product, the premises or the water supply. It should also be located well away from the production areas.
- 3A.1.1.10 Protection from the weather for the receiving and dispatch areas as well as for all materials or products in transit, should be provided.
- 3A.1.1.11 A perimeter wall or fence should prevent unauthorised persons from accessing the mill and should keep stray animals out.
- 3A.1.1.12 If the milling facility is located in a rural area, cattle grids or other appropriate measures shall be taken to prevent cattle from entering the milling grounds.
- 3A.1.1.13 No animals whatsoever shall be allowed on the milling grounds. Exceptions can be made to a blind person in the sales or servicing department accompanied by a guide dog or when it is used for security purposes. Security dogs are not allowed in production or packing areas.
- 3A.1.1.14 Take precautions to preclude, as far as possible, birds from nesting or perching on the grounds of the plant, while simultaneously complying with the regulations of the conservation of wildlife. Frequent inspections to eliminate the invasion of these contaminants are of utmost importance.
- 3A.1.1.15 A clean condition shall be maintained in the yards, outside structures and

pathways. The grounds should be kept free from uncut weeds and grass, litter, waste and other foreign materials. The excreta from birds and animals shall be removed to avoid foot-borne soil and harmful micro-organisms being carried into the plant. All outside structures shall be kept clear of debris, bird droppings etc. to prevent the contamination of the food product.

3A.1.1.16 All outhouses, service buildings, unused buildings etc. shall be kept tidy and clean to avoid the harborage and breeding of micro-organisms, insects, rodents or birds.

3A.1.1.17 All equipment should be installed and located in an orderly manner so that adequate maintenance and cleaning are permitted. Equipment and engineering materials should be stored in a manner that would not provide breeding sites for micro-organisms, insects, rodents or birds.

3A.1.1.18 All engineering materials shall be stored in an orderly manner on elevated racks or pallets in clearly defined areas.

3A.1.1.19 Gutters, open drains, potholes and pools shall be monitored very carefully and on a regular basis to prevent water from becoming stagnant. Inadequate drainage and incorrectly sloped surfaces cause water to become stagnant and stagnant water should be eliminated. The capacity of the drainage system must be sufficient to cope with the maximum process requirements placed on it.

3A.1.1.20 Roofs, valleys end gutters shall be maintained and kept clear of debris to prevent the contamination of food or materials, by rain water or other impurities. Also to prevent walls and floors from becoming damp or wet due to rain. It should be inspected at appropriate intervals and the inspections recorded.

- 3A.1.1.21 All drains should be fitted with debris traps to ensure the retention of heavy debris. Any manhole covers should be properly greased and sealed. Drainage entry and exit points into the building should be pest proofed. To prevent blockages and accumulation of debris, damaged drains should be replaced as soon as possible. Records of the maintenance of drains should be kept.
- 3A.1.1.22 Openings for piping, conduits, conveyors, vents etc. should be well-grouted and the edges should be smooth. It is advised that openings at or near to ground level should be covered with screen.
- 3A.1.1.23 External doors shall be constructed in such a way as to prevent the entry of rain water into the factory.
- 3A.1.1.24 Tight windows and doors, barriers such as elevated docks, metal flashings, overhangs and rung steps discourage and prevent rodent access. Cracks and crevices should be sealed.
- 3A.1.1.25 Hard paving of at least 45cm in width should surround the exterior of all the production and storage buildings. Parking, walkway and traffic areas should be paved to avoid excessive dust. Areas that serve the establishment shall have hard, paved surfaces which should be suitable for wheeled traffic. Provision for adequate drainage and cleaning should be made.
- 3A.1.1.26 Trees should be at least 10 meters away from the production and storage buildings. Grounds should be kept free from uncut weeds, grass, litter, waste and miscellaneous materials.
- 3A.1.1.27 Precautions shall be taken to prevent contamination from trucks, vehicles, forklifts or by foot.

3A.1.1.28 Records of all the inspection, maintenance and corrective action procedures done on the exterior of the plant and at defined intervals should be kept.

3A.1.1.29 Holes, drains and other places where pests are likely to occur must be kept sealed.

### **3A.2 Building Interior**

3A.2.1. *Design, Construction and Maintenance* (SABS 2001a; Anon. 2004; Du Toit 2004; Fisher 2004; Meyer 2004)

3A.2.1.1 Toilets and change rooms should be located separate from the production areas.

3A.2.1.2 All surfaces of walls, partitions and floors should be made of impervious, durable materials with no toxic effect in the intended use. Walls and partitions should have a smooth surface; all cracks and crevices should be sealed and easily cleaned. The edges should be sloped to minimize dust accumulation.

3A.2.1.3 Walls should be kept free from cobwebs, dampness, condensation and moulds.

3A.2.1.4 Junctions between walls and walls as well as between floors and ceilings should be closed and ideally coved.

3A.2.1.5 Joints on paneled walls should be sealed.



- 3A.2.1.6 Acrylic or epoxy-based paint should be preferably used for the finish of walls. Where tiles are used, only the industrial type should be allowed and the joints between the tiles should be sealed with a non-absorbent material.
- 3A.2.1.7 Horizontal ledges and window sills should be avoided but in cases where they are present they should be kept free from soil and other items.
- 3A.2.1.8 All openings for conveyors, services, vents etc. should be smoothly finished and sealed.
- 3A.2.1.9 Walls such as those in the packing area should be protected from damage by moving equipment. Galvanized guard rails could be used for this purpose.
- 3A.2.1.10 Proper maintenance of walls including the replacement of damaged tiles, sealing of cracks and joints on wall surfaces as well as getting rid of flaking paint should be done regularly.
- 3A.2.1.11 Avoid placing fixtures, signs, switch boxes etc. on internal wall surfaces but where they are present; they should be properly sealed to avoid the accumulation of soil. Attachments such as shelves shouldn't be allowed as far as possible to prevent any horizontal surface to act as a dust trap.
- 3A.2.1.12 Walls should be maintained in a clean condition at all times and finished with a hygienic easy to clean surface.
- 3A.2.1.13 Temporary walls shouldn't be a hazard to the process or product and should give adequate protection from contamination.
- 3A.2.1.14 Floors should be constructed of durable, water resistant material such as concrete or an approved synthetic material. Only industrial type tiles that

are properly sealed should be considered where floor tiles are used. A wood policy should be in place that allows proper cleaning and fumigation of wooden floors where present, to avoid the infestation of pests such as weevils.

- 3A.2.1.15 Floors should be resistant to attack by product spillage, cleaning agents and cleaning solutions.
- 3A.2.1.16 Floors should be smooth to facilitate easy cleaning and it should be safe to walk on when wet, dry or greasy. It should also be maintained in good condition at all times e.g. free from cracks, holes and corrosion.
- 3A.2.1.17 Concrete floors should be suitably constructed in a way that prevents the build-up of soil or the release of dust or alternatively it should be sealed.
- 3A.2.1.18 Floors should be kept free from litter, oil, accumulated water etc. Disinfectant should be used to clean the floors of sensitive production areas.
- 3A.2.1.19 Stairways in production areas especially over production or packing lines should be completely sealed. Metal stairways should be constructed from non-corrosive material to be protected from corrosion. Mezzanine floors, bridges over equipment and bridges to mezzanine floors should have side walls in all instances where the absence of it could lead to contamination of the area below.
- 3A.2.1.20 Floors should be free from cracks and open joints and constructed to allow adequate drainage and cleaning where needed. Damaged flooring should be repaired as soon as possible.

- 3A.2.1.21 Doors, windows and window frames should be free from mould, flaking paint etc. and kept clean as well as in good condition. The frames of exterior windows should fit properly and it should be completely sealed to prevent insect ingress.
- 3A.2.1.22 Windows that may be opened in the production area should be fitted with removable and cleanable insect-proof screens.
- 3A.2.1.23 Doors leading into the production areas other than the emergency exits shall be fitted with self-closing devices, air curtains or plastic strips.
- 3A.2.1.24 Doors, windows and window frames should be tight fitting at all times.
- 3A.2.1.25 Glass windows in the production areas should be protected or constructed of alternative materials such as PVC to ensure that the product is not contaminated by breakages. Cracked or broken windows should be replaced immediately. Glass should be avoided as far as possible within a milling environment and should be replaced with PVC to avoid glass splinters in the final product. Therefore the covers of the roller stands and sight glasses should be replaced.
- 3A.2.1.26 Internal window sills shall be kept free from dust and debris. If newly built sills, it should have a slope of 45°.
- 3A.2.1.27 External doors should be kept closed and constructed in a manner as to prevent the entry of rain water and pests into the facility.
- 3A.2.1.28 Wooden doors should be avoided but, if used; flush doors are allowed to prevent the accumulation of soil and should be coated with a non-toxic, easily cleanable material.

- 3A.2.1.29 Doors should be easily cleaned and disinfected, should have smooth non-absorbent surfaces, and have automatic closing devices, overlapping plastic strip curtains or rubber swing doors to avoid the entrance of pests.
- 3A.2.1.30 Ceilings should be smooth, impervious to water and dust and easily cleanable.
- 3A.2.1.31 Overhead pipe work and structures should be minimized to facilitate cleaning and shall be fixed above ceilings, into walls or fixed at least 40 mm away from ceilings, walls and floors. If present, it should be free from dust, rust, mould, flaking paint, cobwebs and other extraneous material.
- 3A.2.1.32 The ceiling should be totally sealed where there is no space above the ceiling.
- 3A.2.1.33 Where skylights are present, it shall be clean and unable to open.
- 3A.2.1.34 Openings in ceilings for conveyors, vents, piping etc. should be properly sealed and the edges should be smooth.
- 3A.2.1.35 Canopies that cover equipment, air vents and air vent covers and screens should be kept clean and dust free.
- 3A.2.1.36 Any internal point of access to the outside such as roofs and structures should be controlled to prevent soil from entering the plant. The access door should be locked, unless otherwise required by fire regulations.
- 3A.2.1.37 False ceilings should be smooth, adequately supported and impervious to water and dust. It should preferably be constructed of materials not likely to disintegrate.

- 3A.2.1.38 Stairs and elevators should be designed constructed and maintained in a hygienic condition in order to prevent contamination of the product. The maximum allowable load for an elevator should be clearly posted inside the elevator. The elevator should have an intercom system that should be maintained in proper working condition at all times.
- 3A.2.1.39 Elevators should be kept clean. Elevators should be maintained in a hygienic condition free from conditions that could present a risk of contamination to the food. The well of the elevator should be kept free from any condition that could present a risk of contamination to the product.
- 3A.2.1.40 Electrical cables and wires should where possible be enclosed in conduit or orderly arranged on screens. Electrical trunking and cable trays should be kept free from dust, cobwebs etc.
- 3A.2.1.41 Electrical equipment should be appropriate and if possible, all defective equipment identified, repaired or removed unless a complete cleaning schedule exists for that specific piece of equipment.
- 3A.2.1.42 Washstand (s) with hot and cold water, paper towels, antibacterial soap and plastic lined litter disposal bins should be present at the entrances to the mill and outside or next to toilets and lunch rooms.
- 3A.2.1.43 Battery charging stations must be separated from product handling areas and kept clean at all times.
- 3A.2.1.44 To avoid contamination and accidents, pedestrian gangways should be available.
- 3A.2.1.45 Special signs should be present in the plant to inform and remind the

personnel about the smoking policy. No eating and drinking signs should also be posted in areas where such activities are prohibited. Signs to guide personnel to fire exits, stairs, elevators etc. during emergencies should also be present.

3A.2.1.46 More sensitive areas are defined as areas where the product are exposed and the subsequent processing does not contain a step that effectively destroys all harmful micro-organisms. It is evident that the packing department within a milling environment would be regarded as such an area. It is therefore important that these areas should be separated by partitioning, location or any other effective means. Only hand wash basins and no toilet facilities should be located in the packing department.

3A.2.1.47 All furnishings should be in good condition, of solid construction and the inner and outer surfaces of furnishings kept clean at all times. It should be constructed of either metal or plastic and in cases where it is wood based; it should have a non-toxic and easy to clean finish as well as a cleaning schedule to avoid the infestation of pests. Where necessary, the furnishings should be very well ventilated, sloped and the tops kept clean from dust and extraneous material.

3A.2.1.48 The entrance doors to the production area should have openings less than 1 cm between the walls, floor and appropriate barriers to prevent insect ingress.

3A.2.2 *Lighting* (Mills and Pedersen 1992; SABS 2001a; Anon. 2004; Fisher 2004)

3A.2.2.1 Lighting (whether natural or artificial), should be appropriate so that production or inspection could be effectively conducted in a safe and

hygienic manner. It is important that the food colour should not be altered and that the respective commodity standards should be met.

3A.2.2.2 Adequate natural or artificial lighting of an intensity of at least 220 lux in general product handling areas as well as artificial lighting of at least 540 lux at inspection points throughout the product handling areas should be provided. Fluorescent strip lights should be protected by shatterproof diffusers or sleeve covers in production areas. The artificial lighting should not alter colours and white light should be used where the colour of the food is a critical quality parameter and it has to be monitored.

3A.2.2.3 Light bulbs and fixtures located in areas where there is an exposure to the product or packing materials, should be of the safety type or should be protected to prevent contamination of the product in the case of breakage. Fixtures shall be constructed and situated so that it would be easily maintained and cleaned when the department is not in production.



3A.2.2.4 Sky lights shouldn't be directly above exposed raw material or finished product and should be designed in such a way as to prevent access by pests.

3A.2.2.5 Lighting in pesticide storage areas should be adequate so that pesticide labels could be read easily.


3A.2.2.6 The exterior plant grounds should have proper lighting so that the facility would be well lit at night. It is recommended that yellow sodium lamps should be used on the outside of the building but it should be located away from doors to minimize pest attraction.

3A.2.3 *Ventilation, Air quality and Compressed air* (Mills and Pedersen 1992; SABS 2001a; Anon. 2004)

- 3A.2.3.1 Proper ventilation (naturally and mechanically) that provides sufficient air exchange to prevent unacceptable accumulation of dust as well as to remove contaminated air, is of utmost importance in the milling environment.
- 3A.2.3.2 Air-intake points shall be fitted with fly screens which should be fitted with dust filters. These air-intake points shall be located so as to avoid the intake of air contaminated by micro-organisms, dust aerosols, chemicals and smoke. The air-intake levels should be at least 1 m above the internal floor levels and outside surfaces.
- 3A.2.3.3 The design of all ventilation and extraction systems should be of the sort that allows proper cleaning.
- 3A.2.3.4 Compressed air should be dry when it comes into contact with the product to prevent micro-organisms from building up in the air lines. Air should be free from micro-organisms, chemicals, dust and soil that could contaminate food or be hazardous to health. Compressed air supplies must be filtered and passed across water and oil traps which should be regularly drained.
- 3A.2.3.5 Non-return valves shall appropriately be fitted in the air lines to prevent the entry of food into the lines.
- 3A.2.3.6 Clean, dry, filtered air should be used for pneumatic conveying of dry bulk ingredients including wheat.
- 3A.2.3.7 Within a dusty environment such as a mill, it is advised that dust extractors should be installed where necessary; the units should be inspected and maintained to ensure their functionality.



- 3A.2.3.8 Ventilation systems should be kept clean and maintained in good condition to avoid the introduction of contaminants into the process environment.
- 3A.2.3.9 Compressed air should not be used for cleaning purposes since it will cause soil and dust to spread around the mill.
- 3A.2.3.10 In cases where relative humidity or the control of air is important to protect the quality of the product, these parameters should be measured and recorded. Unwrapped foods should be handled and processed in areas with an ample supply of filtered air.
- 3A.2.3.11 External air used in the process area should be dry, filtered and clean.
- 3A.2.4 *Waste disposal* (SABS 2001a; Anon. 2004; Fisher 2004)
- 3A.2.4.1 Waste storage facilities shall be designed to eliminate the entry and harbourage of pests and to avoid the contamination of the product, potable water, equipment, buildings, and roadways on the premises as well as the environment in general. There should be no cross-connection between the sewage system and any other waste effluent system in the mill, nor should it pass directly over or through production areas unless it is properly controlled to prevent contamination. The system should be appropriately equipped with traps and vents.
- 3A.2.4.2 Waste material containers should be covered and food waste should be emptied at least on a daily basis whereas non-food waste could be emptied once weekly to minimize pest infestation.

- 3A.2.4.3 Waste material containers shall be located as far as practicable from processing areas and must be sited on proper hard standing with adequate drainage and access for cleaning and pest control.
- 3A.2.4.4 Waste material containers shall be provided in appropriate locations in the mill. Only bona fide waste containers shall be used for waste disposal and these containers shall be of such that they cannot be mistaken for food containers, leak proof, appropriately covered and shall be emptied daily. Packing material even when damaged shall not be used for waste material.
- 3A.2.4.5 Waste should be removed and facilities and containers cleaned and sanitized frequently to minimize contamination. Regular cleaning and disinfecting of the area and receptacles is essential.
- 3A.2.4.6 Product and non-product debris should be handled separately in easily identifiable enclosed containers.
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- 3A.2.4.7 Waste disposal should be monitored and records kept.
- 3A.2.4.8 No glass should be allowed into the production area. All glass breakages should be cleared up immediately and the broken pieces placed in a lidded bin for that purpose specifically. A written Glass Policy should exist.
- 3A.2.4.9 Waste disposal bins should be available, identified; preferably not hand operated, covered and must have a plastic bag inside.
- 3A.2.5 *Inedible Areas* (Mills and Pedersen 1992; SABS 2001a; Anon. 2004; Fisher 2004)

- 3A.2.5.1 It is advised that a separate facility should be provided for the cleaning and sanitizing of equipment used for inedible materials e.g. the cleaning of brushes or sampling equipment used for raw materials.
- 3A.2.5.2 In the case where canteen facilities is provided, these areas should be located, ventilated and refrigerated in a manner as to ensure no cross contamination of the products produced.
- 3A.2.5.3 Where the company has its own microbiological laboratories on site, it is strongly advised that it should be physically separated from the production area.
- 3A.2.5.4 A central garbage collection point should be located outside the raw materials and production building.
- 3A.2.5.5 A pesticide storage area, large enough for proper and efficient storage of pesticides should be separated from the production area or a separate building on the premises secured by lock and key. The room should be well ventilated and away from raw materials, supplies or finished products. It shall be constructed so as to contain pesticide leaks or spills. All application equipment should be identified and a procedure for the disposal of empty pesticide containers shall exist. This area should also be equipped with safety and first aid equipment.

### **3A.3 Sanitary Facilities**

- 3A.3.1 *Employee facilities* (SABS 2001a; Anon. 2004; Fisher 2004; Hooper 2004; Van Schalkwyk 2004; Visser 2004)
- 3A.3.1.1 Change-rooms, toilets and ablution facilities should be provided at all mills. Male and female toilets should be separated. These facilities

should be adequate, suitable, conveniently located, well lit, well ventilated and appropriately heated. It should be completely separated from the food processing areas and should not open into the food processing areas. A lobby with wash hand basins should be between toilets and the food processing areas. The door between such a lobby and food processing areas should be equipped with a self-closing device and the doors of the lobby supplied with push plates on both sides. The lobby should be big enough and facilitated to enable personnel to hang up their protective clothing before entering the toilet. The number of toilets and wash hand basins should be adequate and in accordance with the requirements of the administering authority.

- 3A.3.1.2 Hot and cold running water as well as hand cleaning and antibacterial hand foams or soap should be provided at each hand washing point next to the toilets. These hand-washing facilities should be positioned in such a manner that the employee has to pass them when leaving the toilet area. A suitable, hygienic means of drying for the hands should also be provided close to the hand-washing facility such as disposable towels or air hand-dryers. Air hand-dryers should not be used in sensitive production areas to preclude the possible spread of aerosolized bacteria.
- 3A.3.1.3 Well positioned notices directing employees to wash their hands after using the toilet, by the urinal area, in break areas, at sinks and on every entrance door to the production area should be posted in these areas.
- 3A.3.1.4 Suitable refuse containers and in ample supply should be provided in or near each change-room, hand-washing facility and toilet area.
- 3A.3.1.5 Wash-hand basins should be provided in production areas where if they're absent, a food safety risk can occur. Access to such hand-washing facilities should at all times be unobstructed. They should be supplied

with hot or cold water and preferably be knee, foot or automatically operated.

- 3A.3.1.6 Rest rooms should be provided and provision made for facilities where staff could lock away their food, eating and drinking utensils, outdoor clothing and valuable possessions. Adequate seating facilities should be provided to meet the maximum usage. Lockers should facilitate easy cleaning and should be inspected frequently in order to discourage the growth of micro-organisms.
- 3A.3.1.7 Hand wash sinks and drying facilities should not be used for utensil or general purposes.
- 3A.3.1.8 A medical room with adequate equipment for the first aid treatment of illness or injury is essential.
- 3A.3.1.9 Facilities for the disposal of smoking materials should be provided at exits of smoking areas.
- 3A.3.1.10 Where drinking within the mill is allowed, the proper option would be a drinking fountain as it can be easily controlled, cleaned and tidied.
- 3A.3.1.11 Where canteen facilities are available, the food preparation area should be of good design with adequate storage, well run and properly maintained.
- 3A.3.1.12 Automatic vending machines are allowed as long as they are suitably located, adequately cleaned and maintained. Proper disposal facilities for cans and papers should be provided.
- 3A.3.1.13 Changing facilities only for the change of clothing shall be provided in cases where uniforms are changed on site.

3A.3.1.14 Hand-washing facilities with antibacterial soap and disposable towels for personnel should be available in or near the pesticide storage area as well.

3A.3.2 *Equipment cleaning and Sanitizing facilities* (Du Toit 2004; Fisher 2004; Van Schalkwyk 2004)

3A.3.2.1 Facilities where equipment such as sieves are replaced should be separate from production areas.

3A.3.2.2 Separate facilities for utensil washing and general purpose cleaning should be appropriately identified and where possible, segregated from production areas.

3A.3.2.3 Adequate, designated storage space should be provided to allow for the complete segregation of clean, dry utensils. Cleaned utensils should be stored in a clean, well maintained storage area and the utensils stacked in a manner to prevent recontamination.

3A.3.2.4 To prevent mould growth, good draining and drying of equipment and utensils should be present and where necessary adequate ventilation should be provided.

### **3A.4 Water quality and supply**

3A.4.1 *Water* (Mills and Pedersen 1992; SABS 2001a; SABS 2001c; Anon. 2004; Marais 2004)

3A.4.1.1 Potable water, free from hazardous substances and in ample supply should be available at the point of use. Where water is used in the milling process as an ingredient as in conditioning, it shall comply with SABS 241.

3A.4.1.2 If any form of water treatment occurs on site, the system should be checked routinely and the results recorded (i.e.  $\text{Cl}_2$ ,  $\text{O}_3$ ,  $\text{ClO}_2$ , Sodium hypo chlorite plant). The minimum chlorine levels in treated water should be between 0.1 ml and 0.2 ml per litre at the point of use. At least 20 minutes should be allowed for the chlorine to come into contact with the water before use.

A responsible person should be assigned to check that the chlorination equipment is working effectively. They should make sure that no leakages occur and that the pump is in working condition. The chemicals used for treatment of the water, should also be in ample supply at all times. Regular samples should also be taken and tested to make sure that the water is safe and within specifications of SABS 241. Records should be kept by trained personnel.

3A.4.1.3 Data from periodic testing should be available to show the compliance with chemical and microbiological standards.

3A.4.1.4 Water storage tanks or reservoirs should be constructed of a suitable material and covered properly to prevent contamination of the water by birds, rodents, organic and inorganic matter and should be inspected weekly. The air vents of these tanks/reservoirs should be insect-proof as well as rodent-proof. Frequent inspection should occur regularly to ensure that no contamination took place. These water reservoirs should be on a cleaning schedule.

3A.4.1.5 Where back-siphoning of contaminated water can occur such as in places where pesticides are mixed to appropriate concentrations, vacuum brakers should be included in the system.

- 3A.4.1.6 Analyses of water samples should be obtained from the municipal authorities on a regular basis to prove that the water used complies with the standards of SABS 241.
- 3A.4.1.7 Non-potable water systems could be used for fire control but shall be separate, identified and shall not connect into the potable system.
- 3A.4.1.8 A potable supply of hot and cold water should be available from raw material to dispatch for cleaning purposes.
- 3A.4.1.9 Where a mill is using borehole water, it is advised that the water should also be tested at least on a monthly basis. If it doesn't conform to SABS 241 standards, a filtration or chlorination system should be considered.

### **3A.5 Certificates / Documentation required with respect to the premises**

#### **3A.5.1 *Certificate of Acceptability***



- 3A.5.1.1 The food premises should have a valid certificate of acceptability. The person in charge of the food premises should apply in writing to their local authority for such a certificate and the local authority should after thorough inspection and approval, issue the certificate in the name of the person in charge. If the person in charge is replaced by someone else, a new certificate should be issued within 30 days in the name of the new responsible person. The certificate of acceptability should be displayed for the information of the public on the food premises or a hard copy thereof shall be available on request where the display thereof is impractical. No person may make any changes to the certificate of acceptability (Anon. R918).



### **3B.PURCHASING, TRANSPORTATION AND STORAGE**

The main raw ingredient within a milling environment is the wheat received from corporations that received it directly from the farm. On our local farms good agricultural practices are not in place therefore other specifications to ensure the quality of our final product should be in place. Also proper transportation and storage procedures should exist and some of these are discussed below.

#### **3B.1 Purchasing**

3B.1.1 *Suppliers* (CAC 1997; SABS 2001a; Carelse 2004; Fisher 2004; Marais 2004)

3B.1.1.1 A suitable, qualified person should be used to identify, list and establish the appropriate chemical, functional and organoleptic specifications for all raw materials and in-process materials. Raw materials should be purchased from approved suppliers and a list of the approved suppliers should be available and maintained.

3B.1.1.2 Written specifications for all materials purchased as well as for the finished product should be established by the manufacturer to ensure that the food source is free from foreign bodies.

3B.1.1.3 A certificate of analysis (COA) for ingredients, raw materials and packaging materials should be received with each delivery. The certificate received of the graded wheat can act as a COA for raw wheat.

3B.1.1.4 A system should be in place to evaluate the delivered ingredients such as the raw materials and packaging materials. No raw material or ingredient should be accepted if it is known to contain insects, micro-organisms pesticides, veterinary drugs or other toxic substances that would not be

reduced to an acceptable level by further processing downstream. The incoming materials should be inspected to prevent contaminated or damaged goods that could result in spillage, are not brought into the plant without taking precautions against this contamination.

3B.1.1.5 Suppliers should have effective pre-requisite programs in place and should be verified annually. Audits should be carried out on suppliers of raw materials.

3B.1.1.6 Certificates of acceptability for raw materials should be maintained.

### **3B.2 Transportation and Distribution**

3B.2.1 *Food carriers* (Mills and Pedersen 1992; SABS 2001a; Anon. 2004; Fisher 2004; Hooper 2004)



3B.2.1.1 Vehicles used for transportation or distribution of foodstuffs should be clean, free from odours, weatherproof, free from foreign objects, free from pests and easily cleaned. Inspection for interior damage is essential and protruding objects capable of damaging the product should be eliminated.

3B.2.1.2 Food carriers should be loaded, arranged or unloaded in a manner that prevents damage, contamination or deterioration of the food and packaging materials.

3B.2.1.3 Vehicles used for transportation should be inspected before loading to ensure cleanliness, that they are weatherproof and to certify the absence of foreign odours, pests, humidity, material incompatible with a food product and dirt. Doors and latches should be tight to prevent the entry of moisture and pests and to ensure proper fumigation when needed. Appropriate warning signs should be posted to the vehicle after fumigation

took place and only removed when it is safe to do so. After proper aeration, the vehicle could be used and the warning signs removed. Records should be kept of daily checks and maintenance.

- 3B.2.1.4 The internal surfaces of the vehicle body should be impervious to water, easy to clean and the vehicle body should be sealed to avoid the entry of pests, exhaust fumes or other sources of contamination.
- 3B.2.1.5 The outside of an insulated container or vehicle body should be weatherproof, clean and in good condition.
- 3B.2.1.6 Transportation of product and non-product items in the same container should not take place unless it can be demonstrated that no risk of contamination to the food is present.
- 3B.2.1.7 In cases where bulk units or tankers are used for transportation of the food and the food comes into direct contact with the inner surfaces, these tankers and bulk units should not be used for non-food items unless its harmlessness can be demonstrated. These tankers and bulk units should also be cleaned at appropriate intervals and should be suitable for food use.
- 3B.2.1.8 Cleaning in place washing units or washing units containing a re-circulation system for washing food tankers or bulk units should not be used to wash tankers or bulk units that contained non-food products.
- 3B.2.1.9 Conveyances and containers used in transporting food, should be kept in a clean, repaired condition. Effective cleaning and disinfections should take place in cases where these conveyances are used for the transportation of different foods or non-foods. In some cases such as for bulk transport, containers and conveyances should be designated and marked for food-use

only and be used only for that purpose. It should protect the product against weather conditions.

- 3B.2.1.10 Reception and unloading of foodstuffs must be performed by adequately trained personnel.
- 3B.2.1.11 Where damaged product is accepted onto a vehicle also carrying sound finished product, the damaged product should be clearly labeled and separated from the rest. It should also be handled in such a manner as to reduce the likelihood of contamination.
- 3B.2.1.12 The load should be equally distributed on the vehicle.
- 3B.2.1.13 In the case where a contractor distribution company is used, their vehicles and administrative procedures should be checked and accepted prior to signing the contractual agreement.
- 3B.2.1.14 The loading area should be free from trash, insects, rodents, birds and dust and preferably sealed or proofed against pest infestation. Any spillage should be cleaned up in order to discourage pest ingress.
- 3B.2.1.15 The receiving company should establish proper receiving and unloading procedures to ensure that the product is not contaminated at the point of receipt. Damaged or infested goods shall not be accepted until action has been taken.
- 3B.2.1.16 Conveyances, containers and bulk transport should be suitable for food use.
- 3B.2.1.17 The dead ends in bulk tankers where old product can accumulate, should be cleaned on a regular basis.

3B.2.2 *Temperature control* (Mills and Pedersen 1992; Du Toit 2004; Fisher 2004)

3B.2.2.1 Samples taken for microbial analyses should be transported at regulated and / or acceptable temperatures to the laboratory where it is to be tested.

3B.2.2.2 The finished product should be transported under conditions to prevent damage and deterioration to the product.

3B.2.2.3 The temperature in the pesticide storage areas should be controlled sufficiently to protect the types of pesticides stored.

3B.2.2.4 The temperature in various sections of the mill should be controlled and well ventilated in order to protect the quality of the product.

### **3B.3 Storage**




3B.3.1 *Incoming material receiving and storage* (Mills and Pedersen 1992; Anon. 1993; Anon. 1994; SABS 2001a; Du Toit 2004; Fisher 2004).

3B.3.1.1 Adequate storage facilities (silos) should be provided for the storage of incoming wheat. Separate storage areas should be provided for processed and unprocessed foods.

3B.3.1.2 No wheat should be accepted by a mill if it doesn't conform to specifications. Physical and biological tests will be done in order to grade the incoming wheat. If it is known that the wheat contains high levels of undesirable substances (impurities) such as toxins, micro-organisms, pesticides, parasites, insects etc, the raw material should be rejected. Where appropriate, raw materials should be identified

- 3B.3.1.3 Different grades of wheat shall be stored separately in different silos.
- 3B.3.1.4 Wheat storage silos should be rodent-, insect- and bird proof, should be kept in a hygienic condition and cleaned and fumigated regularly. Therefore maintenance of silos should take place regularly.
- 3B.3.1.5 Silos should be constructed of suitable materials such as cement and fitted with suitable close-fitting covers kept in place at all times. The interior of these grain storage bins should be smooth and free from cracks and crevices. In cases where these storage tanks are vented, the venting should be maintained and designed to not contaminate the contents. Inlet valves and pipe work should be kept in a hygienic condition and precautions taken to avoid access to the pipe work by rodents, birds and insects.
- 3B.3.1.6 Conveyances should be designed and constructed so that they do not contaminate foods, could be cleaned effectively and permit effective separation of different grades of wheat.
- 3B.3.1.7 Incoming materials such as fortificants and packaging materials should be handled and stored in a manner as to prevent damage, deterioration and contamination. Where appropriate, rotation is also required.
- 3B.3.2 *Non-food chemicals receiving, storage and usage* (Mills and Pedersen 1992; SABS 2001a; Fisher 2004).
- 3B.3.2.1 All non-food chemicals, water treatment chemicals, chemicals for sanitation, pesticides, paints, lubricants etc. should be approved for the food premises and together with the associated application equipment should be segregated from the food source to prevent contamination.

- 3B.3.2.2 All non-food chemicals received should be inspected and the procedure documented to ensure that damaged goods that could cause spillage are not brought into the mill without appropriate measures being taken to avoid contamination. Damaged goods shall not be taken to the storage facility unless it has been inspected for evidence of pest or insect infestation and appropriate measures have been taken accordingly.
- 3B.3.2.3 Emergency procedures should be in place in the case of an accident or spillage.
- 3B.3.2.4 Only when a substance that could contaminate the food product is necessary for hygiene or processing purposes can the substance be stored in food-handling areas. No hazardous substance may be used or stored in food-handling areas.
- 3B.3.2.5 First aid equipment should be kept secure in a locked cupboard and should only be issued by trained staff.  All treatments should be fully recorded in a medical record book together with the patient's name, date, disease and the medical supplies issued.
- 3B.3.2.6 All raw materials as well as the packaging materials should have a batch code and accompanying documentation to identify them in storage and processing.
- 3B.3.2.7 A formalized procedure for the issue of food ingredients such as fortificants from stores shall exist. The amount issued, batch code and date of issue should be documented. When these ingredients are moved it should be done in such a way that their identities are not lost.
- 3B.3.2.8 Where an operator add an ingredient manually to a batch, the addition of each ingredient to the batch should be recorded at the time of

manufacturing to ensure traceability of ingredients and to minimize the risk of accidental omission.

- 3B.3.2.9 Cleaning and disinfecting agents should be used in accordance to the manufacturer's instructions and their use kept to a minimum when production is in progress.
- 3B.3.2.10 Clothing, gloves, approved respirators and other safety and monitoring equipment should not be stored with the pesticides
- 3B.3.3 *Finished product storage* (Mills and Pedersen 1992; Anon. 1993; Anon. 1994; SABS 2001a; Anon. 2004; Fisher 2004; Meyer 2004; Van Schalkwyk 2004).
- 3B.3.3.1 The finished product should be stored in containers constructed of suitable materials, fitted with suitable close-fitting covers and kept in place at all times. Containers shall be designed to ensure proper cleaning and maintenance.
- 3B.3.3.2 Finished product shall be stored away in separate areas from other chemicals, raw materials or materials used in the process.
- 3B.3.3.3 The finished product should be palletized, stored on pallets with a cardboard or plastic layer (slip sheet) to avoid splintering and not be placed directly on the floor.
- 3B.3.3.4 Finished product should be stored, rotated where possible on a first in first out basis (so that the customer has sufficient shelf life remaining on receipt of the product) and handled under conditions to prevent damage or deterioration.



- 3B.3.3.5 The finished products should be stored in a manner that allows inspection, cleaning and pest control. (It is recommended that finished product should be stored at least 45 – 50 cm from walls and other materials and 25 cm off the floor).
- 3B.3.3.6 Finished products should be stored in a manner that provides physical protection and restricted access in closed storage areas under the appropriate conditions as was agreed on in the finished product specification.
- 3B.3.3.7 Broken or contaminated pallets shouldn't be used to transport finished product. A physical inspection of the pallet before it's used is advised.
- 3B.3.3.8 Storage areas should be maintained in a dry, clean conditioned and in a well ventilated state. All materials should be stored off the floor on clean pallets and at least 20 cm from the wall in order to allow proper cleaning, pest control and ventilation.
- 3B.3.3.9 Packing materials should be stored in a separate area which is dust free and pest proof. Specifications for packing materials should exist but most importantly, it should be able to protect the food. It should also be free from contamination, should not taint the food or impart off-flavours or off-odours to the product.
- 3B.3.3.10 Loading areas should be sealed and pest proof to prevent contamination during the loading operation. All loading areas should also be kept clean, tidy and well maintained to prevent the ingress of pests.
- 3B.3.3.11 Prior to the release of the finished product, the finished product should be checked and approved by the quality assurance department. Examples of tests that could be done on the final product: test for moisture %, protein

%, ash %, colour, falling number, alveograph, mixograph, particle size, vitamins and baking quality. Records should be kept.

- 3B.3.3.12 Batches of finished product that has been approved by the quality assurance team should be stored in separate areas and under appropriate conditions.
- 3B.3.3.13 Batches of finished product that doesn't meet the required specifications, should be quarantined, labeled clearly and held in a separate area to prevent accidental use.
- 3B.3.3.14 As damaged goods are discovered, they should be stored in a designated area in order to not expose other products within the storage facility to contamination or probable infestation.
- 3B.3.3.15 If a batch of approved finished product is stored unlabelled on a temporary basis, it should be labeled and coded at a later stage; extreme caution should be taken to guarantee its exact identity.
- 3B.3.3.16 Returned, damaged or goods segregated for reprocessing should be physically segregated from other finished product to avoid contamination. An entire different storage facility for recall work shall be preferred.
- 3B.3.3.17 Where damaged goods should be disposed, all labeling should be removed to prevent the products from re-entering the distribution chain.
- 3B.3.3.18 A formalized procedure should exist that deals with the consequences of accidents or damage during storage and distribution.
- 3B.3.3.19 Management controls should ensure that all products should be easily accessible, all aisles kept clear and products stored in designated areas,

movement around the area should be unimpeded, products should be released or used in proper stock rotation, maximum utilization of the available space should occur and suspect product should be identified.



### 3C. EQUIPMENT

Equipment in any food manufacturing plant is very important in order to get the job done. Therefore it is of utmost importance that it should fulfill its intended role, it should be properly designed, maintained, calibrated and should always be in proper working condition. It should not add any contaminants to the process therefore a few guidelines for the milling industry with regard to equipment are listed.

#### 3C.1 General equipment

3C.1.1 *Design and installation* (Mills and Pedersen 1992; Anon. 1993; Anon. 1994; SABS 2001a; Middleton *et al.* 2003; Anon. 2004; Carelse 2004; Fisher 2004; Godrich 2004; Meyer 2004; Mousia and Pandiella 2004; Van Schalkwyk 2004)



3C.1.1.1 When purchasing new equipment, it should be of hygienic design. Equipment should be designed, constructed and installed so that: all parts are accessible for cleaning, inspection and pest control; they can deliver the requirements of the process; contamination of the product during operations is prevented; all food contact surfaces are smooth, non corrosive, non absorbent, non toxic, free from cracks and crevices and capable of withstanding repeated cleaning.

3C.1.1.2 The material used for equipment should not transmit toxic substances, odour or taste or cause colour changes. Stainless steel or inert materials should be used. Materials such as wood that cannot be properly cleaned and disinfected should be avoided except for when its use would not be a source of contamination or when a proper wood policy is in place. Surfaces coming into contact with food shall comply with regulations from the Health Act, 1977 (Act 63 of 1977).

- 3C.1.1.3 Different metals should not be used where electrolytic deterioration can take place.
- 3C.1.1.4 No dead ends in pipe work should be present because it cannot be cleaned adequately.
- 3C.1.1.5 Storage and blending bins should be fitted with suitable, close-fitting covers kept in place at all times.
- 3C.1.1.6 Food conveyors to and from filling and closing machines, carrying open containers should have suitable covers to protect the open food containers and product from overhead contamination.
- 3C.1.1.7 For service and cleaning purposes, access under, inside and around the equipment should be provided. Mounting of equipment could take place directly on the floors or walls as long as they are adequately sealed to prevent the infestation of micro-organisms. Equipment mounted to the floor should be at least 60 cm from the adjacent walls and other equipment and at least 30 cm from the floor to give easy access to all parts for cleaning and should be elevated or properly sealed to prevent the harborage of micro-organisms.
- 3C.1.1.8 Equipment should not have screws, screw nuts, rivets etc, which can become loose and can lead to a food hazard. If screws, nuts and bolts is used inevitably, it should be self-locking and precautions taken to prevent interruption of smooth operation of the piece of equipment of plant. It should also be covered or protected to prevent product contamination.
- 3C.1.1.9 Only electrical or battery operated fork lift trucks in enclosed areas should be allowed to prevent fume contamination.
- 3C.1.1.10 Furnishings should be of solid construction and in good repair.

- 3C.1.1.11 The inner and outer surfaces of furnishings should be kept in a clean condition.
- 3C.1.1.12 Ideally, furnishings should be constructed of metal or plastic but in cases where it is a wood based product, it should be non-toxic and easy to clean.
- 3C.1.1.13 Where necessary, furnishings should be ventilated.
- 3C.1.1.14 The tops of furnishings should be kept free from dust and extraneous material and where appropriate, it should be sloped.
- 3C.1.1.15 Glass should be strictly prohibited in the food production and storage areas. A glass and foreign body policy should exist. If glass pipes, flow meters or other glass equipment are used, a documented procedure for routine inspection for cracks and splinters should be in place. Broken glass windows should be reported and replaced immediately. In the case where the product was contaminated by the breakage, the contaminated product should be dealt with.
- 3C.1.1.16 All pumps should be constructed of suitable materials, the pumps should be capable of being stripped down for ease of cleaning and inspection, and they should be in good condition and have the power to ensure proper circulation. The frequency of stripping down should be according to a cleaning schedule.
- 3C.1.1.17 All connecting pipe work should be made up of sections which can be easily dismantled to remove any trapped debris and for effective cleaning purposes. They should be in good condition, impervious and have an easily cleanable surface to minimize foreign body contamination. Regular swabs should be taken to analyse the degree of contamination.

- 3C.1.1.18 Stainless steel is the preferred material for the use of food equipment surfaces.
- 3C.1.1.19 Only fully enclosed products protected by an outer packaging is allowed to be packed on wooden pallets. A wood policy should be in place.
- 3C.1.1.20 Agitator motors should be fitted with oil catch trays which cannot overflow into the storage or blending vessel and controls to prevent excessive leakage of lubricants should exist.
- 3C.1.1.21 Equipment such as sieves, carter disks, treur cylinders, de stoners, separators, combiners, scourers, magnets and metal detectors should be used to control foreign body contamination by cleaning the incoming wheat as well as to protect the final product. It is advised that the following equipment should be the minimum requirements within the cleaning house of a mill.
- Aspirator to control separation of light impurities.
- Separator to separate large coarse material and small finer materials from the grain.
- Gravity Selector to separate stones and other heavy impurities, low density and damaged kernels and dust from whole clean grain.
- Scourer to remove dirt, mud balls etc.
- Magnets to remove ferrous material.
- This equipment should be on a cleaning schedule.
- 3C.1.1.22 Utensils used in production areas such as brooms, brushes, dust mops and vacuum cleaning systems should be made of materials such as metal and plastic and should be colour coded to prevent contamination.
- 3C.1.1.23 Because of potential microbiological and foreign body contamination

the use of cleaning cloths is not recommended but in cases where it is used, it should be replaced or washed on a regular basis. Disposable cleaning cloths are a good option.

- 3C.1.1.24 Wire wool is not accepted and scouring pads should only be used if simple brushing is inadequate. The pads should be colour coded and used in conjunction with the daily sanitation procedure and renewed before any signs of deterioration.
- 3C.1.1.25 Vacuum systems are preferred above compressed air hoses in cleaning systems and in inaccessible areas air jet is recommended.
- 3C.1.1.26 Proper equipment such as a flashlight, equipment opening tools, spatula, sample containers, sieves, pans etc. should be available for inspection for pest infestation purposes.
- 3C.1.1.27 To prevent cross-contamination, colour or shape coding of the equipment could be used in pesticide applications.
- 3C.1.1.28 Elevators and conveyers should be designed to permit easy cleaning through drop-bottoms, clean-out doors etc. Dead ends can be designed out of the equipment through installation or by reducing the length of the conveyer.
- 3C.1.1.29 Equipment such as the tempering bins used for high moisture conditions should be supplied by suction devices. The equipment should be designed properly to eliminate dead spots.
- 3C.1.1.30 All equipment should be of hygienic design. Equipment such as bucket elevators, boots, screw and drag conveyers should be accessible through



clean-out openings or even through easy disassembly especially for in house cleaning purposes.

3C.1.1.31 Equipment such as sifters, purifiers, roller stands etc. should be designed in such a matter as to allow both inspection and cleaning simultaneously.

3C.1.1.32 Magnets should be used throughout the milling system to remove ferrous metals.

3C.1.1.33 Entoleters (impact machines) / sterilators should also be used to break open kernels of wheat that have been infested with insects.

3C.1.1.34 Feed-in sifters with at least a 30-wire sieve or finer should be used in mix-back systems or where feed-in sifters are used within a milling environment.

3C.1.1.35 Dust collectors should be kept enclosed since it provides ideal locations for infestations.

3C.1.1.36 Bulk storage bins should not allow condensation and therefore when constructed of concrete, should have double-constructed or heated outside walls. Steel bulk storage bins should be enclosed in a structure where temperatures around the outside of the bin can be regulated.

3C.1.1.37 A wheat debranning system is useful to remove the aflatoxins and micro-organisms from the outer surface of the wheat kernel.

3C.1.1.38 Ideally it would be recommendable that the finished product should go through a metal detector with the capability of detecting ferrous material of 2 mm in diameter and non-ferrous material of 2.5 mm in diameter. A trained person should also check the sensitivity of the search head and

record the results. These results should be kept for at least the shelf life of the product.

3C.1.1.39 The metal separation system should be positioned as close to the end of the process as possible. It is recommended that the metal detection system be fitted with an automatic rejection system that rejects contaminated product into a locked, inaccessible container. This system should be checked when the metal detector is checked. An alternative would be to stop the line..

3C.1.1.40 Micro feeders should be installed to control the amount of fortificant mix added to the flour.

3C.1.1.41 Equipment with interior surfaces that are in direct contact with the product should be self-emptying or self-draining.

3C.1.1.42 All mills should at least have a redress system in place to eliminate any physical hazards that might be added to the final product by human error or operation's deficiency.

3C.1.1.43 It is advised that in cases where mills mix-back returns, a rebolt sifter, impactor system and metal detector should be in place in order to remove any form of physical contamination that might have escaped other methods of detection.

3C.1.2 *Equipment maintenance and calibration* (Mills and Pedersen 1992; SABS 2001a; Anon. 2004; Du Toit 2004; Fisher 2004)

3C.1.2.1 Reparation of equipment should take place after they've been inspected on a regular basis for cracks because micro-organisms could grow in cracks and might not be killed by normal cleaning procedures. Defective

equipment should be identified and repaired. Temporary repairs and modifications that might affect the quality of the product are not recommended.

3C.1.2.2 Only approved lubricants for food production should be used and the bearings inside and outside the product zones should not be excessively lubricated and the leaking oil seals repaired frequently.

3C.1.2.3 All motors where there is a possibility that oil could leak onto the product, should be fitted with oil catch trays because no oil of any kind may leak onto the product.

3C.1.2.4 The sieves, filters and gaskets should be checked and maintained on a regular basis. Filters of ventilation systems should be cleaned and replaced appropriately.

3C.1.2.5 A list of equipment that requires regular maintenance should be available. The maintenance procedures and frequency as well as the reasons for the activity should be recorded.

3C.1.2.6 All equipment that may have an impact on food safety and quality should have an inventory with an effective calibration and verification program.

3C.1.2.7 Equipment in the production area shall be cleaned after every maintenance procedure.

3C.1.2.8 Challenge tests should be carried out on all metal detectors and in the case where such a challenge test fails, all product produced since the last successful test, shall be quarantined, isolated and evaluated. Records should be kept of these challenge tests.

- 3C.1.2.9 All metal detectors should be calibrated to maintain the sensitivity to detect metal foreign objects. This should be scheduled as part of the preventive maintenance program and records should be kept.
- 3C.1.2.10 Documented contingency plans should exist in case metal detectors fail such as a spare replacement unit, product transferal, adequate raw material sieving etc.
- 3C.1.2.11 The calibration and verification of scales should be done according to a program and the results recorded. During automatic mixer feeding, it should be verified that the pipelines and automatic scales are completely emptied for each batch.
- 3C.1.2.12 Adequate systems to control volume and/or weight should be in place to meet legal and specified requirements.
- 3C.1.2.13 Equipment should be maintained in good working order and appearance and should be free from product debris, flaking paint or other contamination hazards.
- 3C.1.2.14 Records of equipment used for the product manufacturing and maintenance of the plant should be available when required.
- 3C.1.2.15 Metal surfaces if not stainless steel should be kept in good condition, free from flaking paint and free from rust.
- 3C.1.2.16 Agitator motors, their mounting frames and oil trays should be kept free from rust and flaking paint.
- 3C.1.2.17 Equipment should only be used for its intended purpose and shouldn't serve as shelving, storage or food preparation surface.

- 3C.1.2.18 Maintenance and inspection records should exist and staff should observe all precautions while working on the equipment. For instance, all screws, bolts, nuts, washers etc. should be checked and fastened; a record of all tools used in maintaining the piece of equipment should be kept and removed from the area; all spare parts or fittings should be removed from the area; equipment and surrounding areas should be left clean and tidy before production could start again; the machine operator should check that all machine parts are intact and all necessary guards fitted.
- 3C.1.2.19 Magnets in the cleaning house should be cleaned and checked daily and these processes recorded so that accumulations of metal can be removed. Magnets further downstream in the production line should be on a cleaning schedule.
- 3C.1.2.20 Maintenance on a production line is not allowed while production is in progress however it is allowed on adjacent non-functional lines provided that the process operation is properly screened.
- 3C.1.2.21 All measuring equipment used in laboratories should be calibrated regularly against a given standard. Results of calibration should be formally documented.
- 3C.1.2.22 In cases where equipment is taken off site for calibration, provision should be made for “reserve” equipment which is also accurate, maintained and calibrated to be available.
- 3C.1.2.23 Brooms and hand brushes should be maintained in good condition and free from deterioration and soiling and when not in use, hanged in storage facilities provided. Brushes should also have coloured, easily detectable synthetic bristles which cannot become loose easily through continuous use.

- 3C.1.2.24 When cleaning implements become badly worn and become a foreign body risk, they should be discarded.
- 3C.1.2.25 Pesticide application equipment should be checked for proper operation and calibration before use.
- 3C.1.2.26 Handling and cleaning equipment in the mill should be inspected and cleaned frequently to ensure that the grain that goes through to the milling side is properly cleaned and that further contaminants are not added. The interior of cleaning equipment should be checked and static grain and dust removed. At the same time the mechanical condition of the equipment should be checked.
- 3C.1.2.27 Equipment containing dead spots such as screw conveyers and milling equipment should be checked regularly.
- 3C.1.2.28 Bulk flour bin inspection lids should be sealed at all times to prevent the introduction of contaminants to bulk storage flour.
- 3C.1.2.29 The rotors of the impact machines should be checked at regular intervals for their efficiency as well as to make sure that it is operating at the recommended speed.
- 3C.1.2.30 Micro feeders should be calibrated and maintained regularly in order to prevent overdosing.
- 3C.1.2.31 In order to verify that the cleaning equipment is in good working condition, it is advised that the % screenings that is associated with a certain load of wheat should be controlled and documented at all times. Each and every mill should make sure that they lay down the minimum % screenings limit and that it is revised on a regular basis. Whenever the

minimum % screenings drop, it is a very good indication that some or all of the cleaning equipment is not in proper working condition.

3C.1.2.32 It is important that the wheat debranning system is cleaned and maintained on schedule. Where these systems are in use, it is important for management of that specified mill to lay down minimum and maximum requirements for the offal screenings. Once the minimum limit was not achieved for a certain time period, it should be evident that the system is not in effective working condition.

3C.1.2.33 The redress / rebolt system should be cleaned, checked and the results recorded on schedule. Any sign of overtails is an indication that upstream in the production process, there could be a defect in equipment.



### **3D.PERSONNEL**

Without human labour it is very difficult for any mill to operate therefore personnel in all departments are needed. In order to produce a product that is of good quality and safe to consume, the personnel need to know what they are doing. That's the reason why training of all food handlers especially in personal hygiene and the safety of the product is very important.

#### **3D.1 Training**

3D.1.1 *General food hygiene training* (SABS 2001a; Anon. 2004; Fisher 2004)

3D.1.1.1 Management is responsible to arrange training for all food handlers regarding the hygienic handling of food as well as personal hygiene (good hygiene practices). It should be clear to all food handlers what precautions to take in order not to contaminate the food source.



3D.1.1.2 Training should be done by competent personnel, it should be updated appropriately and records of training should be kept.

3D.1.1.3 The training program includes appropriate training on the company's Hygiene Code of Conduct at the beginning of employment. It also comprise of the manner in which foodstuffs are handled and packed, the probability of contamination, the nature of the food, the food's ability to sustain growth of pathogenic or spoilage microorganisms, awareness of food safety issues; basic personal hygiene and hygienic and sanitary requirements of the equipment.

3D.1.1.4 It is advisable that employees should be informed in writing of the company's policy on personal hygiene when work commence as well as



the disciplinary actions that could be taken against them in cases of non conformances.

3D.1.1.5 All production and quality assurance personnel should be fully trained in good manufacturing practices.

3D.1.1.6 Training records should be kept on each individual member of staff.

3D.1.1.7 Routine checks and supervision should be in place to ensure the effectiveness of the training and instruction programs and to confirm that designated procedures are being followed. Verbal or oral tests are advisable means of testing.


3D.1.1.8 Systems that ensure that employees remain aware of all necessary procedures to maintain the safety and wholesomeness of the food should be in place.



3D.1.1.9 Personnel employed as drivers should be adequately trained to meet the specific quality to the hygienic and safety requirements of the transported goods.

3D.1.1.10 Engineers should be adequately trained in hygiene procedures such as personal hygiene and product protection. When entering the production and packaging areas they should adhere to the same rules such as hand washing as the other operators.

3D.1.1.11 Off site engineers brought into the plant should be shown the company's personal hygiene code of practice and taken through it. To overcome language problems, picture based guides could be of good use.

- 3D.1.1.12 By implementing regular hand swabs or contact plates before and after washing hands, the effectiveness of hand washing could be monitored. These results could then be used in hygiene training. This is advisable for the more sensitive areas where can be direct contact with the product.
- 3D.1.1.13 New employees should be informed at recruitment of the company's "No smoking policy".
- 3D.1.1.14 Cleaning operatives should be adequately trained so that they fully understand: the cleaning schedules; chemicals listed and safety precautions required; the need for protective clothing; the appropriate dilutions of cleaning agents; the personal hygiene standards expected of them as well as the use and care of cleaning equipment.
- 3D.1.1.15 Personnel employed to only fulfill a cleaning role, should be identified by either the use of different coloured protective clothing, design or colour of hat or by overall symbols. 
- 3D.1.1.16 Production supervisors or junior managers should be trained to at least a basic food hygiene qualification (1 day) whereas senior and middle production management should have gained advanced food hygiene qualification (3 days).
- 3D.1.1.17 Personnel in the packing areas of mills should be extra cautious in order to prevent accidental finished product contamination. Proper hair restraints should be in place; only shirts without pockets should be allowed or in cases where shirts do have pockets, nothing in the shirt pocket should be allowed and no jewellery should be allowed.
- 3D.1.1.18 Employees should have the necessary knowledge and skills enabling them to implement the standards contained in this document.

3D.1.2 *Technical training* (Anon. 1993; Anon. 1994; Du Toit 2004; Fisher 2004)

3D.1.2.1 Training should be provided to address the complexity of the manufacturing process and the tasks assigned to employees. (Employees should know what their responsibilities are and how to monitor their performances. They should also know what actions to take in certain cases.) It is of utmost importance that work instructions and procedures exist and that the personnel are trained to deal with chokes due to poor operations efficiency in the milling machinery. It is also advisable that the product that was exposed to the floor or the open environment, when the choke was being cleared, should not be mixed back directly into the system. If it is mixed back, the mix-back procedure should be controlled.

3D.1.2.2 Training for maintenance personnel in the calibration and fixation of equipment that could affect product safety is essential.

3D.1.2.3 Personnel and supervisors responsible for sanitation should be trained to understand the principles and methods required for effective cleaning and sanitation.

3D.1.2.4 Personnel responsible for pest control should be qualified otherwise the services should be outsourced to a pest control company. Qualifications should be kept on record.

3D.1.2.5 Provision should be made for a fully trained nurse on site or suitable staff should be trained in first aid.

3D.1.2.6 The person in charge of receiving the grain (wheat grader), should be well trained to do so, knowledgeable and dependable in order to do his specified task. A suitable wheat grading certificate that shows that the wheat grader is qualified should be kept on record. The wheat grader

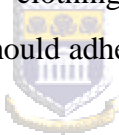
should have the authority to reject wheat if it does not conform to the minimum requirements or re-classify it into another class if necessary.

### **3D.2 Hygiene and Health Requirements**

3D.2.1 *Cleanliness and conduct* (Mills and Pedersen 1992; SABS 2001a; Anon. 2004; Du Toit 2004; Fisher 2004; Marais 2004; Meyer 2004; Visser 2004; Wessels 2004)

3D.2.1.1 All employees should be medically fit. If the administering authority requires it, any food handler should be medically examined and the records of such examinations kept in confidential files.


3D.2.1.2 All staff should behave in a manner as not to contaminate the food and wear clean, protective clothing when entering or working in the production area. They should adhere to the company's hygiene policy.



3D.2.1.3 Visitors and contractors should also be required to wear suitable protective clothing (e.g. laboratory coat) when entering the mill to prevent them from being a source of contamination to the food. No jewellery should be allowed, a hairnet or hat and earplugs provided. No loose hanging clothes should be allowed to avoid it from getting stuck into machinery.

3D.2.1.4 Attention should be paid to ensure that maintenance and subcontractors do not carry soil on their clothing into production areas or areas sensitive to contamination.

3D.2.1.5 Personal garments should not be worn over protective clothing and no part of any personal garment should protrude from protective clothing above the knee.

- 3D.2.1.6 Clean prescribed clothing and covering that covers hair (long hair should be tied), including beards (beard covers) should be worn by personnel in the mill including engineers, management and other casual visitors. Clothing should have no external pockets above the waistline and if internal pockets are provided, it should be at hip level. It should be free from loose fastenings such as buttons but when available, it should be securely fastened.
- 3D.2.1.7 Headwear should retain all hair; it should be of generous size and comfortable to wear. A hat worn together with a hairnet is a good option.
- 3D.2.1.8 Ear plugs or ear muffs for ear protection against noises of machinery should be worn at all times in the mill.
- 3D.2.1.9 A protective clothing and footwear policy should be in place according to the standards set out in SABS 049.
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- 3D.2.1.10 Footwear should be clean and workers should have separate footwear for use in the factory to preclude the introduction of pathogenic micro-organisms. Safety boots or trainers should be provided to employees.
- 3D.2.1.11 Protective clothing such as laboratory coats and uniforms should be kept in a clean condition should be cleanable and not used outside the factory or worn to and from work unless authorized to do so. Uniforms should be replaced when necessary and laundering should be done by a competent service provider with acceptable standards. Management should be responsible for an adequate supply of laundered protective clothing.
- 3D.2.1.12 Protective work wear should be colour coded to identify service operators with a different role e.g. Milling personnel wear white and maintenance personnel wear blue overalls.

- 3D.2.1.13 The frequency of changing uniforms should take place on a more regular basis in the more sensitive areas. In less sensitive areas uniforms can be change on a lesser frequency.
- 3D.2.1.14 The hygienic transfer of laboratory coats and uniforms from the laundry to the food premises is essential. The vehicle should be properly cleaned and the uniforms protected from contamination especially after it's been laundered.
- 3D.2.1.15 Gloves should only be used where the workers' hands need to be protected against physical, chemical or temperature harm. Disposable gloves should be used where possible and non-disposable gloves should be thoroughly cleaned and disinfected. If they become damaged or torn, they should be removed and discarded.
- 3D.2.1.16 Clothing and personal items should not be stored in food-handling areas.
- 3D.2.1.17 No jewellery should be worn although plain wedding bands and wrist watches could be allowed in some cases. Fingernails should be kept short, clean and free from varnish and lacquer (no false fingernails). Adequate supervision to ensure compliance is needed.
- 3D.2.1.18 No eating, drinking, smoking, or any unhygienic practice such as spitting, sneezing or coughing over unprotected foods should be allowed in food-handling areas. Eating, drinking and smoking should only be allowed in designated areas.
- 3D.2.1.19 Hands should be washed before work is started, immediately after the toilet has been used, after handling debris, refuse or food waste; after they became soiled or visibly contaminated, when blowing the nose or touching the mouth, after handling money, a handkerchief or refuse container and

after smoking. Also after handling any material capable of transmitting disease and when on duty in a food-handling area hands should be kept clean by frequent washing with disinfectant and running water. Hands should be thoroughly dried. Adequate supervision to ensure compliance with this provision is needed.

3D.2.1.20 Facilities such as change rooms, toilets etc. should be kept clean and odour-free and in good condition to preclude the establishment of sites for the harbourage of micro-organisms, insects, rodents or birds.

3D.2.1.21 Only metallic pens should be used in the raw material, production and packaging areas to allow for detection by metal detectors if lost. The use of other stationary such as pencils, pens etc. should be minimized in the production area.

3D.2.1.22 Management should set the example by abiding to the personal hygiene requirements.



3D.2.1.23 Restrooms should be properly maintained and kept clean at all times.

3D.2.1.24 The interiors of bins should be inspected cleaned and repaired when empty. Static deposits of grain could be a source of contamination.

3D.2.1.25 More frequent inspection and cleaning should take place in situations where high moisture conditions exist.


3D.2.1.26 The chemical, functional, organoleptic and microbiological tests and procedures and frequencies used for cleaning and sanitation should be identified and listed.

3D.2.1.27 Contact lenses are not permitted in the raw material and production areas.

3D.2.1.28 Employees engaged in raw material and production areas should refrain from smoking, spitting, chewing or eating as well as from sneezing or coughing over unprotected food products.

3D.2.2 *Communicable diseases* (CAC 1997; SABS 2001a; Fisher 2004)

3D.2.2.1 Any food handler who is infected with a disease which can be transmitted through food, a carrier of such a disease or who have infected wounds, boils, skin infections, sores, gastro-intestinal disorders, vomiting, diarrhea or any other abnormal sources of microbial contamination should immediately report his illness to management. Management should ensure that any known or suspected person suffering of the above illnesses would not be allowed to work in any food-handling area where the likelihood can occur that the food product can be directly or indirectly contaminated or where the disease can be transmitted to other workers.

3D.2.2.2 Staff should make sure that  the requirements in D.2.2.1 are met.

3D.2.2.3 Before any person who suffered from an infectious disease returns to work, he should be declared medically fit by his doctor, especially when the person still has the ability to contaminate the food source. Records should be kept for each individual case.

3D.2.2.5 No open cuts or wounds should be allowed and a person suffering from them should only be allowed to handle the foodstuff or food contact surfaces when the injury has been dressed and treated to avoid contamination.

3D.2.2.6 After treatment of a cut, sore or graze the area should be covered by a trained first aider or nurse with a coloured waterproof dressing containing



a metal strip and of a different colour than that of the food produced. A check out and check back register should exist for the records.

3D.2.2.7 All employees should report any food poisoning symptoms they had during their holiday on their return to work. They should also be screened by a doctor prior to work.

3D.2.2.8 Employees with chronic pathogenic infections should not be allowed in high risk areas but should be transferred to other parts of the business.



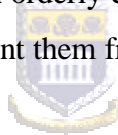
### 3E. SANITATION AND PEST CONTROL

Sanitation include plant cleanliness, personnel cleanliness, respect for the food produced and good overall appearances. This should be maintained within the food industry and should basically be a way of life. The good manufacturing practices should also include control over all pests which can be carriers of disease and this should be accomplished with a very good pest control program.

#### 3E.1 Sanitation

3E.1.1 *Sanitation program* (Mills and Pedersen 1992; SABS 2001a; Middleton *et al.* 2003; Anon. 2004; Du Toit 2004; Fisher 2004)

3E.1.1.1 Buildings, equipment, utensils and all other physical facilities of the mill shall be maintained in an orderly condition and shall be cleaned at regular intervals to prevent them from becoming a source of contamination.



3E.1.1.2 The plant grounds shall be inspected frequently as part of the overall inspection program but during particular seasons or in areas where particular products are discovered, it shall be done more regularly. Attention should be given to places where housekeeping is difficult or impossible.

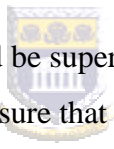
3E.1.1.3 The building exterior, roof, drainage troughs, exhaust vents and air intakes should also be inspected to achieve the overall objective to produce a quality product by excluding sources of contamination.

3E.1.1.4 Materials and equipment used for cleaning should be suitable for use in a food plant, supplied by a reputable company and should not be a source of contamination itself.

- 3E.1.1.5 An established, documented cleaning procedure for the cleaning of all food contact surfaces such as equipment, walls, floors, windows etc. should exist. Cleaning should include dry cleaning, wet cleaning, disinfection and sterilization. Cleaning in accessible areas in mills should be by dry cleaning such as vacuum systems or compressed air and in inaccessible areas by air jet.
- 3E.1.1.6 A cleaning program for each room, group of rooms, production area, walls, floors, windows, surfaces, utensils, equipment, fixtures, fittings and drains should exist. This program should state the frequency, method, contact time, temperature and strength of cleaning solutions to be used for each item of equipment. Evidence that the cleaning was adhered to such as records should exist. Where necessary, these areas should be disinfected.
- 3E.1.1.7 An area separate from the food area should be allocated, clearly labeled and marked for the storage of detergents and disinfectants.
- 3E.1.1.8 Personnel handling detergents and disinfectants which in most cases are hazardous, should be informed of the appropriate treatment in case of an accident. Safety goggles, face shields and gloves should be available and should be used as safety measurement when handling detergents and disinfectants.
- 3E.1.1.9 Avoid household chemicals as well as those from non-reputable suppliers. It is recommended that only chemicals that were approved for food industries are used.
- 3E.1.1.10 In cases where hazardous materials are mixed or dispensed, an eye-washing and shower facility should be close to the mixing or dispensing point.


- 3E.1.1.11 Brooms and brushes in the production area should preferably not be made of wood. It should have coloured nylon bristles which are easily detectable in the food source, clean, in good condition and when not in use should be hung upside down to aid the drying process. Brushes used for the cleaning of floors should not be used on equipment surfaces.
- 3E.1.1.12 Cleaning cloths and scouring pads should not be a source of contamination and it is advised that disposable or one-day cloths be used. Cleaning cloths of a woven fabric should be used only when they were disinfected or sterilized by a documented schedule. Disposable cloths should be the alternative option; it should be of a contrasting colour to the food produced.
- 3E.1.1.13 Equipment such as sampling utensils should be cleaned before use.
- 3E.1.1.14 Equipment that has been wet cleaned and especially where there is a possibility that the product can be contaminated should not be used unless it's dry.
- 3E.1.1.15 Vacuum cleaners should be emptied outside the processing areas.
- 3E.1.1.16 Cleaning of floors and equipment with water under force should not take place during production as soil might contaminate the food. Only approved and adequate cleaning agents and disinfectants should be used. Any food contact surface that have been cleaned by such products, should be rinsed thoroughly with potable water to remove any residues before it is used again.
- 3E.1.1.17 After a day's work or during a change of shift, floors, drains and walls of food handling areas should be cleaned.

- 3E.1.1.18 Change-rooms and toilets should be kept clean at all times. In fact all internal and external areas should be kept clean.
- 3E.1.1.19 Roadways and yards in the immediate vicinity should be kept clean.
- 3E.1.1.20 Colour coded equipment should be used for cleaning so that the same brushes won't be used in both the toilet and processing areas. Each department should have an inventory of all colour coded equipment or otherwise uniquely used equipment that's checked daily and damaged or broken items replaced.
- 3E.1.1.21 Contamination of food, potable water and the environment should be avoided by proper storage and disposal of waste material. Waste should be removed from the food handling areas at least once daily. In the case of hazardous waste, it should be disposed in accordance with the Hazardous Substances Act, 1973 (Act 15 of 1973). Immediately after the disposal of the waste, receptacles used for the storage of waste and any equipment that came into contact with the waste should be cleaned and disinfected.
- 3E.1.1.22 Avoid construction materials that cannot be properly cleaned and disinfected unless their use wouldn't be a source of contamination.
- 3E.1.1.23 All cleaning operatives should be trained and retrained to continually meet the required upgraded standards.
- 3E.1.1.24 The sanitation program should be carried out in a manner that does not contaminate food or packaging material during cleaning and sanitizing.
- 3E.1.1.25 Where required, operations begin only after sanitation requirements are met.


- 3E.1.1.26 Clear, legible and easy to follow cleaning procedures and schedules should be available for every department within the factory.
- 3E.1.1.27 The cleaning schedules should dictate the frequency and method of cleaning and disinfecting agents that are to be used for all plant equipment and surroundings.
- 3E.1.1.28 In cases where companies employ different ethnic groups, the cleaning procedures should also be explained in a language that is understandable to the workers.
- 3E.1.1.29 A clean as you go philosophy should be adopted throughout production to minimize the amount of food debris and soilage left for cleaning at the end of a shift.
- 3E.1.1.30  Cleaning practices should be supervised and checklists should be available for each department to ensure that every piece of equipment has been properly cleaned. The supervisor in charge should sign the checklist after inspection and only when it's been cleaned to an acceptable standard.
- 3E.1.1.31 The cleaning supervisor should also have an inventory of all cleaning equipment within the department which should be checked daily and any damaged or broken utensils replaced immediately.
- 3E.1.1.32 It's also the job of the cleaning supervisor to check the dilutions of cleaning agents and to take corrective action if it is either too weak or too strong.
- 3E.1.1.33 Physical inspection of the equipment should reveal clean, smooth surfaces.

- 3E.1.1.34 It is of utmost importance that good housekeeping procedures as well as “clean as you go” procedures are in place at all times. The whole site, buildings, perimeter, staff facilities etc. should be cleaned and tidied throughout the day.
- 3E.1.1.35 Throughout the mill it is important to be alert of any source of overhead contamination but more so in the packaging area where the system is not enclosed.
- 3E.1.1.36 Bulk flour conveyers should be cleaned and all dead stock removed at least monthly. Filters on pneumatic conveyers should also be cleaned monthly.
- 3E.1.1.37 Bulk storage bins should be cleaned on an observed need basis.
- 3E.1.1.38 Any material that may lodge in the rotor of impact machines such as string, paper etc. should be removed regularly.
- 3E.1.1.39 Packing bins should be cleaned regularly and where needed, it should be fumigated monthly.
- 3E.1.1.40 Daily cleaning of the adhesive applicators on small package lines is required. The entire unit should be cleaned on a weekly basis.
- 3E.1.1.41 Accidental spills in or on the sealing unit should be cleaned on a shift basis or immediately after the glue was spilled to prevent hard-to-clean situations.
- 3E.1.1.42 Areas where portable bulk storage units are filled, should be in an enclosed area such as the warehouse areas but should be separated from

other activities. These areas should be cleaned regularly. Daily cleaning of the floors and monthly cleaning of overhead structures is suggested.

- 3E.1.1.43 Housekeeping in bulk loading areas for trucks and railcars are just as important as within the mill. The overhead areas should be cleaned at least once monthly and the drive areas should be swept or wet cleaned on a more regular basis.
- 3E.1.1.44 In cases where the services of external cleaning contractors are rendered, they must be given clear, concise, written instructions of what should be done. Their performance should also be assessed on a regular basis.
- 3E.1.1.45 In order to facilitate the cleaning and sanitation operations, adequate preventive and corrective maintenance should be carried out on buildings, equipment and installations.
- 3E.1.2  *Cleaning chemicals, disinfectants and detergent-disinfectants* (SABS 2000; SABS 2001b; Fisher 2004)
- 3E.1.2.1 Raw materials used in the manufacturing of cleaning chemicals, disinfectants or detergent-disinfectants shall not contain potentially harmful or toxic products nor shall they form toxic or potentially harmful byproducts. Chemicals, disinfectants or detergent-disinfectants that is known to leave residues that might be harmful to human beings, shall not be used.
- 3E.1.2.2 Cleaning chemicals, disinfectants and detergent-disinfectants shall not contain perfumes and should not leave intolerable odours. The colour, flavour or odour of the product shall not be affected by it.



- 3E.1.2.3 Cleaning chemicals and detergent disinfectants shall effectively remove soils for which they are claimed to be effective, when it is used in accordance with the manufacturer's recommendations. The pH of products intended for personal use (on unbroken skin), shall be in the range of 4 to 9.
- 3E.1.2.4 Disinfectants and detergent disinfectants shall kill the organisms for which they are claimed to be effective when it is used in accordance with the manufacturer's recommendations.
- 3E.1.2.5 The cleaning chemicals used shall comply with the requirements for storage as is set out in the latest version of SABS 1828.
- 3E.1.2.6 The disinfectants and detergent disinfectants used shall comply with the requirements for storage as is set out in the latest version of SABS 1853.
- 3E.1.2.7 Cleaning agents that are  purchased in solid or powder form shall be readily soluble in water at the temperature and quality as was recommended by the manufacturer.
- 3E.1.2.8 The manufacturers of cleaning chemicals, disinfectants and detergent disinfectants should be able to provide certification by a recognized body, material safety data sheets in accordance with SABS ISO 11014-1, certificates of analysis and any other significant information.

## **3E.2 Pest Control**


3E.2.1 *Pest Control Program* (Anon. 1993; Mills and Pedersen 1992; Anon. 1994; SABS 2001a; Anon. 2004; Fisher 2004)

3E.2.1.1 To deter and destroy the infestation of pests on the premises, there should

either be trained personnel on site or the services of an approved pest control organisation should be rendered. Where an outside contractor is used, a staff member should always accompany him.

- 3E.2.1.2 Pest control companies should at least visit the site six times per year at regular intervals but where evident problems occur, daily visits should be specified till the problem is cleared.
- 3E.2.1.3 After fumigation and capture, the disposal of the pests is required to be hygienic and safe. Documented procedures are therefore needed.
- 3E.2.1.4 Pest control inspections should be recorded in the on site Report Book with the correct date of inspection.
- 3E.2.1.5 A responsible member of the management team must be made responsible to ensure that all the recommendations made in the report are acted upon with in an agreed time scale.
- 3E.2.1.6 Rodents, birds, animals and insects should be excluded as far as practicable from the milling grounds. Pest control should be scheduled regularly with records of the activities maintained.
- 3E.2.1.7 Access to pests should be prevented by keeping buildings in good repair and condition. The factory grounds should be maintained to avoid the establishment of breeding sites for micro-organisms, insects, rodents or birds. Animals should be excluded from factory grounds. The surrounding areas and establishments should be regularly examined for the evidence of infestation.
- 3E.2.1.8 An effective and continuous program for pest control of the premises and equipment shall exist. This include a pest control protocol, the name of

the person at the manufacturer assigned the responsibility for pest control, the name of the pest control company, a list of chemicals used, the concentration of the chemicals used, the location of application, the method and frequency of application used in accordance with the label instructions, a map of pest control devices and a self-inspection program. Material safety data sheets of the chemicals used should also be kept.

- 3E.2.1.9 Fixed equipment on floors should be 0.3m from the ground and 0.5m from the walls or it should be adequately sealed to prevent the build-up of soil behind or under the equipment.
- 3E.2.1.10 Air-intake points and windows that open should at least be fitted with a fly screen or removable wire mesh screens.
- 3E.2.1.11 External doors should be fitted with self closing devices or protected by an internal lobby with a self-closing door. It should also be rodent-proof.
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- 3E.2.1.12 Trained personnel should carry out a monthly inspection for evidence of the infestation by insects and rodents as well as for the presence of birds and wild and domestic animals.
- 3E.2.1.13 Raw material deliveries should be inspected for the presence of infestation in accordance with defined written procedures.
- 3E.2.1.14 If evidence of the infestation of pests is found in or around the mill, action to remove or control the infestation should be taken. Treatment with chemical, physical or biological agents should only be taken by or under strict supervision of trained personnel. Control measures should be carried out in accordance with the recommendations of the administering authority. Pesticides and pest-control agents should be registered for use

in South Africa, environmentally acceptable and should be applied in accordance with the provisions of SABS 0133.

- 3E.2.1.15 Insecticides or rodenticides with a similar appearance than the food being manufactured or that are in similar containers to those used for packaging should not be used. Before the application of pesticides food, equipment and utensils should be safeguarded against contamination. After pesticide application, contaminated equipment and utensils should be thoroughly cleaned to remove any residue before being re-used. Only when preventive measures cannot be used effectively, should approved pesticides be used.
- 3E.2.1.16 Birds should be excluded from all production and storage areas and adequate steps taken to ensure that this exclusion is enforced, subject to legal requirements for the conservation of wildlife. A recommendation is the installation of mirrors on the outside of the building to scare away birds with their own reflections.
- 3E.2.1.17 A site drawing and register of bait stations should be kept up to date. Open bait should not be used in processing areas, ingredient storage areas or packaging stores unless the bait station is suitably demarcated and there's no possibility of affecting the product. Each bait station should be adequately labeled and the bait boxes clearly date marked at each site inspection.
- 3E.2.1.18 Pest proof containers should be used for the storage of potential food sources or it should be stacked above the ground and away from walls. Inside and outside areas of the food premises should be kept clean.
- 3E.2.1.19 External bait stations should be tamper resistant and situated around the

external area of the factory site as well as clearly marked. Internal bait stations should be located on an accurate site map and held in the Report Book.

- 3E.2.1.20 Where stored product insects are considered a risk the appropriate treatment should be included in the control programme and fumigation applied as required.
- 3E.2.1.21 Domestic animals should be excluded from the premises and shouldn't be used for pest control purposes.
- 3E.2.1.22 An ideal clear perimeter zone free from rubbish, packaging materials, raw materials, pallets etc. should exist and ideally it should be fenced for security purposes.
- 3E.2.1.23 Good housekeeping standards should be maintained in order to control pest infestation. I.e. controlling the accumulation of food and packaging debris; keeping passages clean and clear; removing redundant equipment; ensure good stock rotation; keeping the exterior of the facility in good condition and proper waste disposal procedures.
- 3E.2.1.24 If pest infestation is found on incoming materials, it should be isolated from the factory, the pest control contractor called immediately and the infestation treated before it spreads.
- 3E.2.1.25 Pest control documentation should be kept up to date, clear, concise, legible and regularly reviewed by the technical department.
- 3E.2.1.26 Data sheets relating to the safety and application of approved baits and pesticides should be available. Information regarding the control of hazardous substances to health should also be readily accessible.

- 3E.2.1.27 All documentation detailing the safe use and application of pesticides requires the signature or identification of the checker to ensure accountability.
- 3E.2.1.28 If a logical Code of Practice for pest control is adhered to, then freedom from pests should be evident on site. This should be further clarified in the pest prevention record book.
- 3E.2.1.29 If evidence of pest infestation is available then the action taken to free the site from the problem should be thoroughly documented and dated, until the infestation is removed.
- 3E.2.1.30 Physical methods for pest control could include the use of: pheromones and food attractants in bait traps; forced aeration; heat; moisture manipulation; impact machines and abrasion equipment (scourers); rodent traps; magnets; metal detectors; equipment design and construction; keeping the building rodent proof and the doors closed.
- 3E.2.1.31 Chemical methods include the use of: pesticides; insecticides; fumigants; rodenticides; avicides etc.
- 3E.2.1.32 Rubber gloves, protective outer garments and respirators should be used when handling or applying chemical forms of pest control.
- 3E.2.1.33 Phosphine producing fumigants in tablet or pellet form are usually used for fumigation of wheat during storage. Adequate concentrations of the fumigant, sufficient contact time and tight enclosure is needed for successful fumigation.
- 3E.2.1.34 In cases where electrocution devices are used, they should be located in areas where it cannot be a source of contamination to the product, it

should have effective catch pans to retain the insects collected, located away from entrances. The insect traps should be cleaned on a weekly basis, the bulbs replaced at least annually and the results recorded.

3E.2.1.35 Insecticides and poisons used in the mill, should be approved by regulatory authorities for usage by the food industry, it should be properly identified, controlled and used according to instructions.

3E.2.2 *Pesticides and Pesticide storage* (Anon. 1972; Mills and Pedersen 1992; SABS 2001a; Anon. 2004; Fisher 2004)

3E.2.2.1 Hazardous substances, chemicals, cleaning chemicals or pesticides should be suitably labeled with directions for use and a warning about their toxicity. It shall be stored in a dry, adequately ventilated area where no possibility for cross contamination can occur of the food or food contact surfaces. This area shall be equipped with power ventilated exhausting to the outside and never cross ventilate with food processing or food container storage areas. It should be stored in a locked room or cabinet for that purpose only and should only be dispensed and handled by authorized and properly trained personnel or under strict supervision of trained personnel. Whenever chemicals should be mixed, it should be done in clean correctly labeled containers. No old food containers should be used for this purpose.

3E.2.2.2 Pesticide storage areas should be totally enclosed by walls and the door locked to prevent unauthorized entry. If wire fence forms any of the walls, it should extend to the ceiling.

3E.2.2.3 Special warning signs should be placed on the entrance to warn the user of the contents of the storage area.

- 3E.2.2.4 Pesticides should be stored off the floor on pallets, racks or shelves with catch or drip pans underneath.
- 3E.2.2.5 Pesticide containers should be stored with the label clearly visible. In the case where a label is damaged, it should be replaced with a sample label from the supplier.
- 3E.2.2.6 A continuous inventory of pesticides should be kept and regular inspections should check the accuracy of the inventory as well as the condition of the storage containers and overall facility.
- 3E.2.2.7 A “first in first out” schedule of use should be followed for all cleaning agents, pesticides, packaging material etc.
- 3E.2.2.8 Pesticides that are cancelled, not in use or suspended should be so labeled and disposed of according to specified guidelines.
- 3E.2.2.9 Highly toxic pesticides such as certain fumigants or rodenticides should be kept under separate security and should be approved for targeted pests.
- 3E.2.2.10 Pesticide application equipment may be stored and secured in the pesticide storage area.
- 3E.2.2.11 For the maximum limits for pesticides residues that may be present on wheat, refer to the updated Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act No. 54 of 1972).



## **3F. RECALL**

Recall refers to the actions taken to remove or correct a product by the supplier of the product in order to protect the end user from an identified hazard that could be harmful to the consumer. A good recall system should be in place to ensure proper traceability of the product.

### **3F.1 Recall System**

#### *3F.1.1 Recall Program* (Anon. 2004; Fisher 2004)

3F.1.1.1 An effective Health and Safety recall program should exist which will include tracking, analysis, actions taken as well as the records of product complaints; the responsible person (s), the roles and responsibilities of coordination and implementation of a recall; methods to identify, locate and control the recalled product; a requirement to investigate other products produced that might be affected and that should be included in the recall; a procedure for monitoring the effectiveness of the recall; procedures to verify the capability of the program to rapidly identify and control a code lot of potentially affected product and reconcile the amount of product produced, in inventory and in distribution. A mock recall should take place at least annually.

3F.1.1.2 The local Health Department should be notified immediately in the case of a recall and information such as: the amount of product produced, in inventory and distributed; the name, size, code or lot number of food recalled; the area of the distribution of the product and the reason for the recall, should be available.

3F.1.1.3 The operator and supervisor should be traceable and such records should be available.

- 3F.1.1.4 Sufficient documentation should exist so that in case of a recall, the finished product can be linked to the raw materials used as well as to the corresponding laboratory records.
- 3F.1.1.5 If a person other than the quality assurance manager has been allocated the responsibility to deal with all product complaints, that person should have sufficient product knowledge, experience and authority to implement the appropriate corrective action.
- 3F.1.1.6 All quality complaints should be recorded when received, investigated within a certain time period according to its urgency and a corrective action report prepared for company records.
- 3F.1.1.7 Corrective action includes responding to the complainant and local enforcement authority involved. Copies of these letters should be kept on file and procedures should be implemented to remove the cause of grievance and avoid its reappearance.
- 3F.1.1.8 Complaints reports should be used to observe trends and should be reviewed frequently. This could be an indication of a potential product recall or specific problem.
- 3F.1.1.9 A designated authorized person should organize the activities of the recall team under complete confidentiality. That person should be the link with the competent authority. If the media becomes involved, the company must have such a designated spokesperson.
- 3F.1.1.10 The recall procedure should be workable and effective within a reasonable time frame but must be reviewed regularly in the event of changing circumstances.

- 3F.1.1.11 The recall procedure should include the exact method of notifying all distribution networks and retailers involved as well as the contact names' details. The procedure should be able to stop the transit of products at any stage in the distribution chain.
- 3F.1.1.12 Full product details, the batch code, the nature of the defect, the action required and the degree of risk concerned should be given in the announcement of a recall.
- 3F.1.1.13 Records of equipment that could have an effect on the quality of a product, should be available when required.
- 3F.1.1.14 Reference samples of flour should be kept for at least a year after the shelf-life or the re-evaluation date or for one year after distribution is completed, whichever one is longer. The sample size should be double the amount required for the specified testing and should be identified with product name, lot number and sampling date.
- 3F.1.2 *Product code identification and Distribution details* (Anon. 2004; Fisher 2004)
- 3F.1.2.1 Each pre-packaged food should have lasting, understandable code marks or lot numbers on the packages. The code has to identify the organization, the day, month and year of produce. Code marks and the exact meaning of the code should be available. Where applicable, case codes should be legible and represent the container within. Classification of a product must declare the name, shelf life, lot number, warning (where applicable), storage instructions and distributor.
- 3F.1.2.2 For each lot of product produced, the producer should have records of customer names, addresses and telephone numbers as well as records of

production, inventory and distribution. The records should be accessible, organized and filed for at least 2 years after the shelf life of the product or in accordance with legislation.

3F.1.2.3 Finished products should be sealed. Labeled with information of its shelf life and protected against moisture. Only knotting or thermal sealing are allowed unless the customer require otherwise. Packaging should protect the product during its expected life under normal conditions.

3F.1.2.4 Implement efficient measures to safeguard against suspect, returned or damaged finished product being accidentally released.



### 3G. QUALITY ASSURANCE

Quality is an important factor when purchasing a product therefore it is important that quality should be defined within a company by developing predefined standards. “Quality assurance means to give to the customer the warranty that the company works on the basis of these requirements” (Scipioni *et al.* 2002) Customers will buy a specific product because of its quality but if they are not satisfied with the product they could have drastic actions taken against the manufacturer. The power of the media and product liability lawsuits could lead to major economic losses. In order to avoid situations like this that could affect the whole company, the quality of the product should be assured at all times.

#### 3G.1 Quality Control


3G.1.1 *Quality Function* (Anon. 2004; Fisher 2004)

3G.1.1.1 The company should have a quality assurance and monitoring structure to guarantee consistent production of safe, legal product which complies with the agreed specifications.

3G.1.1.2 The quality assurance team should consist of sufficient properly trained personnel with clearly defined responsibilities that can maintain the agreed quality standards.

3G.1.1.3 Whenever production is in progress, the quality assurance team should be productive.

3G.1.1.4 The quality function should be included in all activities and decisions regarding product quality and shouldn't be limited to laboratory operations only.

- 3G.1.1.5 The quality function should be independent of production and purchasing functions and should have the responsibility and authority to approve or reject all components in process, packaging materials and finished product.
- 3G.1.1.6 Resources such as offices, laboratories and other designated areas within the factory should be available for the quality assurance team to fulfill its tasks effectively.
- 3G.1.1.7 The responsibility and authority for the management and final approval of process changes, specifications and assays for raw materials, intermediate product and packaging materials, specifications and assays for process control purposes, sampling procedures, instructions regarding hygienic and sanitation practices, processes for reprocessing of rejected materials and the investigation of failures and complaints lies within the quality function.
- 
- 3G.1.1.8 Accept/reject criteria, method of testing, sampling techniques, safety precautions and characteristics to be inspected should be included in the inspection instructions. The quality assurance department should be authorised to accept or reject raw materials, packaging materials, work in progress and finished product against an agreed specification.
- 3G.1.1.9 The product may not be released for sale until all the final inspection and testing is completed, confirming that the product is sound for consumption.
- 3G.1.1.10 A strict policy with regard to quarantined stock should exist to state whether the product should be reworked or disposed.
- 3G.1.1.11 A quality assurance manual with details of the type and frequency of

checks carried out, as well as the documentation records to be filed, is essential.

- 3G.1.1.12 The results of tests, together with any corrective action taken in response to adverse results should be documented and kept for at least a year or longer depending on the shelf life of the product.
- 3G.1.1.13 Quality assurance systems have to consider all the relevant legislation and good manufacturing practices.
- 3G.1.1.14 The quality assurance department should also have the power to stop production in cases where good manufacturing practice was not exercised or where the product is at risk.
- 3G.1.1.15 The reasons for stopping production should then be explained by the quality assurance department and proper corrective action taken prior to restarting the line.
- 3G.1.1.16 A signed, dated agreement between manufacturer and customer should exist and all products manufactured on site should conform to this written specification.
- 3G.1.1.17 No alteration to the product specification should be allowed without the consent of the customer. Amendments made after consultations should be signed, dated and recorded.
- 3G.1.1.18 All manufactured products should be according to written specifications. Non-conforming raw materials or finished products should be clearly identified and dealt with accordingly.

3G.1.1.19 Reports of all the processes required to ensure the safety of the food should be inspected by an experienced and appropriate individual at least a daily. The records should be signed off to demonstrate that the process has been carried out under required conditions.

3G.1.2 *Inspection and Testing* (SABS 2001a; Anon. 2004; Fisher 2004; Vorster 2004)

3G.1.2.1 Incoming wheat shall be graded according to its moisture content, cultivar, odours, taste and colour as well as the presence of the following factors that could affect food safety: toxins, chemicals, noxious seeds, *ergot sclerotia* and moulds. Wheat with more than 0.02% *Ergot Sclerotia* are classified as contaminated according to Act No. 54 of 1972. Wheat is graded into 4 classes: Class bread wheat, class biscuit wheat, class durum wheat and class other wheat.



The latest revised version of the Bread wheat grading table can be obtained from the following website:

[www.nda.agric.za/docs/Plantquality/default.htm](http://www.nda.agric.za/docs/Plantquality/default.htm)

Click on the following links: Local and import regulations, Agronomy, wheat, latest revised version. The wheat grading table would be attached as an annexure to the latest regulation from the Department of Agriculture relating to the grading, packing and marking of wheat intended for sale in the RSA.

3G.1.2.2 Microbiological testing will depend on the nature of the product to be tested for example the shelf life, composition and degree of risk.

3G.1.2.3 Laboratory facilities on site should implement good laboratory practices, should have adequate space and should also have the appropriate equipment required for tests to be done.



- 3G.1.2.4 Laboratory personnel should be competently trained in order to take the analysis, interpret the results and deal with problems as they arise. Standards for microbial limits should be defined.
- 3G.1.2.5 Access to laboratory areas should be restricted to authorized personnel only.
- 3G.1.2.6 Protective clothing such as laboratory coats worn in microbiological laboratories shouldn't be used in production areas.
- 3G.1.2.7 Laboratory waste should be stored in accordance with existing legislation.
- 3G.1.2.8 Stringent precautions should be taken while sampling to avoid contamination which could result in inaccurate test results.
- 3G.1.2.9 The microbiological laboratory and quality assurance department should communicate on a daily basis through designated staff to ensure that corrective action is taken in response of specification results.
- 3G.1.2.10 A sample which previously gave a non-conforming test result and that were retested cannot be released based on the re-test results only. This would only be appropriate if it can be proved that the original test result was invalid based on a documented investigation. Statistical treatment of both the original and re-test data could then be used to release the lot.
- 3G.1.2.11 Finish product testing should conform to written specification.
- 3G.1.2.12 All laboratory methods should be written up including an assessment of the hazards of each chemical used and all test methods should be readily available to analysts. Test methods should be followed as written and without modification.

- 3G.1.2.13 All laboratory equipment should be clean, well maintained, serviced and calibrated regularly to ensure functionality and accuracy. Maintenance reports should be kept for laboratory equipment. All calibrated instruments should be labeled with the date and next date of calibration.
- 3G.1.2.14 All reagents and microbiological media should be controlled and monitored to assure that they are periodically replaced and that old reagents are not used.
- 3G.1.2.15 Positive and negative controls is of utmost importance in microbiological testing to avoid false positives.
- 3G.1.2.16 All results should be recorded at all times.
- 3G.1.2.17 In cases where outside laboratories are used for the testing of samples, the premises should be audited prior to commencement of the contract.
- 3G.1.2.18 All expired or spoiled product should be rejected.
- 3G.1.2.19 The raw materials, in-process materials and the finished product should be tested by an accredited laboratory.
- 3G.1.2.20 Environmental and microbiological analyses of these samples should be carried out by the manufacturer.
- 3G.1.2.21 The required levels of fortificant mix that flour should contain is 200g per ton of flour (0.02%) and in order to make sure that these levels are maintained, ring tests should be done on a regular basis for each batch produced.

### **3H. MANAGEMENT**

One of the most important factors of a successful HACCP system is the competency of the people who developed and operated it (Mortimore 2001). The people mentioned here do not only refer to those personnel that work directly with the product produced but also to senior management that plays a very important role in preparation and planning of such an extensive project. Commitment and visibility from their side could add to the success of the project therefore the roles of management should be defined within a company.

#### **3H.1 Management Control**

3H.1.1 *Interest from Senior Management Level* (SABS 2001a; Fisher 2004)

3H.1.1.1 It is management's responsibility to define and document a company's food safety and hygiene policy and these policies should be positioned at strategic points throughout the factory. Management should make sure that the policies are understood, implemented and maintained at all levels within the organisation. Only authorised people with the responsibility for implementing the policy should sign the statement.

3H.1.1.2 It is also important that the manufacturer establish the chemical, functional, microbiological and organoleptic specifications for the finished product.

3H.1.1.3 Senior management should be fully committed to the company's quality philosophy and the main board of directors should contribute to the quality management system through their own job description or responsibility.

3H.1.1.4 Managers should be involved in the production environment by taking regular factory tours, by communication with "on-line" operatives,

by having discussion/review meetings with senior managers and by motivation of staff by encouragement and reward.

3H.1.1.5 Senior Management should at all times be fully trained and aware of food hygiene and good manufacturing practices.

3H.1.2 *Communication to production level* (Fisher 2004)

3H.1.2.1 All levels of management should be present in regular meetings on a daily or weekly basis, dependent on the size and nature of the company. Discussion points to include in such meetings should be: the previous day's production target; in line problems and equipment faults; number of complaints received; rejected raw materials; damaged or returned goods; product development program, pre-production trials and a summary of non-conformances. By discussing these areas, all levels of management will be fully aware of the company's activities and progress and will be able to distribute this information to their departments.

3H.1.2.2 Communication to production level is essential to ensure consistent quality of the products as well as to involve on line operatives in taking corrective actions.

3H.1.2.3 This two way communication should give evidence that there is sufficient properly trained production staff to ensure that all quality criteria are met.

3H.1.3 *Internal audits* (Anon. 2004; Fisher 2004)

3H.1.3.1 Internal auditing should take place to identify strengths and weaknesses in the operating system and to shed light on proper corrective actions.

3H.1.3.2 To ensure objective auditing, managers should not be allowed to audit

their own departments.

3H.1.3.3 All managers should be responsible for an ongoing audit and review of the production process to ensure safe and legal production of products of an agreed specification.

3H.1.3.4 The attitude and response to all types of audits should be enthusiastic, dedicated and positive. Corrective actions should be completed within the agreed time scales.

3H.1.3.5 Internal audits should be carried out at least on a six month basis and an action plan for resolution should be agreed on by the site manager.

3H.1.3.6 The internal assessments should be verified annually by a suitably qualified employee.

3H.1.4 *Hygiene management* (SABS 2001a; Fisher 2004)



3H.1.4.1 To implement and maintain the food hygiene management system, a suitable, qualified and experienced hygiene officer should be appointed. Written policies and procedures for hygiene and good manufacturing practices should be compiled by a qualified person and kept in a hygiene manual. The hygiene policy should be understood, implemented and maintained at all levels of the organization.

3H.1.4.2 To ensure the safety of the food produced, the policy statement should contain commitment to maintain the hygiene level at least in accordance with the standards set out in SABS 049.

- 3H.1.4.3 It is recommended that the hygiene management should be responsible to the Quality Management Team, who in turn should be entirely liable for the hygiene standards of the equipment and factory premises.
- 3H.1.4.4 Hygiene management should be a controlled, organised system, effectively completing a daily program of duties which have been prioritized in liaison with the Quality Management Department.
- 3H.1.4.5 Managers specifically responsible for areas such as hygiene should be adequately trained and qualified. They should report directly to a senior manager and should possess a degree of organizational, people management and time management skills.
- 3H.1.4.6 A hygiene team should be available to cover all departments on a split shift or single shift basis.
- 3H.1.4.7 The team should be appropriately trained in the use of cleaning chemicals, dispensing equipment, cleaning schedules and safety precautions.
- 3H.1.4.8 All hygiene staff should have undertaken basic hygiene training that match the level of their responsibility.
- 3H.1.4.9 Management at all levels should be dedicated to producing safe, legal products of the specified quality. To achieve this, specialist expertise should be available in all departments to achieve this.
- 3H.1.4.10 Departmental managers' responsibilities with regard to hygiene and quality should be defined and understood. Their commitment to Good Manufacturing Principles should never be in doubt and they should be able to demonstrate and communicate them to their staff.

- 3H.1.4.11 It is also highly recommended that key management and managerial positions should have designated deputies to cover for absence and to ensure that the standards are maintained.
- 3H.1.4.12 Revision of the hygiene system should take place at least on an annual basis or on a more frequent basis to correct shortcomings due to poor hygiene implementation or by changes in legislation. Records should be kept.
- 3H.1.5 *Reports and Corrective procedures* (Fisher 2004)
- 3H.1.5.1 All reports issued, should include a program of corrective action within an agreed time frame.
- 3H.1.5.2 Named managers should be listed and lead times given in the corrective action program.
- 3H.1.5.3 A specific manager should be designated the task of checking that corrective actions have been completed on time by appropriate personnel.
- 3H.1.5.4 The HACCP system should be reviewed at planned intervals by senior management to ensure its continued suitability, adequacy and efficiency in order to improve continually. Records of management reviews shall be maintained at all times.
- 3H.1.6 *Clear definition of responsibility* (Fisher 2004)
- 3H.1.6.1 A major responsibility of managers is to ensure compliance with all appropriate legislation.

- 3H.1.6.2 Personnel at all levels should have a job description explaining their duties and responsibilities. A more detailed job description is needed at management level which includes their specific tasks, reporting procedures and any specific safety requirements.
- 3H.1.6.3 Persons allocated responsible positions should have sufficient authority to discharge their responsibilities effectively.
- 3H.1.6.4 The production and quality assurance managers should be two different people who shouldn't be responsible to each other but to their direct senior. They must join forces to achieve the agreed quality specification.
- 3H.1.6.5 Management should be committed to implement as well as participate in the improvement of the HACCP system. The HACCP system should also be reviewed frequently for its efficacy, appropriateness and continued sufficiency. Management is also responsible for the communication and understanding of the HACCP system within the organisation.
- 3H.1.6.6 A representative from management shall be responsible to establish a clear route for communication throughout the organisation as well as to establish a forum for resolving conflict.

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## CHAPTER 4

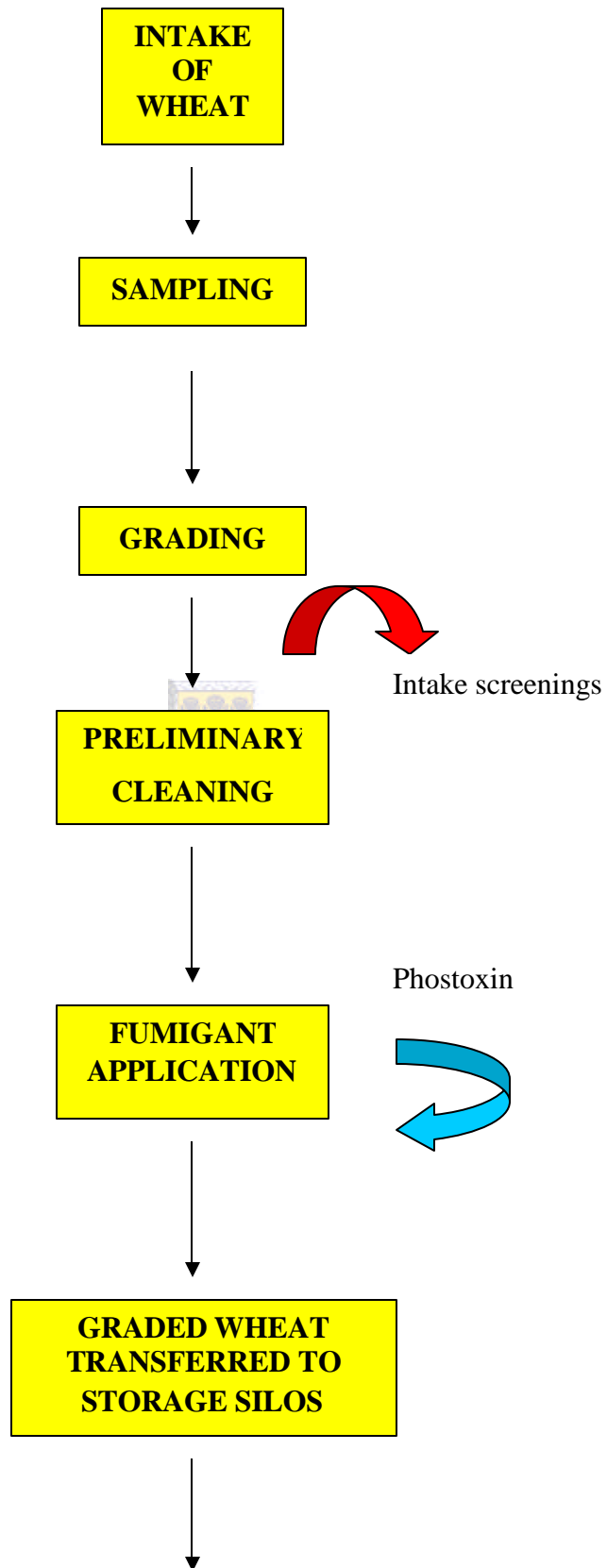
### FLOW DIAGRAMS

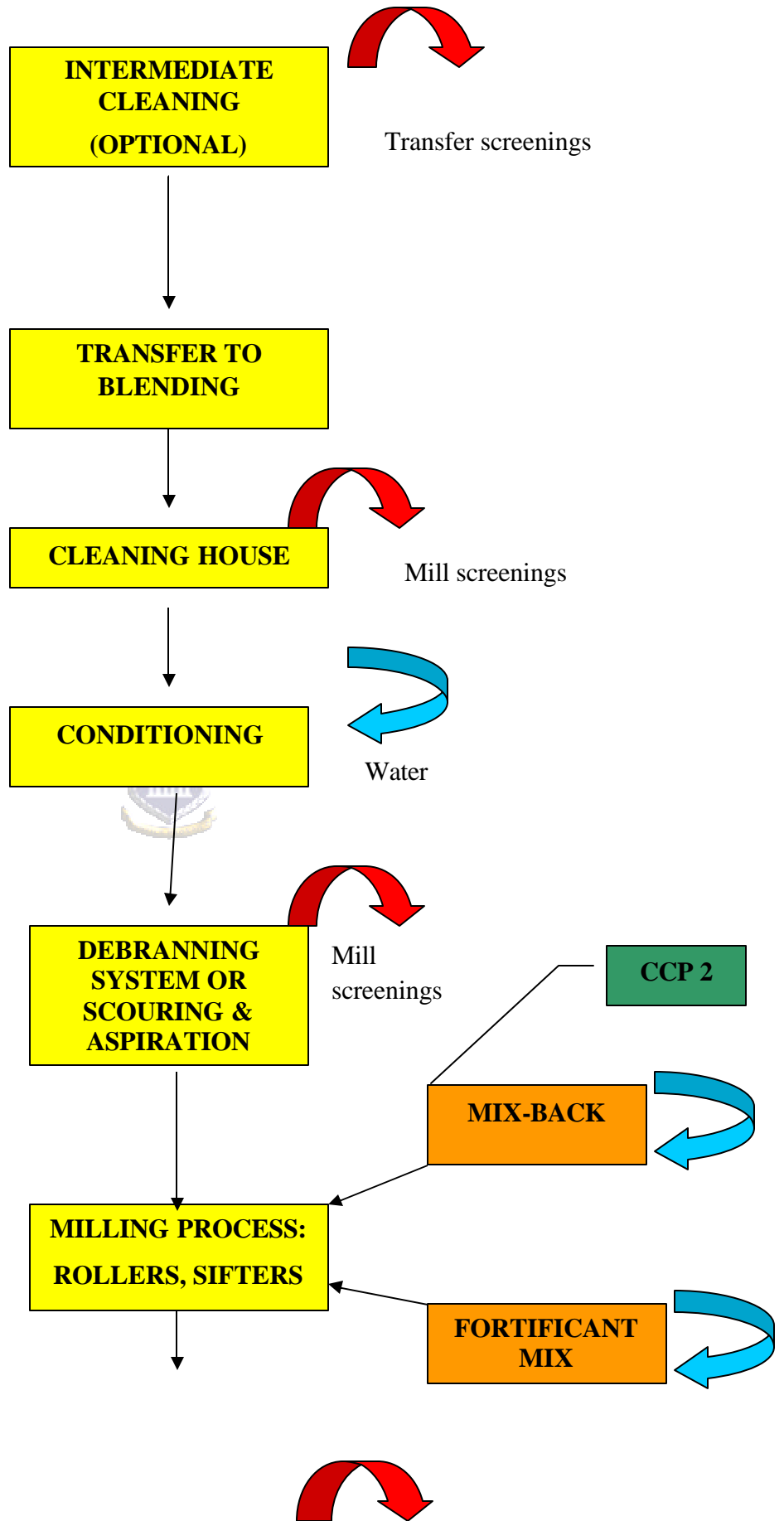
#### 4.1 INTRODUCTION

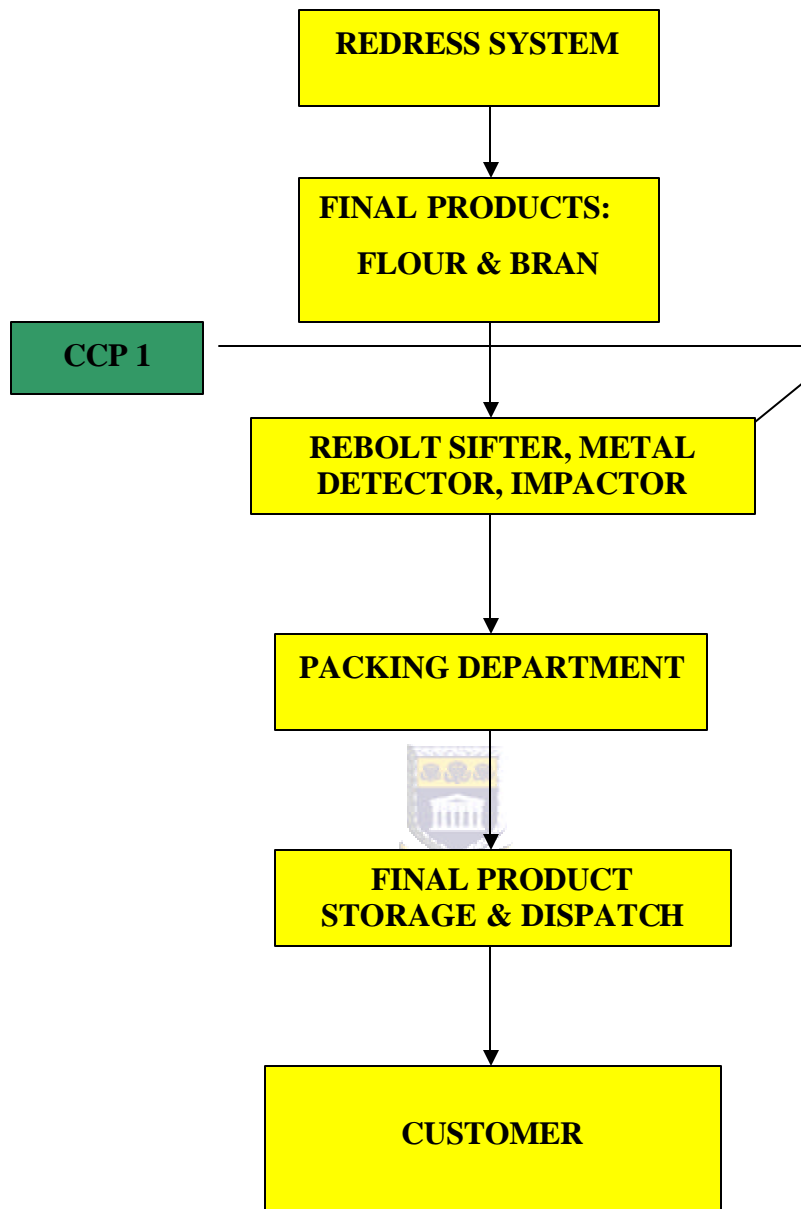
Step 4 in the 12-step procedure for the roll-out of a HACCP plan states that a product flow diagram should be constructed (NACMCF 1998; SABS 1999; Forsythe 2002). This flow diagram should be unique for each food handling enterprise and should have the critical control points indicated on it. It is also important that this process flow diagram should be verified on site during all hours of operation in order to make sure that it is complete. A box-type flow diagram is sufficient (Figure 4.1) but a more detailed process flow diagram is included (Figure 4.2).



A floor plan should also be constructed by the HACCP team. It should indicate all entrances, exits and walkways. The floor plan should be unique for each mill which is also the reason why an example is not included in this generic model.







**Fig. 4.1** Block-type flow diagram of the wheat milling process.

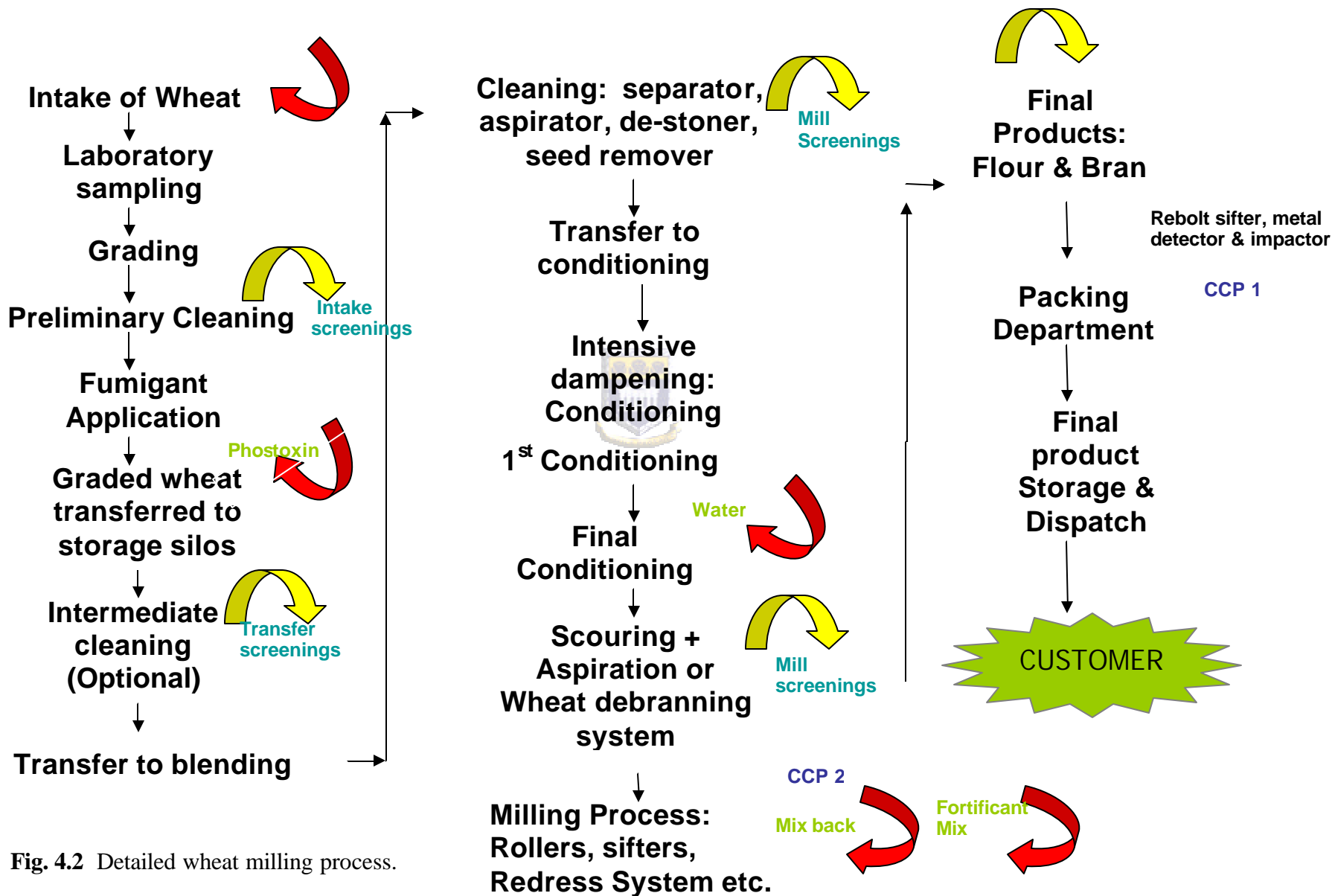
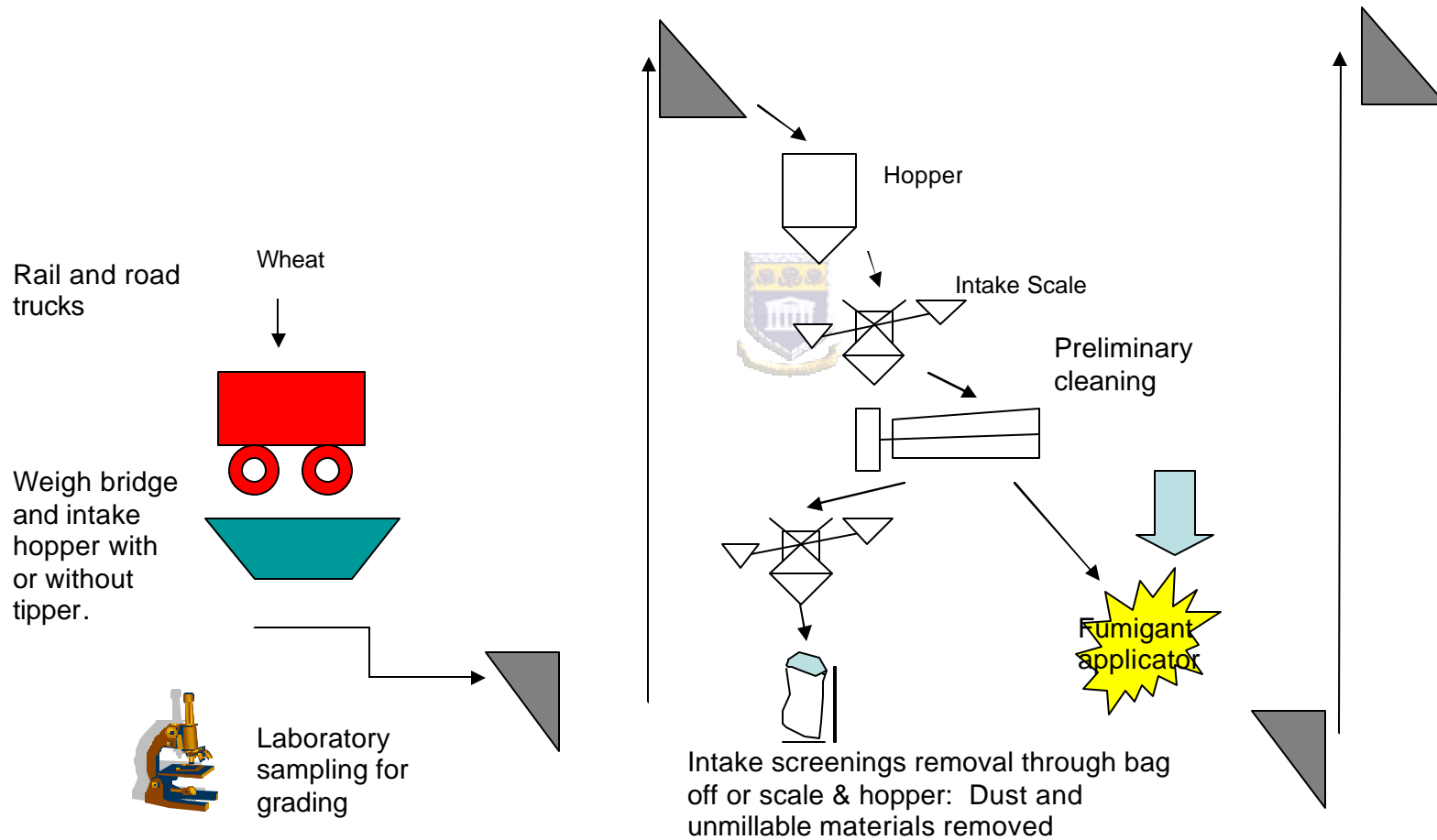


Fig. 4.2 Detailed wheat milling process.



# Intake of wheat and grading



**Fig. 4.2 (a)** Intake of wheat and grading process.

# Transfer to blending

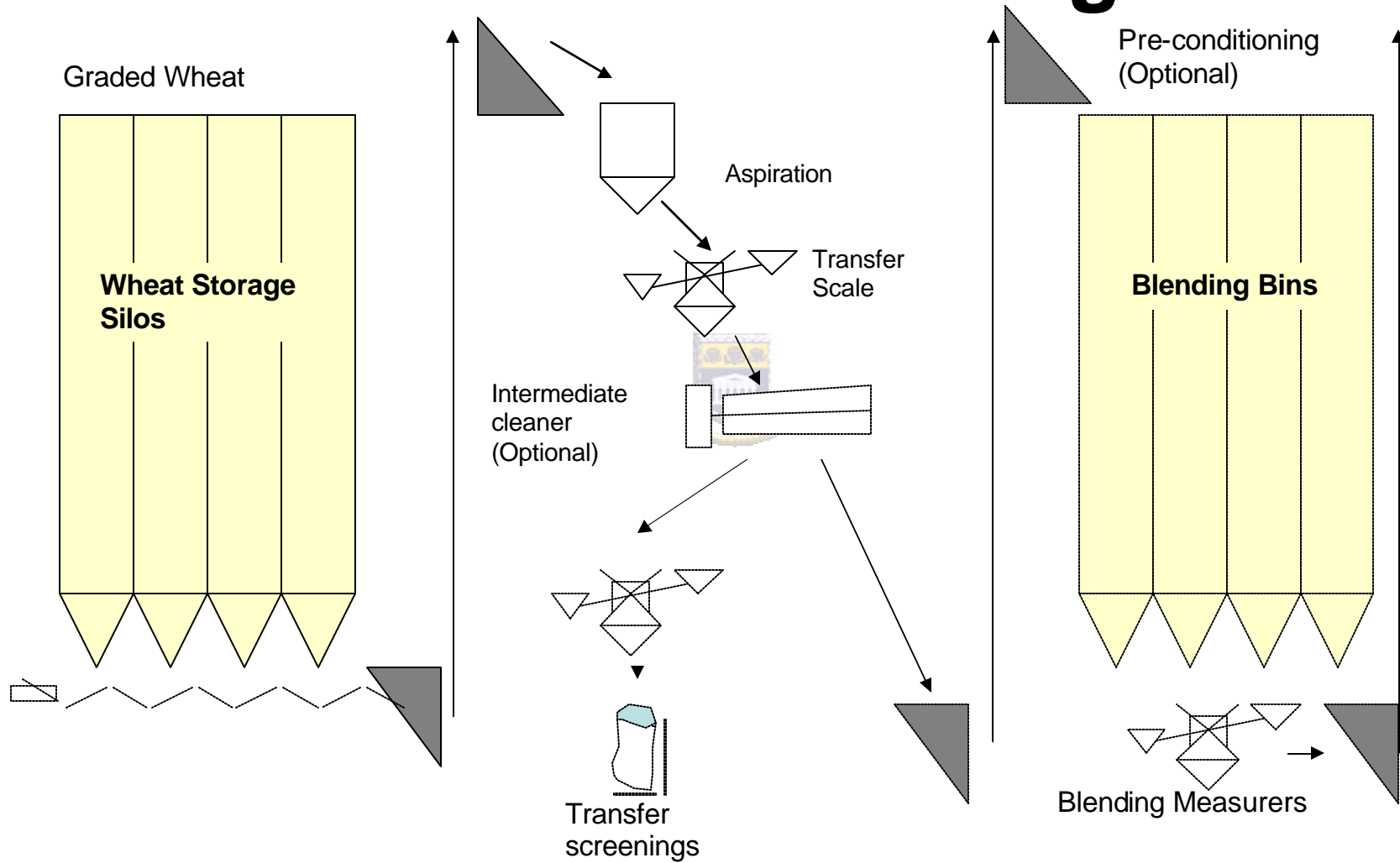


Fig. 4.2 (b) Transfer to blending.

# Wheat cleaning and conditioning

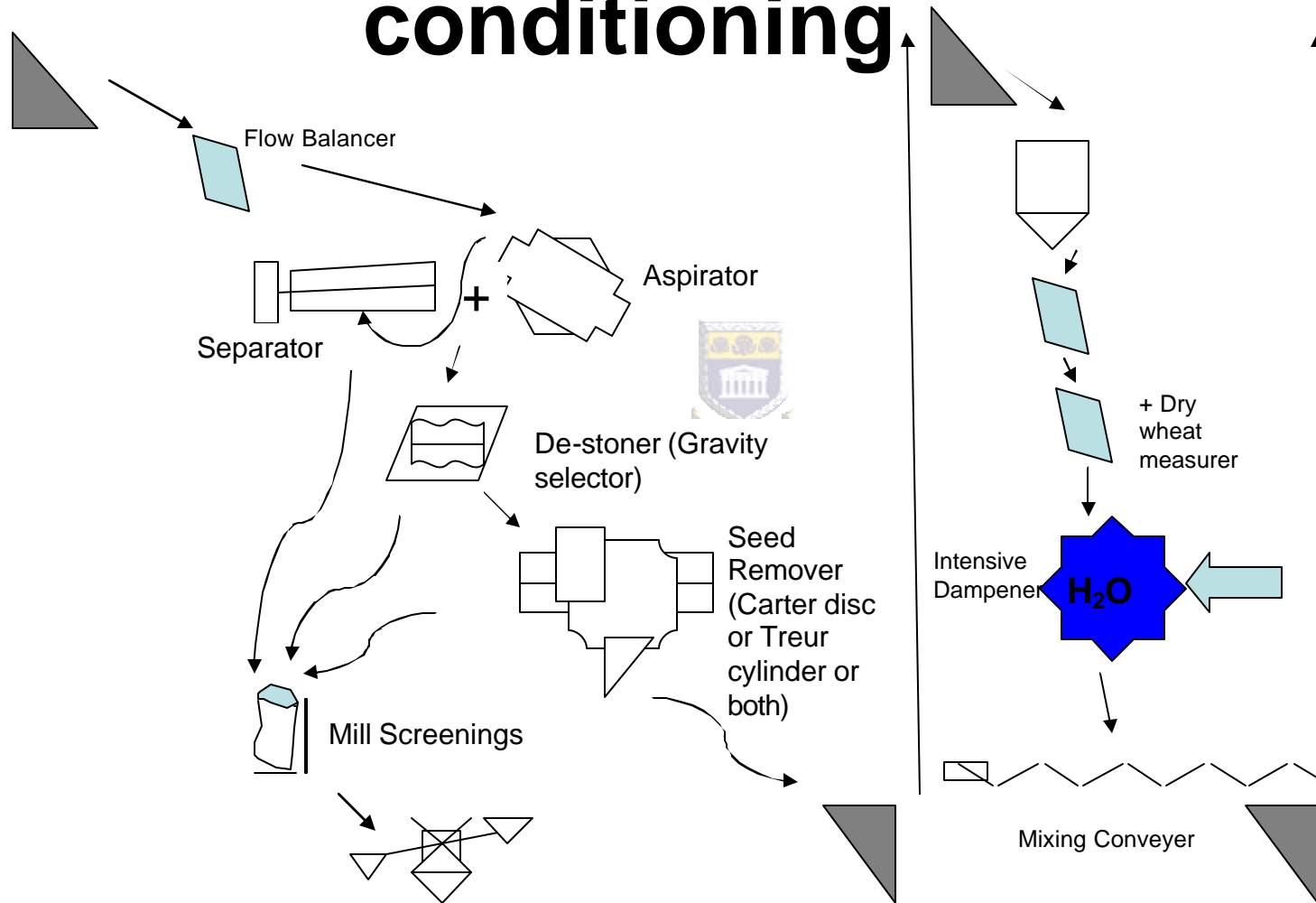


Fig. 4.2 (c) Wheat cleaning and conditioning.

# Conditioning

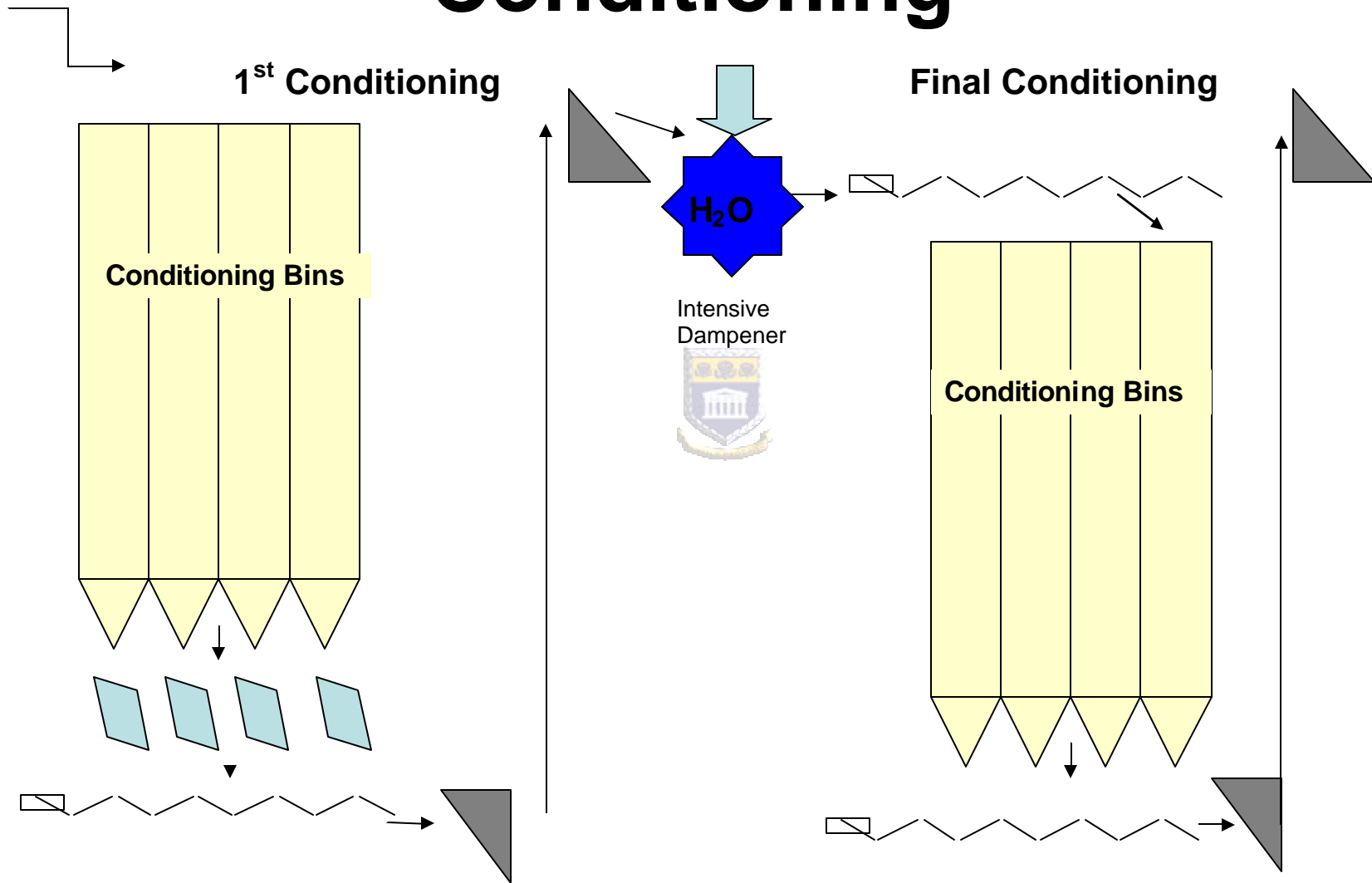


Fig. 4.2 (d) Conditioning.

# Milling Process

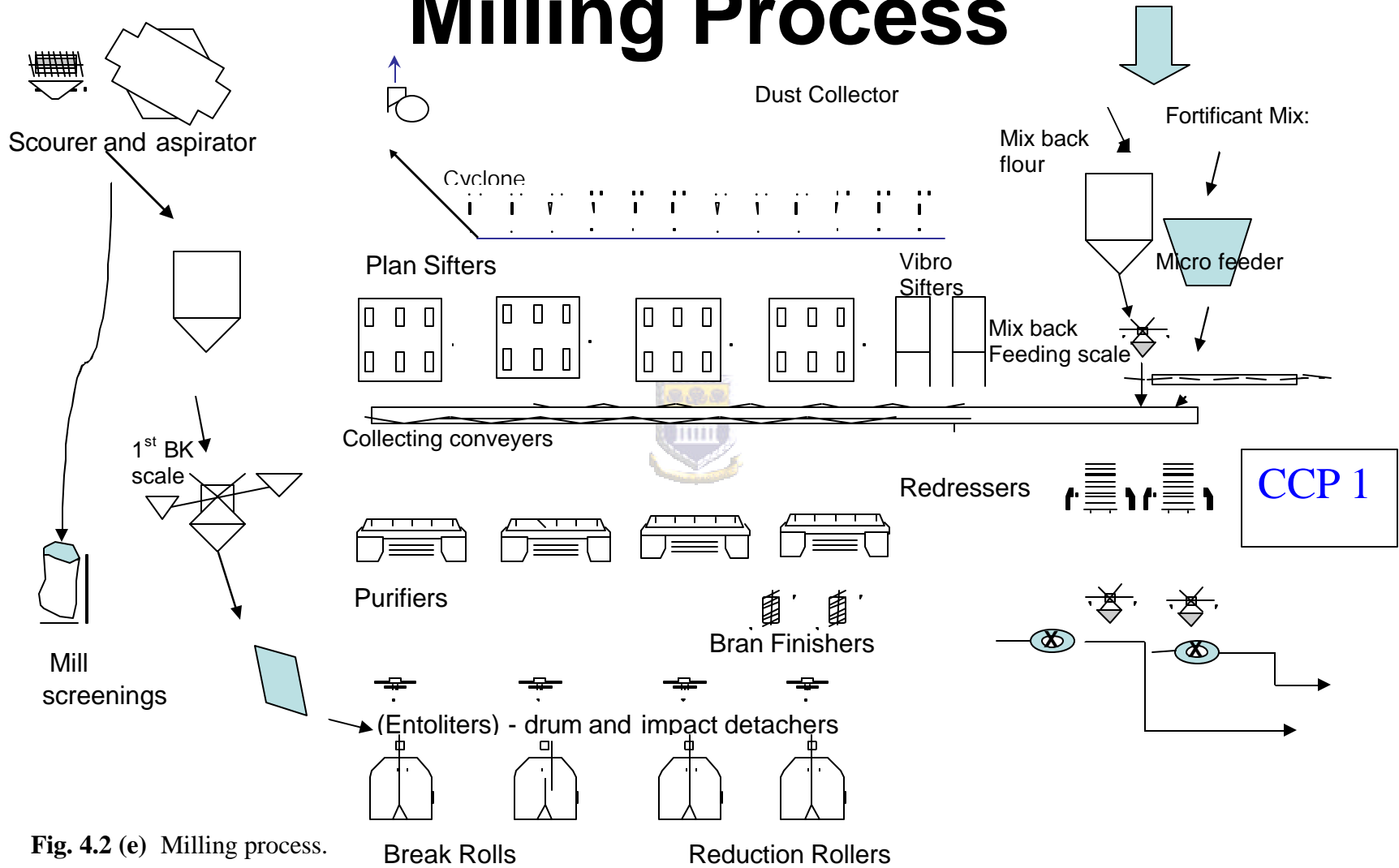


Fig. 4.2 (e) Milling process.

# Flour Blending

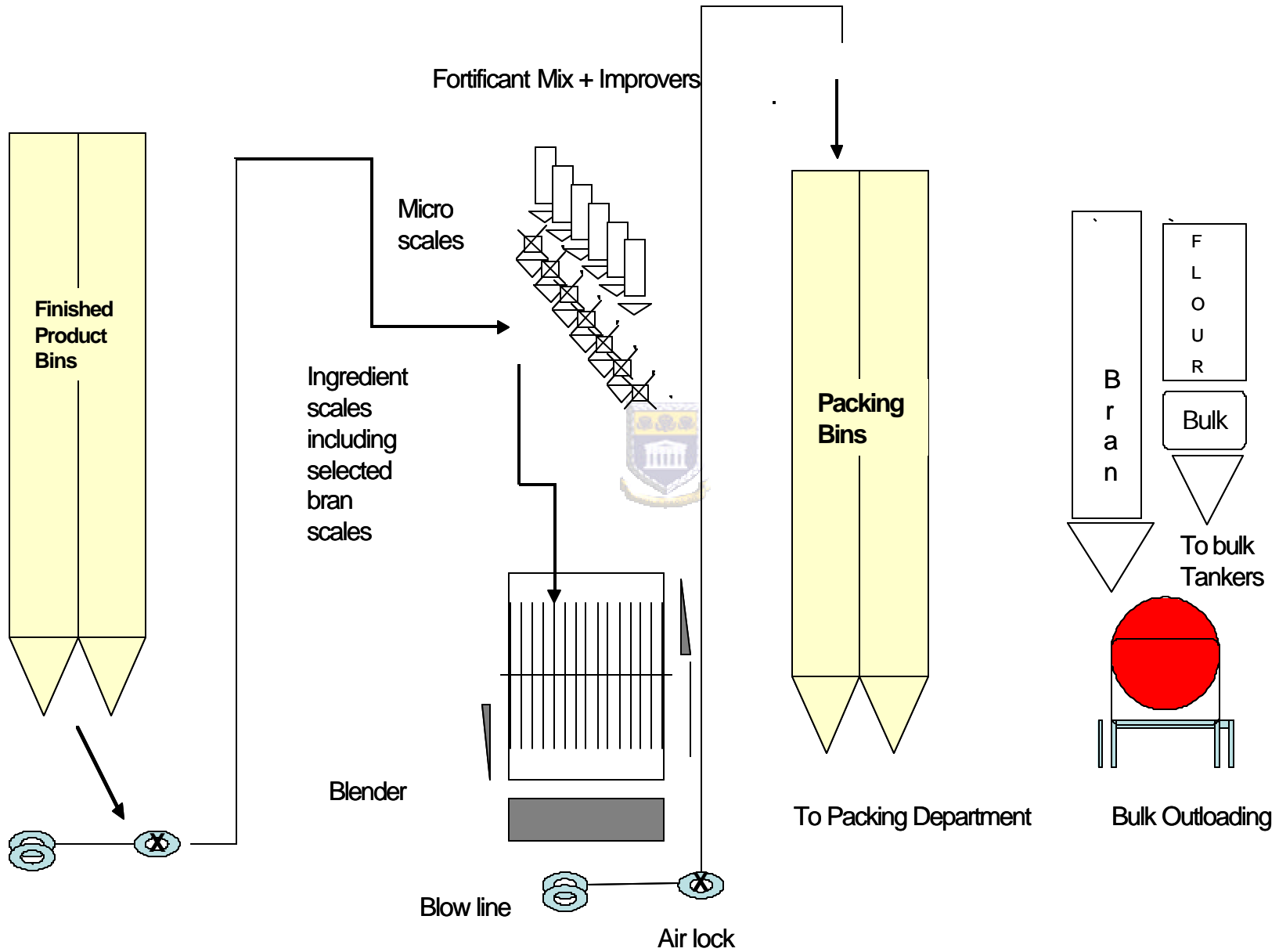


Fig. 4.2 (f) Final product (flour).

# Packing

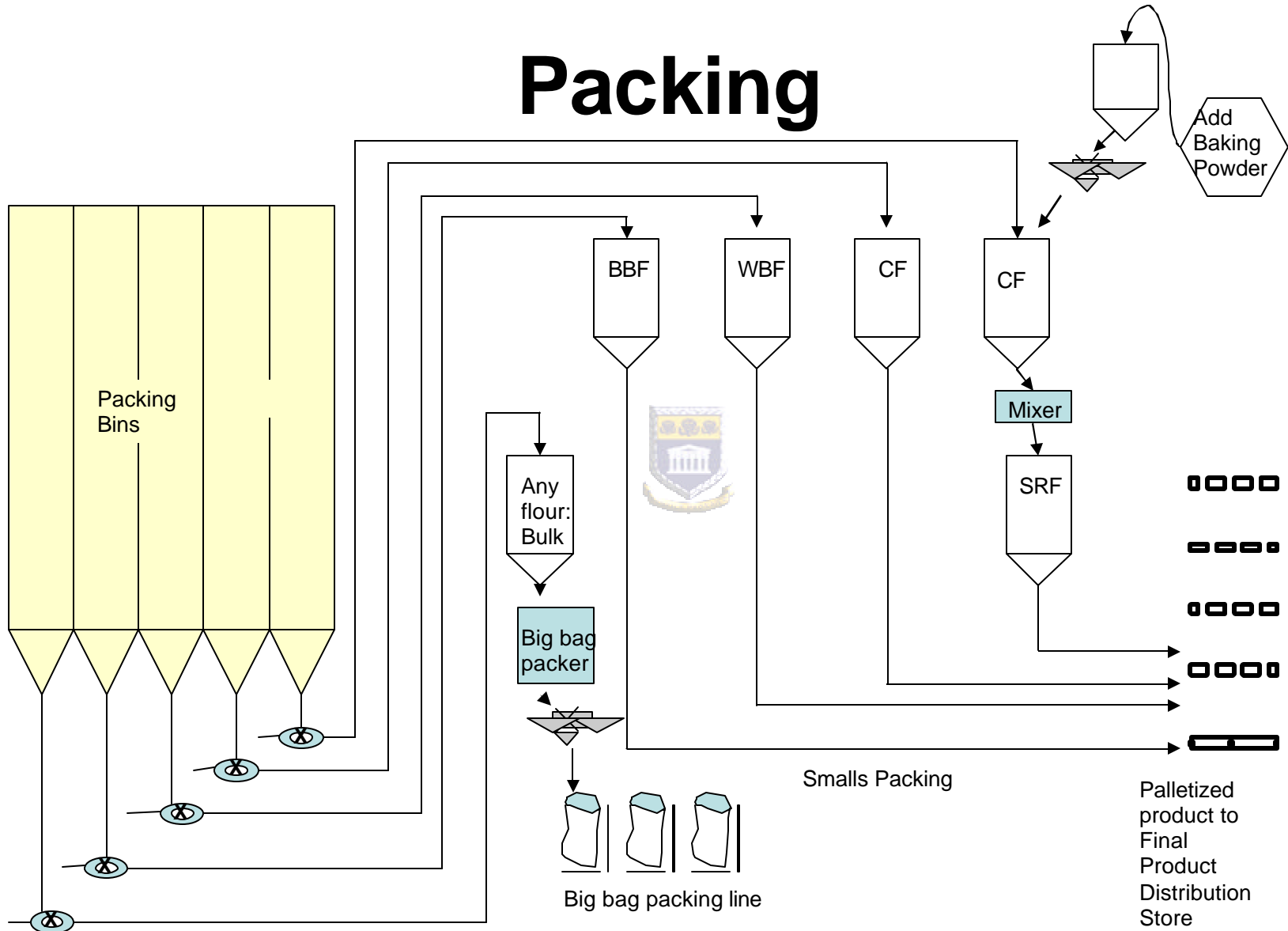
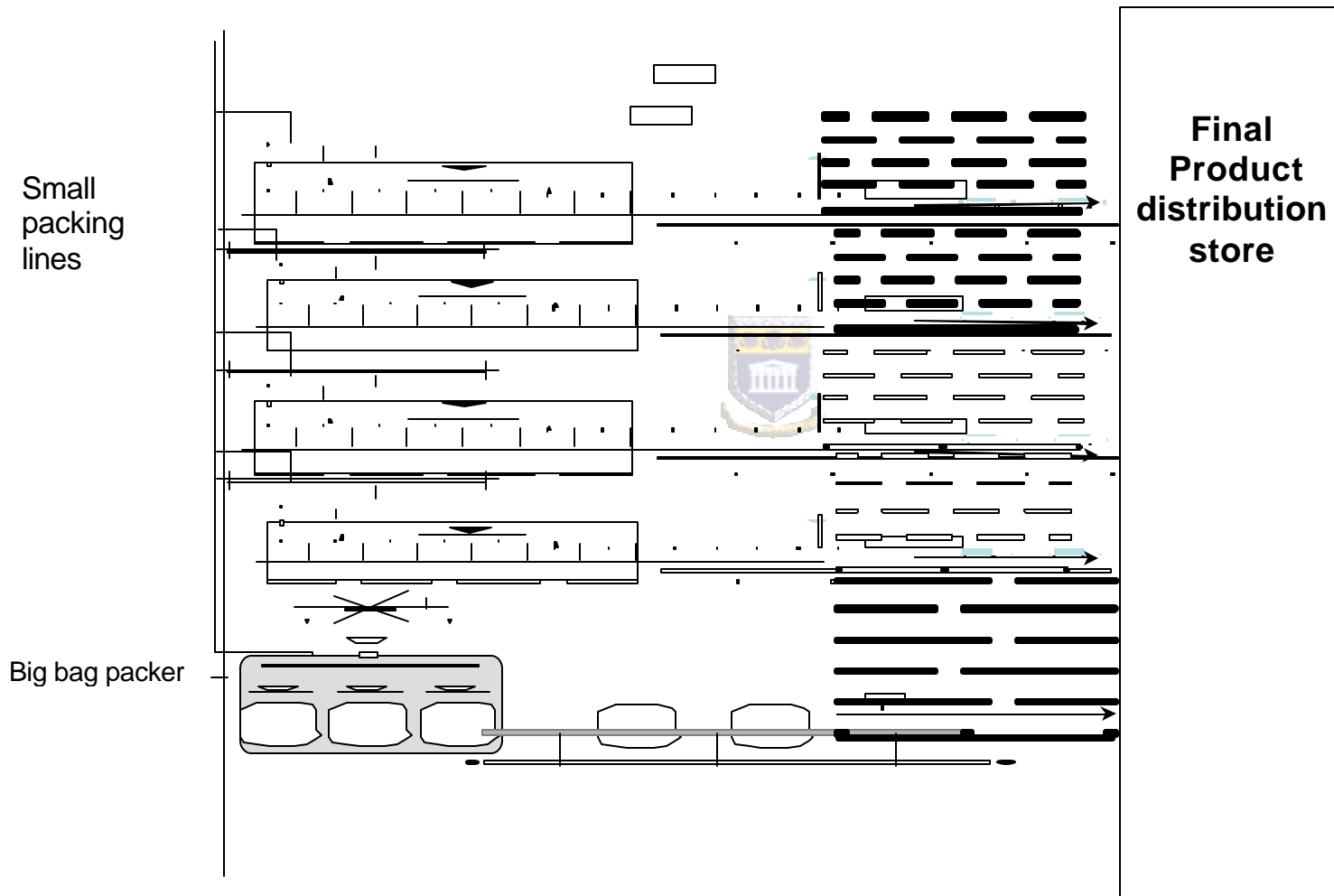


Fig. 4.2 (g) Various packing lines.

# Packing



**Fig. 4.2 (h)** Packing department.



# Mix Back (Rework)

CCP 2

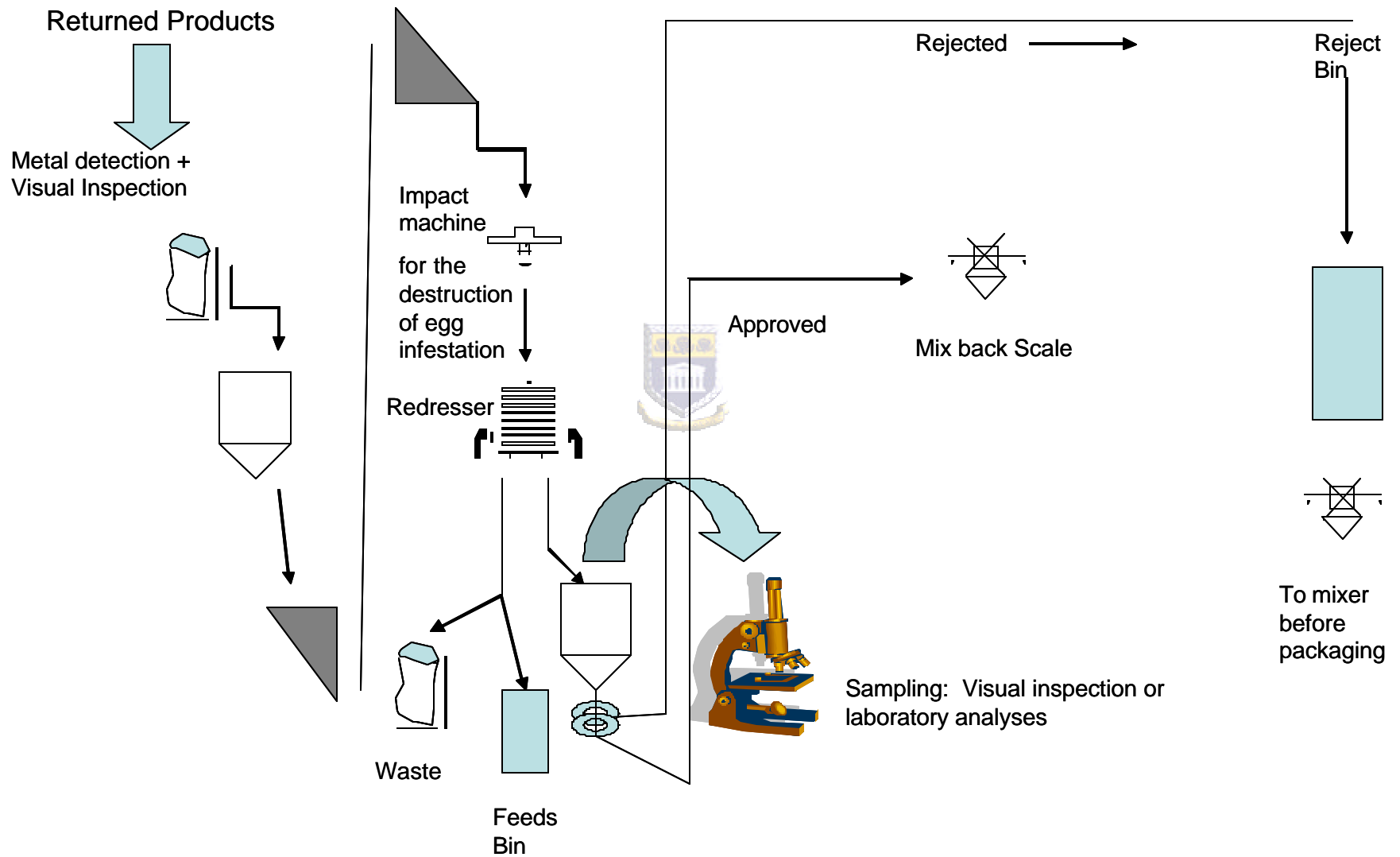


Fig. 4.2 (i) Mix-back/Rework.

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## CHAPTER 5

### GENERIC HACCP PLAN FOR THE FLOUR MILLING INDUSTRY

#### 5.1 INTRODUCTION

The HACCP plan is the formal document that contains and pulls together the key information that is critical for the management of food safety (Mortimore and Wallace 1995). The plan is drawn up by the institution's HACCP team and should contain the flow diagram and the HACCP control chart as well as the additional supporting documentation (Mortimore and Wallace 1995). The process flow diagram for the wheat milling process however was covered in chapter 4.

Effective preparation and planning should take place prior to the application of the HACCP principles (Mortimore 2001). Pre-requisite programs should be in place before the HACCP plan can be implemented; therefore the team has to determine beforehand what elements are required and what are already in place (Mortimore 2001). The pre-requisites that need to be in place were covered in chapter 3.

In order to simplify the HACCP study, it can be approached as a twelve stage procedure as shown in Table 5.1 (CAC 1997; NACMCF 1998; SABS 1999; Uys 2000; Forsythe 2002).

**Table 5.1** Logic sequence for application of HACCP (CAC 1997; NACMCF 1998; Boccas *et al.* 2001; Sjöberg *et al.* 2002)

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Stage 1	Assemble HACCP team.
Stage 2	Describe products.
Stage 3	Identify the intended use.
Stage 4	Construct flow diagram.
Stage 5	On-site confirmation of flow diagram.
Stage 6	List all potential hazards; Conduct a hazard analysis;

	Consider control measures.
Stage 7	Determine CCPs
Stage 8	Establish critical limits for each CCP.
Stage 9	Establish a monitoring system for each CCP.
Stage 10	Establish corrective actions.
Stage 11	Establish verification procedures.
Stage 12	Establish documentation and record keeping.

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## **5.2 STAGE 1: SELECT THE HACCP TEAM**

To effectively implement HACCP it is of utmost important that senior management from all disciplines is involved and show their support by being committed. HACCP should not be carried out by one person alone but should be the result of a team effort. Depending on the size of the organisation, one or even two teams shall be assembled to assist with the implementation, management, maintenance and review of the HACCP plan (Mortimore and Wallace 1995). There must at least be experts from the following areas within the organisation production, quality and engineering (Mortimore and Wallace 1995; NACMCF 1998; Forsythe 2002) “In order to have a HACCP plan that really works in practice, depend on the competency of the people who both developed it and operate it, and the pre-requisite programs which support it” (Mortimore 2001).

A written proof of a person’s assignment and commitment to the HACCP team should be kept on record for every team member (Fisher 2004). The three main objectives of such a team shall be to ensure that the commitment of management is visible, communication routes and a forum for conflict resolving is established.

The core HACCP team should consist of personnel with specific knowledge and expertise with regard to the process and product. The necessary HACCP studies shall be conducted by the core team and they should supervise the implementation and maintain the HACCP plan (SABS 1999). The core team shall consist of:

- 5.1.1 A team leader should be part of management with enough management experience, should be a natural leader with defined responsibilities, authority and sufficient HACCP training. This person should be appointed by management to lead the HACCP team. The team leader shall also have the authority to ensure that the HACCP system is established, implemented and maintained according to the requirements of SABS 0330. He or she should also report to management on the performance of the HACCP system for review purposes and as a basis for improving the system (SABS 1999). It is also the duty of the team leader to assess which resources such as time, people, equipment and funding are needed for the implementation, maintenance and continual improvement of the HACCP system.
- 5.1.2 A facilitator should also have formal HACCP training provided by registered, certified or accredited organisations or persons as well as a validated training curriculum. This person shall be responsible for the organisation of meetings and training and should act as the secretary during such activities. The facilitator will also be responsible for ensuring that specialist advice is available when required, the progress throughout the organisation is communicated, any obstacles regarding the implementation and maintenance of the system is removed, that follow-ups is completed on time as well as to organize experimental studies when required (SABS 1999). The team leader and facilitator can be the same person. In some cases the facilitator can also contribute as a specialist to the team.
- 5.1.3 A quality controller should contribute to the team by providing the expertise in microbiological, chemical and physical hazards associated with the product. Understanding the hazards and the knowledge to know control measures to prevent the hazards from affecting the product (Mortimore and Wallace 1995; NACMCF 1998; SABS 1999).

- 5.1.4 A production expert with the detailed knowledge of the production of the product should also be part of this team (Mortimore and Wallace 1995; NACMCF 1998; SABS 1999).
- 5.1.5 An engineer that would provide the team with knowledge of the process equipment and environment with respect to hygienic design and process capability (Mortimore and Wallace 1995; NACMCF 1998; SABS 1999).
- 5.1.6 Additional expertise could be either internal or external depending on the availability within the organisation. For example a person from the suppliers' quality assurance side could provide the team with details of supplier activities and the hazards and risks associated with raw materials purchased (Mortimore and Wallace 1995; NACMCF 1998; Forsythe 2002).
- 5.1.7 A Research and Development expert should provide knowledge of any new product or process development (Mortimore and Wallace 1995).
- 5.1.8 A Distribution expert should have expert knowledge of storing and handling of the food product (Mortimore and Wallace 1995).
- 5.1.9 A Purchasing expert would help to answer any questions regarding purchasing (Mortimore and Wallace 1995).
- 5.1.10 A microbiologist would be able to provide knowledge on microbiological hazards (Mortimore and Wallace 1995; NACMCF 1998).
- 5.1.11 A toxicologist would provide knowledge on chemical hazards (Mortimore and Wallace 1995).
- 5.1.12 Food Scientist or Technologist would provide knowledge of the food source and new product development (SABS 1999).

5.1.13 An Industrial chemist should provide knowledge of the production of a wide range of important chemicals and materials and can help when a process need to be modified (SABS 1999).

5.1.14 Work Study officer would provide problem-solving advisory service to all management levels in order to increase productivity, profits, cost effectiveness, quality and efficiency (SABS 1999).

5.1.15 A risk assessment expert would be the ideal person to help whenever the need arises for doing risk assessments (SABS 1999).

5.1.16 HACCP consultants could assist the team by training team members in HACCP techniques, assist them in the implementation of HACCP, assess the HACCP studies and implementation, assist in documentation development and assist with the ordering and structuring of meetings (Mortimore and Wallace 1995).



The HACCP team is responsible to define the terms of reference of the HACCP system of the company (SABS 1999). Reference should be to a specific product, product line or process and the microbiological, chemical and physical hazards associated with the product should be discussed. The safety of the product at the point of consumption or at the point of manufacture should also be declared. At the point where the product is supposed to be judged as a safe product, hazards that could affect the product at that point should be listed and considered. Whether only product safety hazards will be included or whether non-safety requirements will also be included should also be discussed (SABS 1999; Uys 2000).

### **5.3 TERMS OF REFERENCE FOR FLOUR**

This HACCP study considers biological, chemical and physical hazards throughout the entire wheat milling process.

The biological hazards could affect the safety of the final product especially if it is consumed by the high risk group of the population such as the elderly, infants and the immunocompromised especially if the product was not subjected to extreme heat or cold conditions.

Biological hazards on wheat include micro-organisms such as bacteria and fungi (Mills and Pedersen 1992). Field fungi such as *Ergot sclerotia* produce mycotoxins and *Fusarium gramineaum* that produce vomitoxin (deoxynivalenol) (Mills and Pedersen 1992). Storage fungi include *Aspergillus spp.* such as *Aspergillus flavus* and *Aspergillus parasiticus* that produce mycotoxins as well as the *Penicilium spp* (Mills and Pedersen 1992). Other commonly found bacteria are the *Bacillus* species. These species produce a highly heat-stable toxin that is associated with the characteristic food poisoning symptoms such as nausea and vomiting. *Bacillus subtilis* causes ropiness in bread.

Yeasts are divided into two groups namely true yeasts and false yeasts. True yeasts form endospores. A typical example is bread yeast. These types of yeasts are usually not a problem on grain or flour unless the moisture is high and oxygen levels are non-existent (Mills and Pedersen 1992).

Vegetative pathogens such as *Salmonella*, *Listeria* and *Staphylococcus* are not excluded on the raw product.

Chemical hazards could be associated with the raw materials such as the pesticides used. Chemical contamination can also take place during the cleaning process due to the use of cleaning materials that might leave residues or during the fumigation of the plant. Examples of chemical hazards within a milling environment would be pesticides, insecticides, avicides, fungicides, cleaning agents, lubricants, antibiotics, fortificants and heavy metals (Mills and Pedersen 1992).

Physical hazards include all foreign bodies such as sticks, stones, sand, glass, plastic, metal, insects, hair, wood, paint, noxious seeds etc (Mills and Pedersen 1992). Most of



these hazards would be removed by the cleaning house section in the mill where a lot of specialized equipment is used to separate the wheat kernel from the foreign bodies. Examples of typical machinery would be separators, cleaners, carter disks, treur cylinders, scourers, aspirators, magnetic separation, sieves, seed removers and combi-cleaners.

Physical hazards could also affect the safety of the product if it is to go through to the final stages where the cleaning equipment failed, sieves broke or metal detectors and magnets failed.

#### **5.4 STAGE 2: DESCRIBE THE PRODUCT**

Wheat flour is found in three forms – whole wheat meal, brown bread flour or white bread flour (Lockwood 1960; Anon. 2004a).

The whole grain is used in the production of whole wheat meal including the fibre-rich bran (outer layer), endosperm (middle layer) and the nutrient packed germ (inner layer). Whole grain flour is a very good source of nutrients such as protein; B-vitamins; minerals such as iron, calcium, zinc and copper; antioxidant nutrients such as vitamin E and selenium as well as fibre. The appearance of whole wheat meal is light brown (Fig. 2.4) and its extraction rate is 100% (Lockwood 1960; Anon. 2004a; Anon. 2005).

White bread flour is refined meaning that the bran is removed from the rest of the grain and in the process many nutrients are removed. Therefore according to government legislation it is important that white flour should be fortified with nutrients such as vitamins and minerals to compensate for losses resulting from the milling process. Other variants such as self raising flour can also be produced by just adding baking powder to the white bread flour. White bread flour has an extraction rate of 70 – 75 % and up to 30% of the bran germ fat and minerals are removed (Lockwood 1960; Anon. 2004a; Anon. 2005).

Brown bread flour contains a little more bran than white flour which adds a darker colour, stronger flavour and odour to the flour (Fig. 2.4). Brown bread flour should also be fortified according to law, it has an extraction rate of 85 – 90% and 10 – 15% of the bran is removed. It is light brown in appearance (Lockwood 1960; Anon. 2004a; Anon. 2005).

Rye flour is also produced in some areas of our country. This specific flour contains less gluten / protein than whole- wheat flour and is also much heavier and darker in colour than most other flours. Without the addition of some higher-protein flour, rye flour won't produce a well-risen loaf of bread.

Flour is a very dry product meaning that it has a low water activity ( $a_w$ ) and a moisture content of between 13 and 14 %. It is packed into bulk containers, bags or smaller paper bags and should be stored in a cool dry place. Flour is prone to pest infestation if it is kept for very long periods of time therefore it is suggested that flour should not be stored for a period longer than six months. The natural oils in the flour can oxidize therefore the flour go rancid after a while and the odour and flavour are affected. The storage conditions, insect activity as well as the type of flour stored, all have an affect on the shelf life of flour.

Typical flour storage should be at ambient temperature and humidity in a clean dry area. Whole grain flour will have a shorter shelf life than white flour because it still contains the wheat germ. The average shelf life for whole wheat meal and brown bread flour would be 3 to 4 months depending on the temperature. For white bread flour it is usually 6 months (Anon. 2004b).

In most cases the product will be consumed only after it was subjected to extreme heat conditions such as baking or boiling, which make the product a medium care product. Such foods are defined because they are a potential source of micro-organisms; they are intended for consumption after a cooking step that is adequate to kill off the pathogens (SABS 2001). In some instances that should be described by the different manufacturers

to which it is applicable, the raw product are being used as is and can be classified a high care product. Such foods do not have a cooking step before consumption that is adequate to kill off pathogens and destroy their toxins (SABS 2001). For the purpose of this study we will look at flour as a high care product.

The final product before packaging are tested for some or all of the following: moisture content, protein content, ash content, strength, water absorption, vitamin content, bran content, particle size, colour, falling number and baking quality.

### **5.5 STAGE 3: IDENTIFY THE INTENDED USE OF THE PRODUCT**

Wheat is known as South Africa's staple food. According to its protein content, wheat is classified to produce either strong flour or soft flour. Strong flour has a high protein content and is used in the making of bread whereas wheat with a lower protein content produce soft flour used mainly for making cakes and biscuits. Soft or weak flour with a protein content of +/- 8% is suitable for making cakes. Plain flour containing +/- 10% protein is suitable for making biscuits and sauces. Self raising flour with a protein content of 10% and added raising agent is suitable for sponge cakes and scones. Strong flour with a protein content of between 11 and 14% is used for yeast dough, flaky and puff pastry. Whole grain flour is used to make a variety of whole grain products which are a very important part of one's diet. It contains nutrients such as fibre, starch, minerals and vitamins which are in short supply in our diet. Antioxidants and phytoestrogens which are important in disease prevention can also be found in this type of flour.

Consumers of wheat products cover a very large spectrum of our population, from babies to the elderly. The only exceptions that do not consume products containing wheat are the people suffering from wheat allergies.

Examples of products produced by flour are: bread; biscuits; cakes; bread crumbs; cereals; pasta; sauces; baby foods and many more.

## **5.6 STAGE 4: CONSTRUCT A PRODUCT FLOW DIAGRAM**

It is important to realize that for each individual mill, a unique process flow diagram and floor plan should be constructed and verified on site (NACMCF 1998; SABS 1999; Forsythe 2002). The critical control points should also be indicated on the process flow diagram (Fisher 2004; Marais 2004). Refer to the generic wheat milling process flow diagram in chapter 4.


## **5.7 STAGE 5: ARRANGE ON-SITE CONFIRMATION OF THE FLOW DIAGRAM AND FLOOR PLAN**

The flow diagram should cover all areas from intake through till the final product stages and should be confirmed on site during all hours of operation (NACMCF 1998; SABS 1999; Forsythe 2002). All relevant information should be included on the flow diagram e.g. indicate the Critical Control Points. The floor plan should consider all the entrances, exits, walkways, equipment and their location. It is the responsibility of the HACCP team to verify both the flow diagram and floor plan on site. Therefore it is best to take the flow diagram into the process area and observe it at each step and during all stages and hours of the operation (Mortimore 2001). The same should be done with the floor plan.

## **5.8 STAGE 6: LIST ALL THE HAZARDS ASSOCIATED WITH EACH STEP IN THE PROCESS AND LIST MEASURES THAT WILL CONTROL THE HAZARDS**

A hazard is defined as a biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect (CAC 1997; NACMCF 1998). It is important that during the hazard analysis, the likelihood of the hazard occurring and the severity of the hazard should be considered (Mortimore 2001). All the hazards that could be present in the wheat milling process are covered in the following tables at various stages in the process.


**Table 5.2** Hazards associated with the intake of wheat and applied control measures

Hazards	Type	Control measures
<p>Glass, stones, sticks, metal, bone, wood, noxious seeds, broken grains, plastic, rubber straw, dust, hair, sand mud balls, paint flakings, insects: grain weevils, lesser grain borers, grain moths, flour and grain beetles, rodents, insulation material, fruit pits (Forsythe 2002)</p>	Physical	<p>Preliminary cleaning, aspiration, removal of unmillable material, intermediate cleaning, cleaning house: aspirator separator, combinator, combi-cleaners, de-stoner, carter disk, treur cylinder, scourer, magnets, metal detectors, pest control program</p>
<p>Residues of pesticides or heavy metals due to industrial pollution of the environment.</p>	 <p>Chemical</p>	Wheat grading specifications
<p>Micro-organisms: <i>Aspergillus</i> spp. <i>Penicillium</i> spp. (Can produce mycotoxins as by products.) <i>Fusarium graminearum</i> (produce vomitoxin / deoxynivalenol / DON) <i>Bacillus</i> spp. (Mills and Pedersen 1992)</p>	Biological	<p>Store grain in a dry place, aerate if possible, control temperature and moisture conditions, temperature should not exceed 25°C, moisture should not exceed grading specifications (13 - 14%), <math>a_w</math> should be &lt;0.90 to prevent <i>Fusarium</i> from growing and producing DON/NIV (Hope and Magan</p>

**Table 5.3** Hazards associated with the fumigation of wheat and applied control measures

<b>Hazard/s</b>	<b>Type</b>	<b>Control Measure</b>
Chemical residues of fumigant (Forsythe 2002)	Chemical	Control the fumigation process.

**Table 5.4** Hazards associated with the conditioning of wheat and applied control measures

<b>Hazard/s</b>	<b>Type</b>	<b>Control Measures</b>
Bacteria, Yeasts & Moulds	 Biological	Making sure that the water used is according to SABS 241 standards.
Overdosage of chemicals such as Cl <sub>2</sub> , Na, K, Ca, Mg, SO <sub>4</sub> , CaCO <sub>3</sub> , N, F, Fe and Al.	Chemical	Regular testing of the water and maintenance of the water treatment plant. Records should be kept of the pH of the water etc. making sure that no overdosing can take place.

**Table 5.5** Hazards associated with the milling process and applied control measures

<b>Hazard/s</b>	<b>Type</b>	<b>Control Measures</b>
Foreign materials added by human error or equipment deficiencies.	Physical	GMPs, sieves, redressers, metal detectors.
Overdosage of fortificant or other additives.	Chemical	Use only the prescribed amount of additives. Store appropriately and label correctly. Record all manual additions. Make sure that scales are calibrated regularly in cases where it is added automatically.
Foreign materials added by mix-back.	Physical	Accept/reject criteria, sieves, redressers.
Micro-organisms added by mix-back.	Biological	Accept/reject criteria. It is strongly advised that returns should not be mixed back into the system mainly because no guidelines or criteria for microbiological specifications of flour



exist at present.

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## 5.9 STAGE 7: DETERMINE CRITICAL CONTROL POINTS (CCPs)

Mortimore and Wallace (1995) define a critical control point as a point, step or procedure at which control can be applied and a safety hazard can be prevented, eliminated or reduced to acceptable levels. People often make the mistake to “choose to manage” some pre-requisites as CCPs to “be on the safe side” (Mortimore 2001). Critical control points could be raw materials, processes, procedures and practices. By making use of a decision tree such as the one included in this document as fig. 5.1, critical control points for the milling industry were identified. For the purpose of the generic model, decision tree number 2 according to SABS 0330: 1999 and Codex Alimentarius was used and only two critical control points were listed. Each step or process within the milling process was carefully considered and the questions answered consecutively. The first CCP is the rebolt sifter, metal detector and impactor system before packaging (Mills and Pedersen 1992) and the second one, the mix-back system (Marais 2004; Uys 2004). If however a mill does not mix-back any returns into the system, that specific mill would have only one critical control point and will be audited mainly on their pre-requisite programs and the one CCP (Marais 2004; Uys 2004).

Various control points within a milling environment exist. These were covered in the pre-requisite programs and are covered in Table 5.6

**Table 5.6** Control points and associated type of hazards

<b>Step / Procedure</b>	<b>Hazards</b>
Wheat grading	Physical, Biological & Chemical
Wheat cleaning	Physical
Conditioning	Biological & Chemical
Wheat Debranning System	Biological



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It is advised that mills should not mix-back returns especially if they do not have control over the process (Du Toit 2004; Fisher 2004). The returns could be used in animal feeds or for another purpose. The main reasoning behind this is the fact that no guidelines or specifications for micro-organisms in the final product exist at this point in time. If however a mill continues to mix-back for some or the other reason, it is strongly advised that a rebolt sifter, impact detacher and metal detector should be in place in order to control at least the physical hazards (Mills and Pedersen 1992; Du Toit 2004).

#### **5.9.1 CCP 1 – Rebolt sifter, metal detector and impactor before packaging**

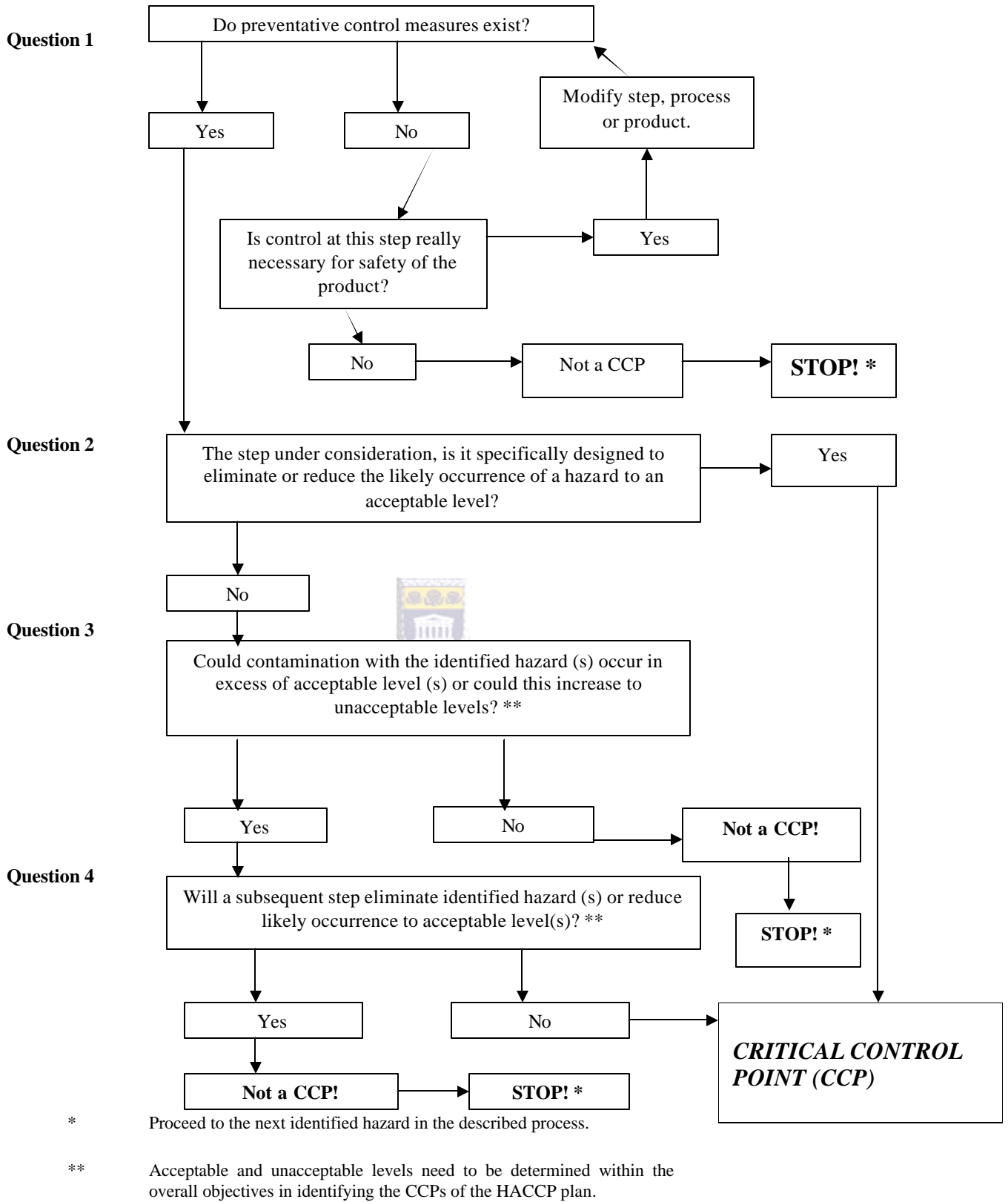
The physical hazards associated with the first CCP namely the rebolt sifter, metal detector and impactor before packaging, are insects, insect eggs and metal pieces. In order to verify whether the abovementioned step in the process is a critical control point, the questions in the decision tree need to be answered. Whether control measures exist at this specific stage. The answer to this question is yes because a rebolt sifter, metal detector and impactor system are in place. Secondly the question is raised whether that step is specifically designed to eliminate or reduce the occurrence of the hazard to an acceptable level. Any living forms of insects will be removed by the rebolt sifter that might have escaped the other methods of detection. The impactor after a rebolt sifter assures that any form of insect that passed through a damaged rebolt sifter sieve, will be destroyed and the metal detector will give an indication of the presence of metal. Therefore the rebolt sifter, metal detector and impactor systems could be regarded as a CCP.

#### **5.9.2 CCP 2 – Mix-back**

The physical hazards that are associated with the mix-back system are basically any foreign object. The first question to answer when following the decision tree is whether control measures exist at this specific step within the process. Control measures do exist since visual inspection of the product subjected to mix-back takes place. Secondly it is

important to know whether that specific step is specifically designed to eliminate or reduce the occurrence of the hazard to an acceptable level. In this case where physical hazards such as glass, stones or any other foreign object are detected in the returned product, the product is discarded immediately. Therefore mix back can be regarded as a critical control point.

Biological hazards can also be a major problem in a mix-back system because micro-organisms cannot be detected by the naked eye or by smell. Visual inspection of the product is the control measure that exists at this step in the process. Whether the step is specifically designed to eliminate or reduce the occurrence of the hazard to an acceptable level is in this case not true because micro-organisms are not visible with the naked eye. Now the decision tree takes a different route and a third question needs to be answered. This is whether contamination with the identified hazard or hazards could occur in excess of acceptable levels or whether it could increase to unacceptable levels. The answer to this question is that the micro-organisms can increase to unacceptable levels since there are no way that the micro-organisms were reduced by visual inspection and smell only. A fourth question whether a subsequent step will eliminate the identified hazard or reduce its likely occurrence to an acceptable level is raised. The answer to this question have to be negative because for this study it was considered that the flour would not be used in the baking industry since there are many areas where the flour is not submitted to extreme heat conditions. Therefore mix-back can then also be regarded as a critical control point.



**Figure 5.1** Decision tree used to identify CCPs (answer questions in sequence).

## **5.10 STAGE 8: ESTABLISH TARGET LEVELS AND TOLERANCES FOR EACH CRITICAL CONTROL POINT**

By establishing target levels and tolerances for the critical control points, one is able to distinguish between a safe and an unsafe product, identify the actual operating limits and identify the degree of latitude allowable (Von Holy 2004). Often experimental activity and reference data is needed in order to lay down critical limits (Mortimore 2001). For both the critical control points zero tolerance is allowed (Du Toit 2004; Fisher 2004). This means that no foreign objects or physical hazards should be detectable in the returned product. No insect eggs or signs of infestation should be allowed neither should any strong odours be detected. No signs of infestation or adulteration in tailings of the redress sifter. Any product with any of the above deficiencies should be immediately rejected. Therefore a very strict accept/reject criteria should exist. In order to prevent micro-organisms such as *Fusarium* that produce toxins, from growing, it is important that returns accepted as mix-back should be kept at temperatures lower than 15°C and that the  $a_w$  of the wheat-based substrate (flour) should not exceed 0.90 (Hope and Magan 2003).



## **5.11 STAGE 9: ESTABLISH A MONITORING SYSTEM FOR EACH CRITICAL CONTROL POINT**

By establishing a monitoring system for the critical control points rules are laid down as to who should act, when they are to act and how they are to act (Von Holy 2004). It is important that the frequency that was set will be able to detect loss of control of the CCP in a timely manner (Mortimore 2001).

### **5.11.1 CCP 1 – Rebolt sifter, metal detector and impactor before packaging**

The person in charge of packing department or a designated responsible person should check the redress tailings of the rebolt sifter for signs of infestation or sieves being broken. Act accordingly and replace broken sieves or equipment where appropriate. Regular challenge tests on the metal detectors should also take place on a regular basis. The metal detector should be replaced as soon as it is found that it is faulty.

### **5.11.2 CCP 2 – Mix-back**

The quality assurance team is responsible to inspect all returns. The company should have a strict accept / reject criteria. If signs of pest infestation, molds, any foreign object or a strong odour are detected, it should be rejected immediately (Du Toit 2004). It is also advised that a rebolt, metal detector and impactor system should be in place before packaging to avoid final product being returned due to physical contamination (Mills and Pedersen 1992).

If however a mill decides to mix back product, it is advised that the product be fumigated before it is mixed back into the system (Van Schalkwyk 2004). The temperature of the room where the mix-back is kept should be controlled and preferably should not exceed 15°C and the water activity of the flour should not exceed 0.90 (Hope and Magan 2003).

However, it is strongly advised that returns should not be mixed back into the system because the accept / reject criteria don't make provision for specifications of micro-organisms at this point in time. Therefore, if the microbiological load is not known and there is no means of control, over the mix-back process, it should rather be discarded. A maximum limit for the percentage of mix-back should also be set (Du Toit 2004).

## **5.12 STAGE 10: ESTABLISH CORRECTIVE ACTION PLANS**

Corrective action plans for the CCPs could be action that could be taken to bring the process back into control before the deviation could lead to a safety hazard (Mortimore 2001; Von Holy 2004). Or action to deal with the product manufactured while the process was out of control (Mortimore 2001; Von Holy 2004). The procedures should correct the non-conformity and deal with the product that was produced while the process was out of control (Mortimore 2001). Examples of such actions could be a strict accept/reject criteria, to notify the supervisor, stop production, isolate the product. In the case of non-conformity, it is advised that re-processing should not take place and that the product should rather be used for animal feeds (Du Toit 2004).

If the hazards associated with the product while the process was out of control are physical hazards, it would be wise to notify the supervisor and stop production especially if the redress system is at fault. If this material is accepted as material for mix-back, then it is advised that the mix-back material are isolated, fumigated and go through a redress system and impactor (sterilator) that is in proper working condition as well (Du Toit 2004).

### **5.13 STAGE 11: ESTABLISH VERIFICATION AND REVIEW PROCEDURES**

It is important at this stage that the HACCP team document how they plan to verify that the HACCP plan is working (Mortimore 2001). Typical verification activities would include final product testing where the final product should be tested periodically and it should conform to the customers' requirements and specifications (Fisher 2004). Examples of different tests that a mill could do in order to conform to the customer's requirements are: test for moisture %, protein %, ash %, colour, falling number, alveograph, farinograph, mixograph, extensigraph, particle size, vitamins and baking quality (Atwell 2003). Microbiological analyses on the final product as requested by the customer should also take place such as to test for pathogens such as *Salmonella* and toxins that might be present also to test for total viable counts, coliforms, yeasts and molds.

Internal audits to verify that the process (HACCP plan) is working effectively (Mortimore 2001). Independent auditing should take place meaning that someone from the packing department is not allowed to audit the packaging area (Fisher 2004).

Other activities for verification include the review of consumer complaints (Mortimore 2001), checking the records of CCP operations, observing the operations at CCP, checking the records of monitoring instrument calibration, having a formal customer complaint procedure in place and having recall procedures in place.

The HACCP plan should be reviewed periodically because “it is very unlikely that the products produced, the process, the environment, likely hazards or the people in the facility will remain unchanged over time” (Mortimore 2001). Conditions that automatically trigger a review of the HACCP plan are: client and consumer complaints that indicates that there is a health or spoilage risk associated with the product; a likely change in client and consumer use; a change in raw materials or product formulation; a change in the processing system; a change in the plant design and surroundings; any alteration / replacement to the processing equipment; a change in the cleaning and disinfection program; a change in the packing, storage and distribution system; changes to personnel levels and tasks; legislation changes; outcome of verification and validation activities (SABS 1999).

#### **5.14 STAGE 12: ESTABLISH RECORD-KEEPING AND DOCUMENTATION**



Records that should be kept include the HACCP plan itself, CCP monitoring records, training records, verification activities as well as records of amendments to the system (Mortimore 2001). A document control procedure should be in place that should address at least the following: approve the adequacy of documents prior to usage; update and review documents where necessary and re-approve the documents; identify changes to documents and the current revision status; current versions of applicable documents should be available at points of use; documents should be legible and readily identifiable; documents of external origin should be identified and their distribution within the organisation should be controlled; the unintended use of documents should be prevented and suitable identification to them should be applied if they were retained for any purpose; no hand written procedures / documents should be allowed; no handwritten changes to documents / procedures should be allowed.

Records should provide the conformance to the requirements of the HACCP system and should address the identification, collection, storage, protection, retrieval, retention times

and disposition of such records. Minimum HACCP records to be kept are: company profile; management commitment to safety; cleaning and sanitation records; plant construction and maintenance records; records on the nature, source and basis for acceptance of raw materials, water quality, additives, ingredients, cleaning chemicals and packaging materials; processing records including storage, distribution and recall; summary of hazard analysis; listing of HACCP team and assigned responsibilities; description of food, its distribution, intended use and consumer; verified flow diagram; management review; pre-requisite programs; training policy and the HACCP manual format outline in table form, for an example refer to Table 5.7 (SABS 1999; Merican 2000). Records should include supporting documentation such as validation records, records generated during the operation of the plan, HACCP plan modifications and a distribution list in order to control documents that need to be circulated amongst the personnel.

After completion of the HACCP study, a fully focused documented system known as the HACCP plan should be achieved (Mortimore 2001). The following stage would be the implementation of the HACCP plan and afterwards the maintenance of the system to ensure that the implementation remain successful (Mortimore 2001).

### **5.15 ASSESSMENT OF THE HACCP PLAN**

The HACCP plan should then be assessed by a government inspection agency to verify whether the food handling enterprise has the ability to manufacture and distribute safe and quality products. This assessment is mainly two-fold a document review and an on-site verification (Ababouch 2000).

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**Table 5.7** HACCP Plan Summary Table

CCP	Hazards	Critical limits	Corrective Actions	Verification	Records
Rebolt sifter, metal detector and impactor before packaging.	Physical Hazards infestation of insects and insect eggs, metallic pieces	No signs of infestation. Zero tolerance.	Stop production. Replace sieves. Mix-back. Fumigation. Sterilator.	Final product testing. HACCP plan review. Challenge tests.	Tailings report. Metal detector log charts
Mix-back	Physical hazards, infestation of insects and insect eggs and biological hazards.	No signs of infestation. Zero tolerance.	Stop production. Use as animal feed. Rebolt sifter, Impactor and metal detector in place	Final product testing. HACCP plan review.	Mix-back report. Document % of mix-back.



## CHAPTER 6

### MICROBIAL SAFETY OF WHEAT AND FLOUR

#### 6.1 INTRODUCTION

All field crops are exposed to a variety of factors that can in fact affect the quality of the product. These factors include physical hazards or foreign materials such as sticks, stones, glass, metal and many others or biological hazards whether they are bacterial, fungal, viral or parasitic. Even chemical hazards such as pesticides and allergens could affect the quality of the end product. Favourable climate conditions in our wheat growing areas can in fact add to the microbial loads on the incoming wheat. The microorganisms are mainly found on the exterior of the wheat kernel although it is possible for a few of them to invade the kernel (Mousia and Pandiella 2004).

Microbiological tests were performed over a period of twenty six days at Sasko Mill in Paarl in order to determine the microbial levels at three different stages of the milling process. These three stages included the clean dry wheat grist (cdg), the first break wheat (1<sup>st</sup> bk) after conditioning and the final flour product (white bread flour). A great variety of grists were sampled as can be seen from table 6.1 ranging from local to imported wheat.

**Table 6.1** The variation of grists sampled and date of sampling

Day	Date	Grist
1	12 January 2004	100% Moorreesburg
2	13 January 2004	100% Moorreesburg
3	15 January 2004	30% Boere, 40% Gouda, 30% Caledon
4	16 January 2004	40% Riebeeck West, 40% Porterville, 20% Bredasdorp
5	19 January 2004	40% Riebeeck West, 40% Porterville, 20% Bredasdorp
6	17 February 2004	40% Gouda, 40% Klipheuwel, 20% Rietpoel
7	18 February 2004	40% Gouda, 40% Klipheuwel, 20% Rietpoel
8	20 February 2004	40% Klipheuwel, 40% Leliedam, 20% Krige

9	23 February 2004	40% Klipheuwel, 40% Leliedam, 20% Krige
10	24 February 2004	40% Gouda, 40% Leliedam, 20% Rietpoel
11	25 February 2004	80% Gouda, 20% Rietpoel
12	2 March 2004	40% Group 1, 40% Group 2, 20% Group 3
13	25 March 2004	30% Group 1, 30% Group 2, 10% Group 3, 30% Argentine
14	26 March 2004	30% Group 1, 30% Group 2, 10% Group 3, 30% Argentine
15	29 March 2004	30% Group 1, 30% Group 2, 10% Group 3, 30% Argentine
16	2 April 2004	30% Group 1, 40% Group 2, 20% Argentine, 10% Group 3
17	8 April 2004	30% Group 1, 40% Group 2, 20% Argentine, 10% Group 3
18	15 April 2004	30% Group 1, 40% Group 2, 20% Argentine, 10% Group 3
19	16 April 2004	30% Group 1, 40% Group 2, 20% Argentine, 10% Group 3
20	19 April 2004	30% Group 1, 40% Group 2, 20% Argentine, 10% Group 3
21	20 April 2004	30% Group 1, 40% Group 2, 20% Argentine, 10% Group 3
22	22 April 2004	10% Group 2, 30% Group 3, 20% Group 4, 40% Argentine
23	23 April 2004	10% Group 2, 30% Group 3, 20% Group 4, 40% Argentine
24	26 April 2004	10% Group 2, 30% Group 3, 20% Group 4, 40% Argentine
25	27 April 2004	10% Group 2, 30% Group 3, 20% Group 4, 40% Argentine
26	28 April 2004	10% Group 2, 30% Group 3, 20% Group 4, 40% Argentine

Together with the Sasko mill samples, seven different products of Pioneer Foods were purchased off the shelf from a leading retail outlet. These specific products were purchased and tested. The products purchased, their expiry dates and the abbreviations that were used can be found in table 6.2.

**Table 6.2** Packaged product tested

Product	Abbreviation	Expiry date
White bread flour	WBF	30 April 2005
Cake flour	CF	26 April 2005
Self raising flour	SRF	18 July 2005
Bran-rich self raising flour	BRSRF	8 May 2005
Whole wheat flour	WWF	19 July 2005

Digestive wheaten bran

DWB

5 May 2005

Crushed wheat

CW

25 June 2005

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## **6.2 MATERIALS AND METHODS**

### **6.2.1 Sterilisation of equipment**

Before the commencement of each experiment, the equipment (waring blender and stainless steel scoops) was washed with hot water and soap and rinsed 3 to 4 times with sterile distilled water. Then 70% ethanol was used to rinse it and again, followed by rinsing it with sterile distilled water 2 to 3 times. It was left in a oven to dry and covered with foil or placed in sterile sampling bags. The sampling equipment used was made of stainless steel and was covered in foil and then autoclaved. Between every sample the blenders were washed with hot water and soap, rinsed with sterile distilled water for about 3 to 4 times, rinsed with 70% ethanol, again rinsed about 2 to 3 times with sterile distilled water and the excess water was just shook off the blender before use.



### **6.2.2 Sampling of wheat**

Wheat was sampled in duplicate at three different stages in the milling process. The first sample was taken from the clean dry grist, the second from the first break bin and the third sample was the final product or flour sample. A representative 100g sample was taken in duplicate, put in whirlpak bags at the identified sampling points and stored immediately in a cooler box at less than 10°C. The samples were immediately transported to the food microbiology research laboratory at the University of the Western Cape for microbiological analysis within 4 hours.

### **6.2.3 Preparation of dilution series for samples**

A sample (wheat or flour) of 50g were weighed out from the sterile whirlpak bag and transferred to the sterile blender. Ringer solution ( $\frac{1}{4}$  strength), of 450ml was added. The sample and ringer solution were blended at low speed for 30 to 60 seconds. A dilution series was prepared by transferring 1ml of the previous dilution to 9ml of ( $\frac{1}{4}$  strength)

ringer solution. Each sample was done in duplicate and the dilution series were done up until the  $10^{-4}$  dilution.

### **6.3 THE MICROBIAL ANALYSIS OF WHEAT AND FLOUR SAMPLES**

#### **6.3.1 Aerobic plate count (Total viable count / TVC)**

Each dilution was vortexed to resuspend any material that might have settled out and 1ml of each dilution were transferred into petri plates. Within 15 minutes of the original dilution, plates were poured with 15ml of Plate Count Agar (Oxoid) that has been cooled down to 45°C. The sample dilution and agar were mixed by slow rotation on a flat surface and the plates were left to solidify. Plates were then incubated at 35°C and microbial growth recorded after 48 hours.

#### **6.3.2 Coliform count (CC)**

Each dilution was vortexed to resuspend any material that might have settled out and 1ml of each dilution were transferred into petri plates. Within 15 minutes of the original dilution, plates were poured with 15ml of VRB MUG agar (Oxoid) that has been cooled down to 45°C. The sample dilution and agar were mixed by slow rotation on a flat surface and the plates were left to solidify. Plates were incubated at 35°C for 18 to 24 hours and microbial growth (purple colonies) recorded.

#### **6.3.3 Yeast and Mould Count (YC and MC)**

Each dilution was vortexed to resuspend any material that might have settled out and 1ml of each dilution were transferred into petri plates. Within 15 minutes of the original dilution, plates were poured with 15ml of Potato Dextrose Agar (Oxoid) that has been cooled down to 45°C. The sample dilution and agar were mixed by slow rotation on a flat surface and the plates were left to solidify. Plates were incubated at 25°C for 5 days and fungal growth recorded.

The analysis of the data obtained from the experiments were analysed by using the SAS system version 9.1 and box and whisker plots were the best way to present the data.



## 6.4 RESULTS

The samples were duplicated before it was analysed in order to avoid non-conformances but the result section contains only the average values after analysis. The results showed that the clean dry grist contained a large amount of micro-organisms that were present on the wheat even though preliminary cleaning already took place. The aim of the preliminary cleaning was mainly to minimize the amount of physical impurities on the wheat.

The medians for total viable counts at the different sampling stages were 4.4400 for clean dry grist, 1.9536 for first break wheat and 4.1250 for white bread flour. For coliforms the medians were 3.6643 for clean dry grist, 4.2702 for first break wheat and 1.6505 for white bread flour. The medians for yeasts were 4.3526 for clean dry grist, 3.5403 for first break wheat and 4.4130 for white bread flour. For moulds the medians were 1.9536 for clean dry grist, 4.1250 for first break wheat and 3.7975 for white bread flour.

**Table 6.3** Log values of microbial counts for clean dry grist

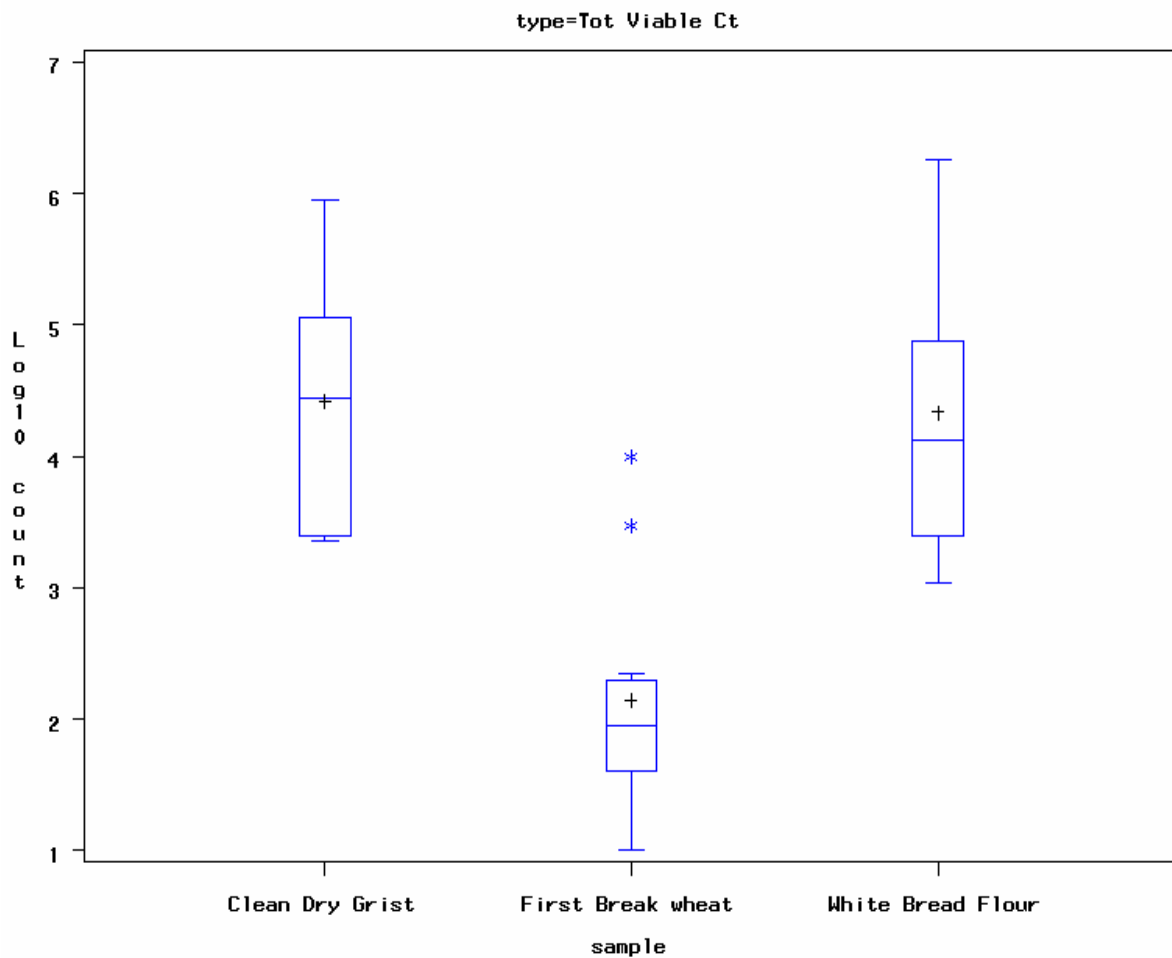
Type	CFU	Mean	Median	Stdev	Min	Max
TVC	$9.09 \times 10^4$	4.4198	4.4400	0.7657	3.3522	5.9494
CC	$1.13 \times 10^5$	3.9806	3.6643	0.9486	2.7924	6.1492
YC	$2.37 \times 10^5$	4.5227	4.3526	0.9949	3.3979	6.1644
MC	$1.45 \times 10^3$	2.1476	1.9536	0.9086	1.0000	4.0000

**Table 6.4** Log values of microbial counts for first break wheat

Type	CFU	Mean	Median	Stdev	Min	Max
TVC	$1.20 \times 10^5$	2.1476	1.9536	0.9086	1.0000	4.0000
CC	$1.31 \times 10^5$	4.3924	4.2702	0.8578	3.3979	5.9031
YC	$2.78 \times 10^5$	3.8785	3.5403	1.1642	2.2041	6.1644
MC	$6.24 \times 10^3$	4.3327	4.1250	1.0422	3.0374	6.2613

**Table 6.5** Log values of microbial counts for white bread flour

Type	CFU	Mean	Median	Stdev	Min	Max
TVC	$2.93 \times 10^5$	4.3327	4.1250	1.0422	3.0374	6.2613
CC	$6.43 \times 10^4$	1.6781	1.6505	1.2363	0.0000	5.0414
YC	$1.58 \times 10^5$	4.6733	4.4130	0.9506	3.3979	6.1189
MC	$1.22 \times 10^3$	3.8947	3.7975	0.9096	2.7709	5.6902



**Fig. 6.1** Total viable counts at the various sampling stages.

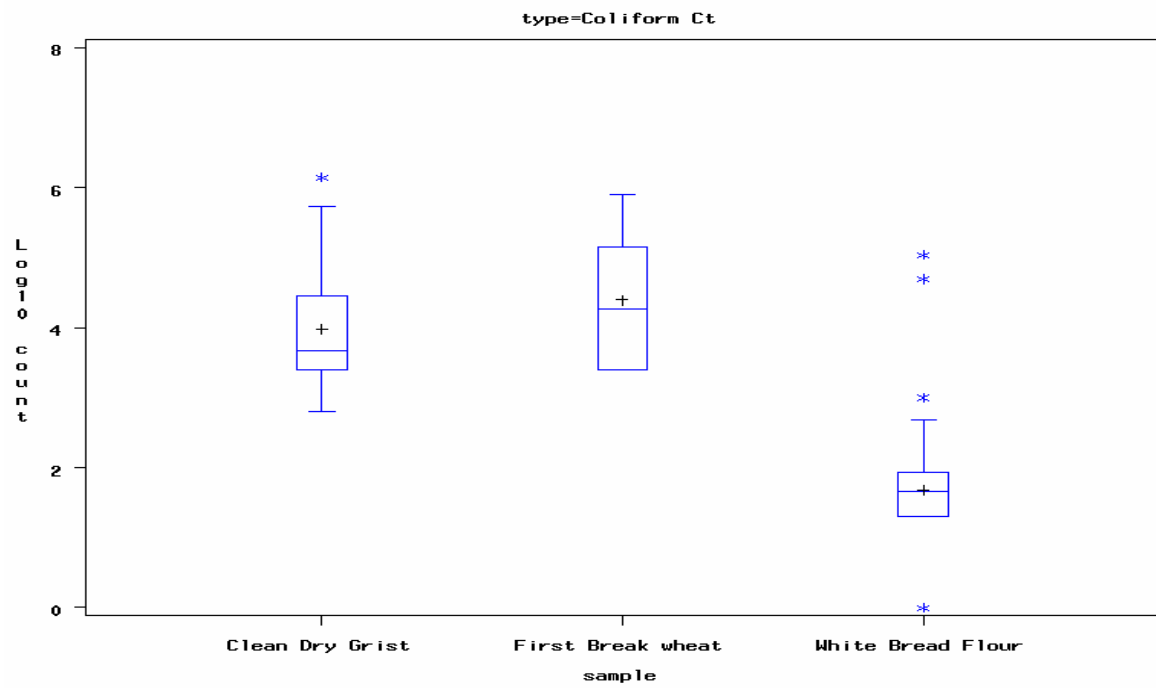


Fig. 6.2 Coliform counts at the various sampling stages.

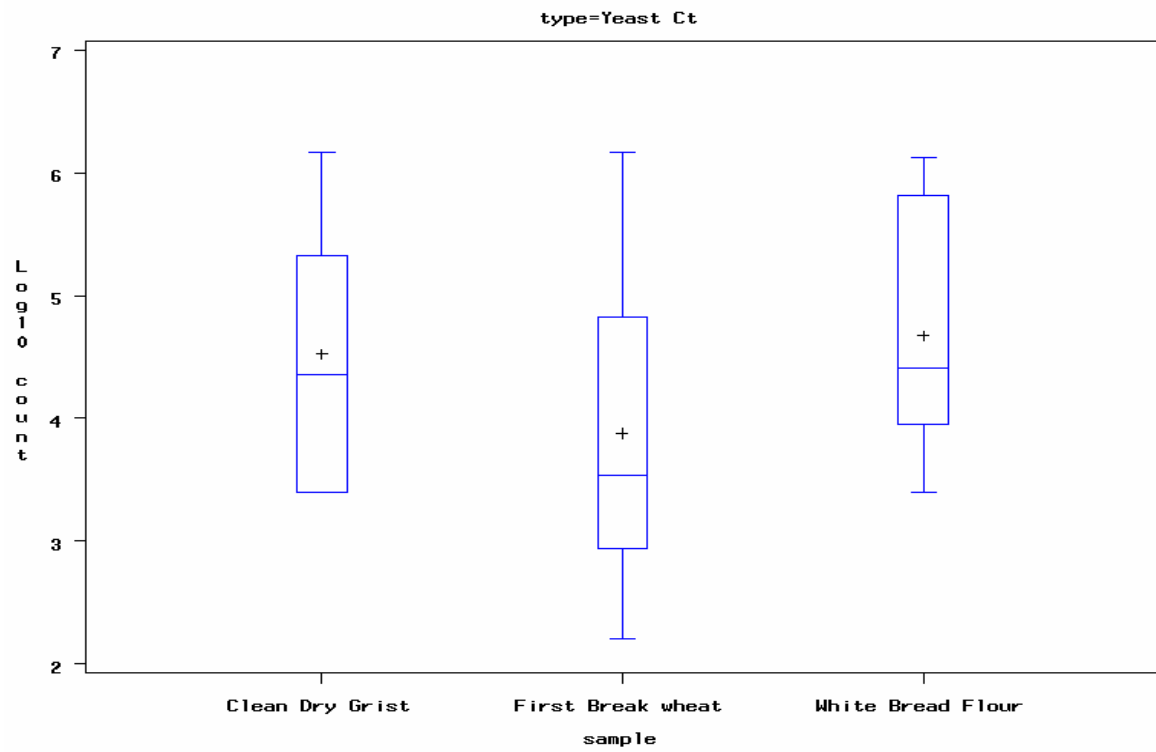
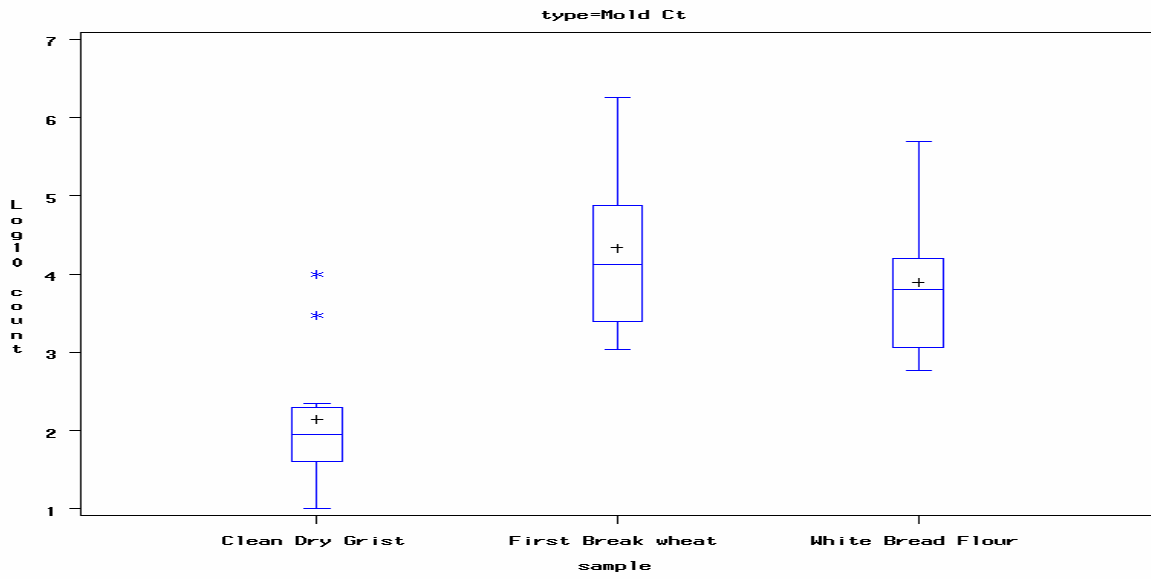
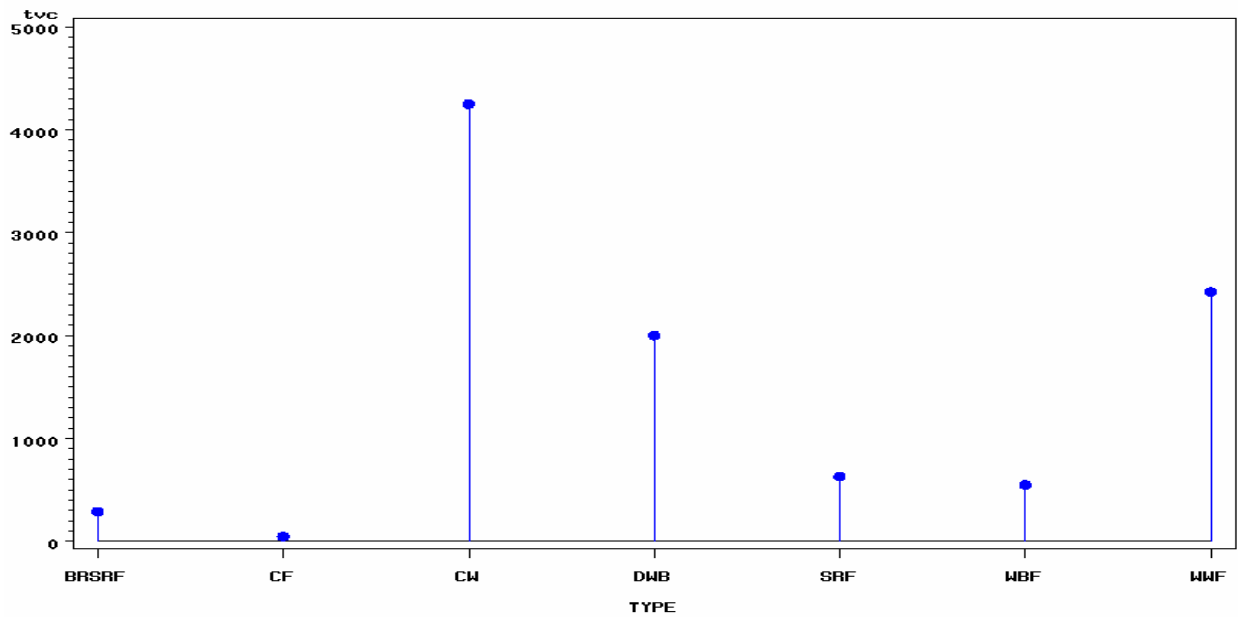


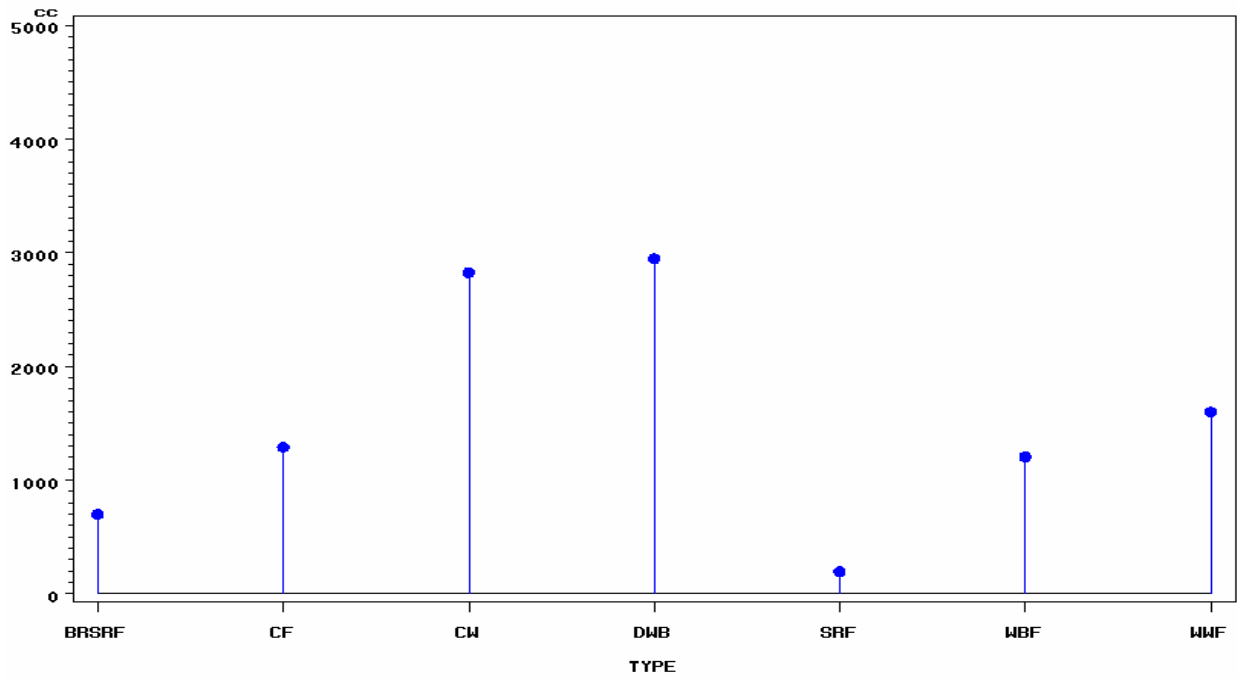
Fig. 6.3 Yeast counts at the various sampling stages.



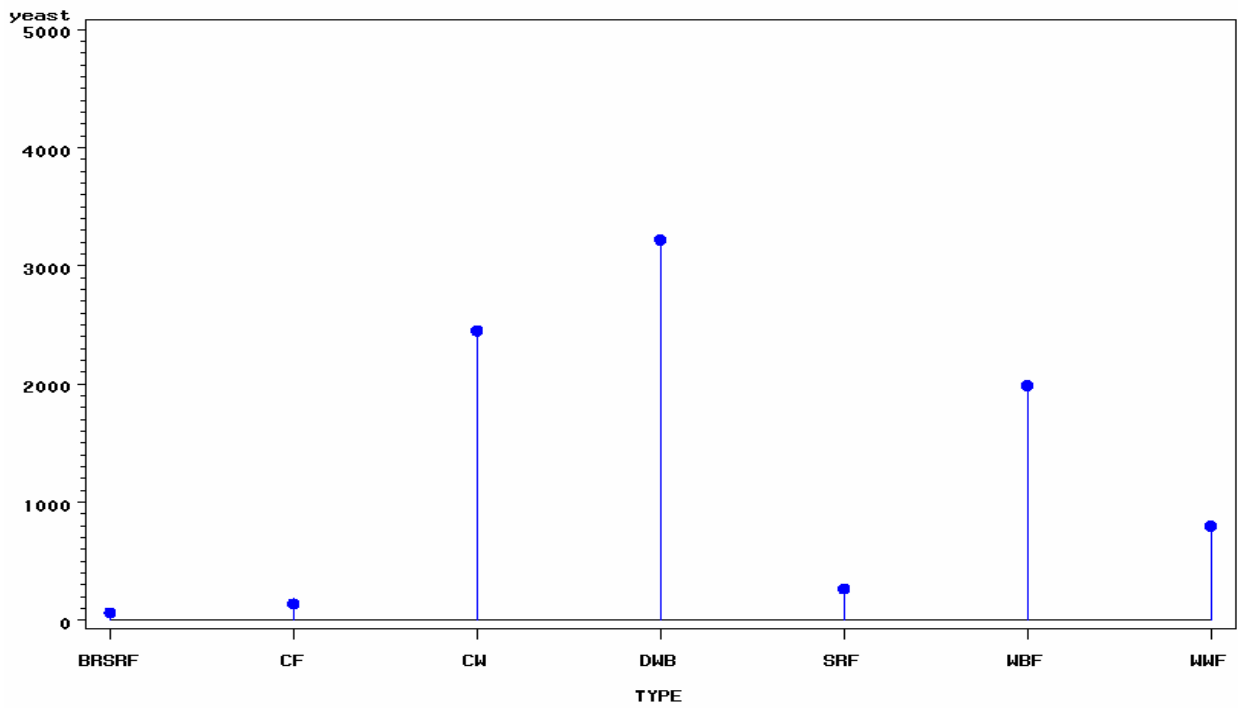
**Fig. 6.4** Mould counts at the various sampling stages.



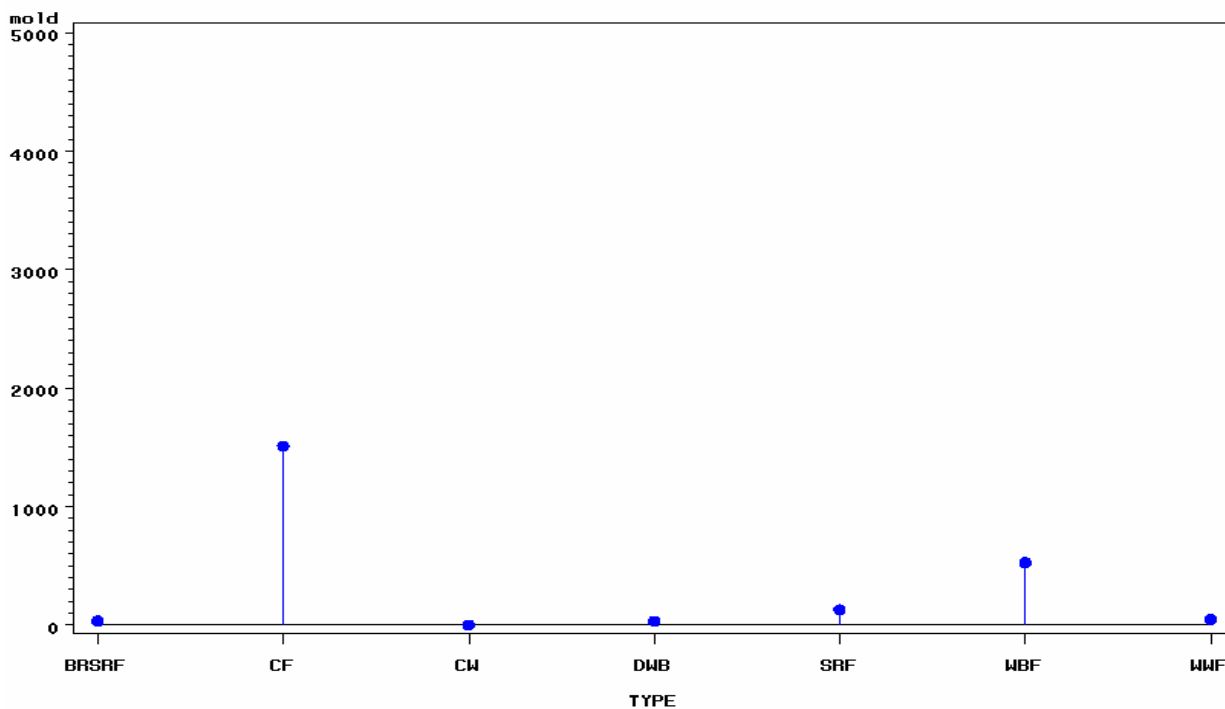
**Fig. 6.5** Average total viable counts for various final packaged products.



**Fig. 6.6** Average coliform counts for various final packaged products.



**Fig. 6.7** Average yeast counts for various final packaged products.



**Fig. 6.8** Average mould counts for various final packaged products.



## 6.5 DISCUSSION

Overall the microbial counts were very high at the initial stages of the milling process except for the mould count. The reason for the high counts was due to external factors that could have had a major impact on the cleanliness of the wheat. Weather conditions play an important role in contamination, other factors that had to be taken into consideration were pest infestation, pesticides used, cleanliness of the harvesting equipment and transport used as well as human handling. The mould counts were the lowest at this stage (Fig. 6.4) and could be due to the use of anti fungal treatment or pesticides or it could be due to the difficulty to visualize mould growth.

A noticeable reduction in total viable counts (Fig. 6.1) and yeast count (Fig. 6.3) took place at first break wheat. The coliform (Fig. 6.2) and mould count (Fig.6.4) however showed an increase in micro-organisms which was expected due to the tempering of the

wheat that also took place before the first break sample were drawn (Obuchowski and Strybe 2001). The wheat at this point in the milling process have already undergone numerous cleaning processes within the cleaning house of the mill and the scouring process where the wheat kernel are polished could be responsible for the reduction of total viable counts and yeasts.

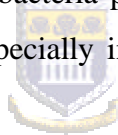
The milling process with various break and reducing rolls as well as sieving equipment such as purifiers, plan sifters and vibro sifters followed before the next sampling stage. The milling process separated the endosperm from the bran by breaking the wheat kernel into smaller fragments because only the endosperm had to be used in the milling process (Mousia and Pandiella 2004). White bread flour sampled directly from the mill showed a slight decrease in mould (Fig. 6.4) and coliform (Fig. 6.2) counts but the total viable counts (Fig. 6.1) and yeast counts (Fig. 6.2) remained relatively high. The decrease in moulds could be linked to the lower water activity levels than in the previous stage where conditioning water was added. The coliform count was lower due to the lowering of temperature to room temperature. The increase in total viable counts and yeast counts could be due to the addition of contaminants in the process itself such as the water added at the conditioning phase, dead ends in the pipe work or maybe contamination from the human handling or machinery (Obuchowski and Strybe 2001).

The expected outcome for this series of experiments was that the milling process would reduce the micro-organisms that came in with the wheat to acceptable levels in the final product because the majority of bacteria are centered on the outer layers of the wheat kernel that surrounds the endosperm (Mousia and Pandiella 2004). This is only true for the coliform counts. For the rest, the total viable counts and yeast counts, it remained the same or even increased in numbers the same is true for moulds.

The already packaged product that was purchased off the shelf had lower microbial counts than those sampled directly from the mill (Fig. 6.5 – Fig. 6.8). This was expected because the flour was stored under conditions that could reduce the growth of micro-organisms. Factors such as the moisture content and the type of packaging played an

important role in controlling the activity of micro-organisms as well as the shelf life of flour (Butt *et al.* 2004). The moisture content of the packaged flour has been approved by the quality assurance team of the manufacturer and it was stored in the preferred paper bag packaging at room temperature.

Currently no microbiological specifications for flour exist in South Africa but if it has to be categorized according to regulation 692 of the department of health, it could only fall into the category of dried spices and aromatic plants (Anon. 1997). It specifies that total colony counts should not exceed 1 000 000/g, yeasts and moulds should not exceed 10 000/g and coliforms should not be more than 1 000/g. For the white bread flour sampled directly from the mill according to above regulations the coliform count of  $6.43 \times 10^4$  cfu was out of specifications. The white bread flour, cake flour and self raising flour purchased off the shelf, had counts within specification. Only those final products containing bran had coliform counts that were out of specification with the highest being the digestive wheaten bran with 6200 bacteria per gram. However, the counts are still very high and can be a health risk especially in cases where the flour is not used for baking purposes.



The other products especially those where the bran has not been removed completely such as the whole wheat flour, bran-rich self raising flour and the digestive wheaten bran itself, were expected to have overall higher counts since most of the micro-organisms are found in the bran and outer layers of the wheat kernel. The expected results were confirmed because the crushed wheat, digestive wheaten bran and whole wheat flour had the highest total viable and coliform counts. Crushed wheat and digestive wheaten bran also had the highest yeast counts but the mould counts were merely non-existent. Again the use of an anti fungal treatment on the wheat kernel could be the reason for the counts.

## **6.6 CONCLUSION**

According to results obtained for total viable and yeast counts during this test period, the amount of micro-organisms that came in on the raw wheat, were the same as the



amount of micro-organisms that went out with the final product. The mould counts increased in the final product, only the coliform counts showed a significant decrease. However, it should be kept in mind that the grist was not constant over the sampling period and depending on the region it came from, it could have very high, very low or average microbial counts. Although the milling process was supposed to have a positive effect on the reduction of microbial counts, processes or procedures within this specific mill could have been the source of contamination to the final product. Therefore the pre-requisite programs such as the good manufacturing practices should be in place in order to produce a product that is safe and of good quality. Factors such as the quality of the water used for the conditioning phase, air quality used for pneumatic conveying, equipment that have been improperly cleaned, personal hygiene, proper training of personnel, standard operating procedures, proper storage of materials and products, disposal of waste, maintenance of equipment and quality control could have a major effect on the microbial numbers of the end product.

Most of the micro-organisms were situated in the outer layers and bran of the kernel. Overall those products that were bran enriched or where the endosperm alone was not milled had higher microbial counts than the flour products where the bran was entirely separated from the endosperm.

Certain fungi produce mycotoxins that are heat stable and when activated can be the cause of major health problems to the consumer. Debranning systems have the advantage of removing the outside layers of the wheat kernel gradually and effectively removing all the bran containing the microbes (Mousia and Pandiella 2004). Therefore it is advised to have such a system in place to eliminate microbial contamination in flour products.

In order to decrease flour contamination, the level of microbial contamination on the incoming wheat has to be reduced or the technology of flour milling has to be improved (Obuchowski and Strybe 2001). The shelf life of flour could also be increased by controlling the water activity in the product as well as through proper packaging and storage (Tessier 2004).

## 6.7 ACKNOWLEDGEMENT

The statistical analysis of the data used in this chapter was analysed by Professor Richard Madsen, a visiting professor from the University of Missouri, USA. Professor Madsen visited the Department of Statistics at the University of the Western Cape during May 2005 and used version 9.1 of the SAS system to analyse the data and in processing the plots Fig. 6.1 – 6.8.

Ref.: SAS Institute Inc., Cary, North Carolina, USA

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## CHAPTER 7

### GENERAL CONCLUSION

It is quite evitable that no food handling enterprise would want to see consumers falling ill from the foods they produce and at the same time loosing the trust of the customers and its reputation (Mortarjemi and Mortimore 2005). Globally there has been an increase in the consumers' awareness of food safety due to some major food safety failures however food borne disease are still on the increase (Panisello and Quantick 2001).

Factors that contribute to outbreaks are temperature misuse, inadequate handling, inadequate environment and the ingestion of contaminated raw materials (Panisello *et al.* 2000). However food handling enterprises cannot always guarantee the absence of pathogens therefore it is insufficient to improve the microbiological quality of foods alone, since foods can easily become recontaminated. Extreme pressure from governments, consumers, media, academia, retailers and the food-service industry as well as the food industry itself also occur (Mortarjemi and Mortimore 2005). In collaboration with all these sectors, and by meeting their expectations, it will be able for the food industry to prepare a safe product for consumer use.

Food safety has been based on end-product testing in the past but it has its limitations such as time delay, as well as the high cost of the direct monitoring of microbial pathogens (Unnevehr and Jensen 1999). It can also be extremely costly, especially if contaminated product is reported once production is already complete. Adding to this economic loss of a company is the recall of the defective product from the retail outlets (Tokatli *et al.* 2005).

Therefore, the most secure and cost-effective method to monitor the physical, chemical and biological hazards from farm to fork in order to produce a safe product is the HACCP system (Efstratiadis and Arvanitoyannis 2000; Panisello *et al.* 2000).

HACCP is not mandatory in terms of the law in South Africa, however, the local trend is to work towards HACCP accreditation so that when government does list a specific sector, certain leaders in the food industry are already in the process or have completed the process of being HACCP certified. Therefore, the aim of this study was to give the flour milling industry some guidelines to follow in the form of pre-requisite programs and a generic HACCP model that can be adapted for individual needs.

Overall HACCP has been regarded as “the magic concept that’s capable of solving all food safety problems” (Heggum 2001) but there are various technical barriers that need to be overcome in order for the HACCP plan to work effectively (Panisello and Quantick 2001). Barriers that might affect the project before HACCP implementation are: the illusion of control, company size, the type of product, the industry sector and the customer’s food safety requirements. Barriers during the process of HACCP implementation are: the lack of HACCP program leadership, lack of co-operation between the industry and the enforcement authorities, personnel persisting with their old habits and attitudes, the lack of time for staff to implement HACCP, the lack of staff motivation and supervision, dealing with a lot of paperwork, lack of equipment or poor design thereof as well as incorrect plant layout. Barriers after HACCP systems have been implemented include: difficulties in the verification and validation of the HACCP plans and the lack of equivalence (Panisello and Quantick 2001).

There are numerous reasons why HACCP programs fail and the most important one is because the pre-requisite programs are not in place. In such situations it can lead to the over complication of the HACCP plan with too many critical control points that could not be managed in the end. Some of them not even true critical control points. It is advised that only the significant hazards are covered in the HACCP plan and that the general hygiene issues should be covered in the pre-requisite programs (Wallace and Williams 2001). In other cases HACCP is a paper exercise or once HACCP has been attained, the program is lapsed because of improper maintenance. It is also important that the HACCP plan should be designed, implemented and verified by an interdisciplinary team and not

just an individual such as the quality assurance manager otherwise HACCP is doomed to failure in such a situation (Higuara-Ciapara and Noriega-Orozco 2000).

In order for a HACCP program to be successfully implemented, managed and maintained, four stages were identified to make HACCP work in practice (Mortimore and Wallace 1995; Mortimore 2001): Firstly, the proper preparation and planning before the seven principles of HACCP are applied which include proper training and resources such as time and money. Secondly, the application of the seven HACCP principles identified by the Codex Alimentarius Commission (CAC 1997). Thirdly, the implementation of the HACCP program and last but not least, the maintenance of the HACCP program. Maintenance is of utmost importance because most companies are relieved once the HACCP plan is implemented but they forget that in order to produce safe and quality food, the plan needs to be maintained at all times.

There is no doubt that the biggest benefit of implementing HACCP is food safety. Food safety is not an option but rather a requirement to keep customers happy and to improve market share. Other benefits that come along with the implementation of HACCP are: fewer customer complaints, maintaining the company's market position, a reduction in liability as well as an increase in efficiency and waste control (Bliedung 1997). Food handling enterprises that adopt the HACCP system whether they're big or small can also boast with improved confidence, a reduction in costs, a more focused approach on what's important, improved team building, more development within the organisation, legal protection and more trading opportunities (Taylor 2001).

Two critical control points were identified for the purpose of the generic HACCP plan which are: a rebolt sifter, metal detector and impactor system to control physical hazards as well as the mix-back system that should be managed in order to control mainly biological hazards as well as physical hazards that enter the mill by means of returns.

The microbiological analyses of the wheat proved that the raw material received from the farms, are not of the best quality and that a definite need for Good Agricultural Practices

exist. Also that the microbial load that came in with the raw wheat were more or less the same as the microbial load on the final flour product. Previous studies have shown that the concentration of micro-organisms were found in the outer bran layers of the wheat kernel and was confirmed with the results achieved from the analyses of various final products. Those products that contained bran had remarkable higher microbial counts than the flour itself. Therefore in order to lower these microbial loads on flour, it is advised that the pre-requisite programs such as the Good Manufacturing Practices (GMPs) and Good Agricultural Practices (GAPs) should be in place. A debranning system could also be an advantage since it reduces microbial counts.

If it is considered that not all flour products are used in the baking or cooking process, it is quite evitable that food poisoning problems due to contaminated flour may occur. Therefore it is important that the flour milling industry adapt HACCP systems in order to manage the food safety hazards identified.

It is important to note that HACCP is not a stand alone but it can be regarded as a supplement to already existing hygiene practices (Heggum 2001). Therefore, food safety is HACCP plus pre-requisite programs (Sperber 2005).

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