ASSESSING THE FEASIBILITY OF MAKING EGG POWDER AT RURAL COMMUNITY LEVEL FOR IMPROVED HOUSEHOLD FOOD SECURITY

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ABSTRACT

Limited knowledge of egg storage and preservation methods has led to the underutilisation of eggs in rural communities, and yet if rural communities could process the eggs into powder as is commercially done, their food security could improve. Processing the eggs into egg powder by sun-drying seems an economically appropriate technology for rural communities, but could negatively impact on the quality and safety of the eggs and as such should be assessed. This study was carried out in the area of Impendle in KwaZulu-Natal Province of South Africa to investigate the feasibility of making egg powder at rural community level. The study investigated consumer perceptions on egg consumption and use, their storage and preservation methods used on eggs locally, as well as consumer knowledge on current egg preservation technologies being used in food manufacturing industries. The results of the study indicated that rural households regarded eggs as nutritious food that forms part of the household monthly food basket. Nonetheless, egg consumption is still subjected to cultural beliefs. The study also revealed an interest in consuming indigenous eggs, but challenges such as inconsistent supply, losses associated with deterioration and predators were noted as the primary barriers. Due to these barriers the community of Impendle mainly consumes commercial eggs. The disadvantages noted with the purchasing of eggs are affordability, perishability; and limited access to egg retailers.

The study further investigated the effects of sun drying and oven drying of eggs in a home setup. A sample of eggs was sun-dried and another oven-dried into powder. The microbiological quality and safety of the egg powders were assessed against an egg (control) using standard methods. Sun dried eggs had the flavour of the fresh eggs, but had a darker colour than that of fresh eggs. After 16 days, the sun dried eggs had a rancid flavour. The oven dried eggs had a cooked flavour and their colour closely resembled that of sun dried eggs. These egg powders did not show signs of physical deterioration over a period of eight weeks. Microbiological analysis results showed that the egg powders met the standards for egg quality and safety as indicated by their levels of *Salmonella spp., E. coli, Coliforms, Listeria monocytogenes,* and Total Plate Count.

The acceptance of egg powder by the rural community was determined by sensory evaluation and focus group discussions. A 63-member consumer panel recruited from the study rural community assessed the sensory acceptability of a scrambled commercial egg powder compared to a scrambled fresh egg on 5-point facial Hedonic scale, 1= very bad; 5= very good. Focus group discussions were conducted to investigate the perceptions of the local rural community about the consumption of egg powder. Focus groups consisted of eight to 12 people drawn from the egg consumption/questionnaire survey participants. The findings showed that the participants could tell the difference between the fresh egg and egg powder in terms of colour and flavour; the flavour of the fresh egg was more acceptable to the panellists than that of the egg powder. With regard to taste, the consumers liked both eggs. Although the focus group panellists indicated that it was their first experience with egg powder as a food item, they generally had positive perceptions about it and thereby showed an eagerness and willingness to learn about egg powder and to use the egg powder technology for improving their food security.

This study shows that eggs are a common and significant food source for the rural community of Impendle. However, this community faces challenges in the utilisation of eggs due to their perishability, which is confounded by their little knowledge on egg storage and preservation, and a limited access to egg retailers. The findings of this study suggest that processing eggs into powder could be a successful preservation method at rural community level, which could improve household food security. If done under hygienic conditions as in this study, the egg powder would be of acceptable microbiological quality safety for human consumption. The study was limited to a small sample of the rural community of Impendle and the study participants did not practically try the technology of processing egg into powder by sun-drying; further studies should, among other issues, address these before attempting to roll out the technology.

DECLARATION

I, **ELIZABETH MNYANDU** hereby certify that I am the sole author of this thesis and that no part of this thesis has been published or submitted for publication.

I certify that, to the best of my knowledge, my thesis does not infringe upon anyone's copyright nor violate any proprietary rights and that any ideas, techniques, quotations, or any other material from the work of other people included in my thesis, published or otherwise, are fully acknowledged in accordance with the standard referencing practices.

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Signed  Date: 16 March 2014

As Research Supervisor, I agree to submission of this thesis for examination.
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As Research Co- supervisor, I agree to the submission of this thesis for examination.
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As Research Co- supervisor, I agree to the submission of this thesis for examination.
Dr. Eric O. Amonsou

Signed  Date 17/03/2013

DEDICATION

To my two boys Hloniphani Lifa Mnyandu

and

Mpumelelo Muziwandile Mnyandu

Luke 18 verse 27 is real!

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To the Impendle communities thank you for allowing me to do my research in your area.

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CHAPTER 1: STATEMENT OF THE PROBLEM

1.0 Introduction

Chicken eggs are categorised as a complete food for the population which is below the poverty line and devoid of nutritious diet (Luber 2009), are an important source of proteins and other nutrients (Cherian 2008). Currently, at household level eggs are eaten fresh, fried, boiled, scrambled or poached and have been used successfully as a source of protein in rural communities (Chauhan & Sharma 2003; Ojo 2003). This is because eggs are a cheaper source of protein compared to other sources (Bunchasak & Kachana (2009). The challenge that remains is that eggs do not have a long shelf life and usually spoil and/or are lost due to breakage. When this happens, many households remain with no immediate source of proteins as some might not be able afford to buy meat daily. This is not only a challenge to the households but also to small-scale farmers who farm laying chickens and seek to sell their eggs into the market. According to Hendriks, Lyne & Chitja (2009) the small-scale farmer is challenged by limited access to markets due to infrastructure, supporting services and manipulation in the fresh egg markets by commercially well-established farmers and thus the small-scale farmer lose some of their eggs to spoilage and or breakage.

Egg production varies throughout the year. Many factors are attributed to variations, such as age, breed, feed, climate and body weight (Mutayoba *et al.* 2011). In winter, egg production tends to be lower (Cherian 2008). As a result of varying egg production patterns, there are periods where households do not have an adequate amount eggs to use as a source of nutrition. The major practices are storage at room temperature and in refrigerators. A study by Jirangrat *et al.* (2010) shows that when stored at room temperature, an egg lasts for 14 days after which it becomes runny. In a refrigerator, eggs will last for 4 - 6 weeks, however most rural households do not own these appliances. It is therefore important to employ a preservation method for eggs that would be appropriate at rural community level to reduce unnecessary egg losses.

Rural farmers practise limited preservation options for eggs and have mostly stored their eggs fresh at room temperature (Ibnouf 2012b). The literature available indicates that it is possible to make egg powder at industrial level (Heidlas *et al.* 1997) and that egg powder has successfully been made at industrial level using spray drying technology (Chen *et al.* 2011; Jingbo *et al.* 2011; Koc *et al.* 2011; Wenzel *et al.* 2010). Egg powder is currently available in

the market and is used as an ingredient in many foods such as soups, cakes and biscuits. In some instances it is also reconstituted to obtain the original whole egg that is then fried or scrambled for consumption. Egg powder has a shelf life of up to one year. It does not take too much space and is easy to handle compared to whole eggs. Egg powder is associated with lower transport and storage costs (Koç *et al.* 2011a). Drying is known for its ability to lengthen shelf life of foods. It has been used successfully in drying meat, cereals, fruits and vegetables by rural households (Sagar & Suresh Kumar 2010). However preservation of eggs by making egg powder at the rural community level is either not documented or is not practised.

The aim of this study is to determine the feasibility of making egg powder at the rural community level for enhanced food security and possible livelihood options thereof.

1.1 Research problem

There is underutilisation of eggs and associated economic losses at the rural community level due to lack of egg preservation knowledge.

1.2 General objective

To determine the feasibility of making egg powder at rural community level through the use of traditional drying preservation methods such as sun dying.

1.3 Objectives

1. To determine consumers' perceptions about the significance of eggs as a food source
2. To determine consumer's knowledge of egg preservation
3. To determine the acceptability of a product made from commercial egg powder by rural consumers
4. To compare the quality of oven dried and sun dried egg powder in terms of odour, colour and evidence of deterioration
5. To determine the microbiological quality and safety of sun dried egg powder and oven dried egg powder

1.4 Study limits and general assumptions

The study was conducted in Impendle area (Gomane, Eswampu and Nguge area) therefore the results of this research are applicable to Gomane, Eswampu and Nguge areas of Impendle. The same participants were used for objectives 1, 2 and 3. In the study it was assumed that all eggs were of same quality regardless of different breeds, age of the chickens and feed. Objective 3 was achieved in a home setting in Durban while objective 4 was achieved in a laboratory in Durban.

1.5 Outline of the thesis

Chapter one presents the background to the problem and sub problems investigated in this research. Chapter two reviews the literature on status of food security in South Africa, the role of in food security; and the nutritional value of eggs. Chapter three presents the description of the study area, Impendle.

The two chapters that follow present papers that cover the sub problems of this study. Chapter four presents the results of the investigation of the consumer's perceptions about the significance of eggs as consumption food source. Chapter five presents results on microbiological assessment of the egg powder that was sun-dried and oven-dried. Conclusions and recommendations are presented in chapter six.

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CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

Eggs are a rich source of animal protein as well as vitamins, fats and minerals (Ojo 2003). However, consumers have different perceptions on egg consumption and benefits varying from social status, dietary, health and also cultural perceptions. Eggs are highly perishable. Unfortunately rural consumers have limited knowledge of egg storage and preservation. This has contributed to the underutilisation of eggs in rural areas. Egg production is also not constant throughout the year as it is affected by seasonal changes. Egg utilisation in rural areas may be increased if the communities acquired appropriate egg storage and preservation knowledge and skills.

This chapter will review consumer perceptions about egg consumption, the role of eggs in food security, nutritional status of rural communities, and the state of food security in South Africa, as well as traditional food preservation techniques which contribute to food security in rural areas.

2.1 Consumer perceptions about the consumption of eggs and their significance as a food source

Despite the fact that the consumption of eggs has a potential to decrease child and adult malnutrition, research has shown that most rural consumers perceive eggs as a food consumed for luxury and as a source of income, rather than as an important protein source for their households (Alders & Pym 2009; Aklilu *et al.* 2008). Eggs, to a certain extent, are associated with households with a high social-economic status. Aklilu *et al.* (2008) reported that egg consumption is uncommon among the Ethiopian poor community as it is considered a luxury. To support this, Alders & Pym (2009) reported that in Mozambique it was only the better off families that raised chickens for home consumption, whilst poor families raised chickens for batter trade and traditional purposes. Eggs are also considered a luxury in Mali by certain families as reported by Integrated Regional Information Networks (IRIN 2012). According to Food Marketing Institute (FMI) (1996), to some consumers, eggs are not eaten for nutritional purposes, but are because they taste good (FMI 1996). This has seen many families, especially among African people, depriving their children of eggs as they are viewed as a high-value only to be consumed by adults.

Some rural consumers also prefer not to eat eggs but leave the eggs to hatch for multiplication. These consumers value the chicken more than the egg. In a study done in Ethiopia, Moges *et al.* (2010a) found that eggs were mainly used for hatching (71.7%) followed by selling for cash income (68%) and home consumption (58.6%). In another region of Ethiopia, Leta & Bekana (2010a) found that eggs were used to generate income for home expenditure (44%), followed by home consumption (24%), for ceremonies (22%) and sacrifice (10%). In Zimbabwe, Alders & Pym (2009) found that the major value for chicken eggs was to increase flock and Moreki *et al.* (2010) reported that the majority of egg producers (52.27%) did not consume or sell eggs, but used them for breeding, especially during cooler months of the year, while 41% of the producers consumed the eggs.

Egg consumption has also been limited by health concerns. For a long time, blood cholesterol levels associated with egg consumption has raised consumer concerns (Sim 2004). This has led to long-held beliefs that eggs are responsible for high blood cholesterol levels, hence causing consumers not to give them priority as a food item (Goddard *et al.* 2007). A survey conducted by the International Food Information Council (IFIC) cited by Thompson *et al.* (2011) showed that 74% of adults surveyed named foods other than eggs as being associated with health benefits. The foods mentioned included broccoli, oranges, carrots, and garlic. This evidence shows that consumers still fear for their health and would rather choose other foods to substitute the value that comes with eggs. However, more recent findings show that there is no relationship between egg consumption and blood cholesterol level or the incidence of heart disease (Kanter *et al.* 2012).

Some consumers do not eat eggs for the fear of food borne pathogens such *Salmonella* (Luber 2009) and also diseases like avian influenza (Hsu *et al.* 2008). It is widely known through research that eggs have a high risk of *Salmonella* and they have been a habitat of this pathogen from ancient times. As much as this is true, the message has been wrongly sent to the consumers to such an extent that the nutritional value of eggs has been overtaken by health risk concerns.

2.2 Beliefs and theories about egg consumption and use in African households

Poultry has a special symbolic importance in the social life and cultural functions and ceremonies among African people. Studies reported that, in some parts of Ethiopia, eggs are

consumed for religious reasons (52.8%). About 42.5% households eat eggs when needed and available whilst 2.5% eat them when they got sick. About 2.2% reported to not have eaten eggs (Moges *et al.* 2010a). Eggs and chicken are also considered as an important dish that cannot be consumed regularly but are reserved for important visitors (Molla 2010).

There are still egg consumption restrictions in some regions of Africa, most of which affect women and children (Meyer-Rochow 2012). Research done by (IRIN 2012) revealed that egg consumption by women and children in certain parts of Mali was associated with bad luck. Similarly just married wives are not allowed to eat eggs and certain types of meat in some cultures in Rwanda, and children under the age of five are also not allowed to consume eggs as it is believed to impedes their speech (Ojulu 2012). In Uganda, women and children over six years of age are forbidden to consume eggs, poultry, mutton, pork and certain kinds of fish (Jelliffe & Bennett 2004). However, these taboos are no longer strictly observed and are ignored by the more educated persons across Uganda and other African regions. The changing technology and economy is also loosening the grip of the taboos.

2.3 Nutritional status of rural communities in Africa with particular focus on South Africa

Undernourishment and malnutrition are major problems in many developing countries, especially in the sub-Saharan countries. Malnutrition is associated with reduced mental and physical development. In general, a poorly fed population reduces economic productivity (Vorster 2010). Of major concern among children and adults are Vitamin A, protein and iron deficiencies, which can be avoided by consumption of poultry meat and eggs (Moreki *et al.* 2010). Protein is essential for both growth and maintenance of muscle mass. Iron also has many physiological roles such as support of the immune system and transport of oxygen, while Vitamin A plays a role in vision and immunity among other functions (Roy *et al.* 2012).

Under-nutrition in South Africa mostly affects children who live in rural area and whose parents have low educational status, coupled with low or no income (Iversen *et al.* 2012). Statistics reported by Faber & Wenhold (2007) show that, in South Africa, 33.3% of preschool children are Vitamin A deficient, 21.4% are anaemic and 5.0% suffer from iron deficiency anaemia. These prevalence figures for childhood malnutrition also vary from province to province. Research done by Mamabolo *et al.* (2005) cited by Faber & Wenhold

(2007) showed that 19% of three-year-old children in the central region of Limpopo Province were stunted. In another study by Kimani-Murage *et al.* (2010) in Mpumalanga Province, stunting was at 18% for children aged between one to four years. Boys were significantly more underweight compared to girls at ages five, thirteen, fourteen and fifteen. The prevalence of wasting was approximately 4% to 9% between ages two to nine years.

Malnutrition also affects other regions of Africa. Hart (2009) describes sub Saharan Africa as a region that is struck by chronic food insecurity. In his report, he concludes that 33% are undernourished, 25% of its children are underweight and 33% are stunted. A sign of chronic malnutrition was also noted in Mali by (IRIN). The research indicated that 15% of children younger than five years were underweight and two out of five children in the same age group were stunted (IRIN 2012). Studies by Oldewage-Theron *et al.* (2006) indicated that there is high prevalence of underweight and stunting in Africa as shown in the Table 2.1

Table 2.1: Prevalence of stunting and underweight among children in Africa (Oldewage-Theron *et al.* (2006)

Region	Underweight	Stunting
Eastern Africa	30.6%	8.7%
West Africa	26.8%	10.2%
Central Africa	25.3%	11.9%
Southern Africa	13.6%	6.6%
Northern Africa	8.6%	8.0%

Table 2.1 shows that malnutrition (underweight and stunting) problems are worse in East Africa, West Africa and Central Africa than in Southern and Northern Africa.

2.4 The status of food security in South Africa

The Food and Agricultural Organisation (FAO) reported South Africa as a food secure nation able to produce enough staple food for its population (FAO (2008b). The national food self-sufficiency index from the South African Department of Agriculture, Forestry and Fisheries illustrated that South Africa is food self-sufficient in almost all the major food products, with the ability to import shortages when necessary as well as being able to meet the food needs of its growing population (Du Toit *et al.* 2011). In another related food security assessment report, Koch (2011) reported that South Africa is a net exporter of agricultural commodities.

Hart (2009) argues that South Africa is to some extent food insecure, with cases of food insecurity prevailing much in the rural areas. Iversen *et al.* (2012) reported that 75% of the chronically poor people are found in rural areas. Labadarios *et al.* (2009) agrees to South Africa's national food secure status, but suggests that about 35% of the population in the country are vulnerable to food insecurity.

Statistics South Africa (SSA) conducted a General Household Survey in 2009 and reported that an estimated 20% of South African households have severely inadequate food access (SSA 2009). This is a 6% increase from the year 2004 The Human Sciences Research Council (HRSC) estimates of 14% of the population to be food insecure (Koch 2011). The General Household Survey (GHS) report for 2010 estimated that 21.9% of the households had severely inadequate access to food (SSA 2011). This is a 1.9% increase to the previous year's estimates. Iversen *et al.* (2012) estimated stunting of children at 20%, most of which were in rural areas. Table 2.2 presents food access problems as recorded by Statistics South Africa in the 2010 GHS.

Table 2.2: Percentage food access problems per province of South Africa (SSA (2011)

Region	**% Food access problems**
North West	33.3%
Kwazulu-Natal	26.9%
Northern Cape	26.0%
Free State	23.6%
Limpopo	20.6%
Eastern Cape	20.3 %

Table 2.2 shows that the highest food access problems are experienced in the North West province and they are almost the same in Kwazulu-Natal and Northern Cape provinces. The Limpopo and Eastern Cape Provinces seem to have the least food access problems. Many problems have been cited as causes of food insecurity among which are high unemployment rate, HIV and AIDS, limited education and unequal distribution of resources (FAO 2008b). Eggs have a potential to significantly reduce food insecurity in rural communities.

2.5 The role of eggs in the food security of rural communities

By definition, food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life (FAO 2008a). Food security is embedded in the fact that every human being has a right to adequate food. The right to adequate food is realised when every man, woman and child, have physical and economic access at all times to adequate food or means for its procurement (FAO 2007). Food can be defined as 'adequate' if it satisfies the dietary needs of people regardless of gender, occupation and culture. As stated by Chauhan & Sharma (2003) eggs are adequate and complete food that can be consumed across gender, occupation and culture.

Many rural households are experiencing a great difficulty in securing adequate food in both quantity and quality. Available literature purports that the problem of food insecurity is pervasive in sub-Saharan Africa (FAO 2011; Rosen & Shapouri 2008). Research has shown that, in rural communities, poultry farming for egg and meat production is exercised to use as food or for income generation and that eggs are relatively cheap compared to other nutritious foods (Moreki *et al.* 2010). Although research has shown that indigenous chickens and small scale egg-layer farming form an integral part of the rural society with a potential to combat food insecurity and enhance livelihoods (Moreki & Montsho 2011; Moges *et al.* 2010a), very little has been done to improve the productivity of indigenous chickens and layers at rural level. For years, eggs have been underutilised as a source of food in rural communities. FAO's evaluation in Mali concluded that poultry farming plays an important role in urban and peri-urban food security (IRIN 2012). The major drawbacks to the utilisation of eggs are their inconsistent availability, difficulty in accessibility and stability of egg supplies.

2.5.1 Availability of eggs to rural communities

Food availability; as defined by the World Food Programme (WFP), is achieved when sufficient quantities of food are consistently available to all individuals within a country (WFP 2012). In general terms it can be defined as the possibility of feeding one's family directly from productive land and or from processed foods obtained from markets (FAO 2007). Although eggs are a cheaper source of protein (Bunchasak & Kachana 2009), their availability is inconsistent. For eggs to form a part of food security they should be available

to every person at all times. Availability of eggs is currently affected by low yields faced by small farmers in the rural areas (Tshikosi 2009). For maximum egg production, there has to be a healthy flock. A healthy flock is determined by availability of food and proper health care. Health problems cause losses in flocks and reduce their productivity. Proper feed and healthcare is necessary for both indigenous chickens and layer chickens.

Diseases and parasites are common during wet and dry seasons, respectively, and the highest death rate of chickens is observed during rain seasons (Leta & Bekana 2010a). This causes extreme loss to layer flock thereby reducing the number of chickens available for egg production. A study conducted by Moges *et al.* (2010a) in North West Ethiopia indicated that 97.5% of indigenous chicken farmers experienced disease problems, New Castle Disease NCD ranking at 98.2% and being the most economically important. Similarly, Serkalem *et al.* (2005) and Kusina *et al.* (2000) cited in Moges *et al.* (2010a) reported that NCD was one of the major diseases affecting productivity of chickens in Ethiopia and Zimbabwe respectively. Most researchers agree that (NCD) is the most devastating disease considered to be a major constraint to development and productivity of indigenous and commercial layer chickens thereby affecting egg production (Okeno *et al.* 2012; Moges *et al.* 2010a; Moges *et al.* 2010b; Molla 2010; Mosisi 2010; Leta & Bekana 2010a; Tshikosi 2009).

Okeno *et al.* (2012) has noted supplementary feeding as one of the constraints in rural areas of Kenya. Lack of constant feed quantity and quality reduce the productivity of indigenous chickens. Supplementary feeding is readily available during harvesting period and little or no supplementation after harvest period in Kenya and Ethiopia (Okeno *et al.* 2012; Molla 2010). Lack of proper nutrition will cause a delay in egg production or reduced productivity. As a result eggs tend to be more available in hot wet seasons but the eggs during this period can deteriorate fast due to high humidity and high temperature (Leta & Bekana 2010a). Molla (2010) also found that the concentration of crude protein, calcium and phosphorus present in grains and weeds available during the rainy season were below the recommended requirements for egg production.

2.5.2 Access to eggs by rural communities

Having the food available is not enough to ensure food security. An issue of access also affects the status of food security for a community. Conceição *et al.* (2011) defines access as when households and all individuals within them have adequate resources to obtain appropriate foods for a nutritious diet. In rural areas, access to eggs is affected by infrastructure (physical access); money to purchase eggs for consumption and or money to purchase chickens to start egg production (economic access) (Tshikosi 2009). There is also limited access to knowledge about poultry farming and egg preservation. Furthermore, small scale farmers also struggle to buy feed for layers and or in cases where they depend on indigenous chickens, there will not be enough or adequate food for the chickens to produce eggs while challenges with their health care are also experienced.

Tshikosi (2009) identified unavailability of extension services for farmers in the rural areas in South Africa as causing losses to chickens that would otherwise provide more eggs. Most extension services that have been put in place do not target indigenous chickens and or small layer farmers in the rural areas. In another study in Kenya, Okeno *et al.* (2012) showed that only 36 percent of farmers practised health care in their flocks and most of them (52.2 %) used ethno veterinary medicines. Mosisi (2010) revealed that farmers in the rural KwaZulu-Natal treated their chickens traditionally with chopped aloe leaves, bark of Tambuti wood, vinegar and brown sugar. Findings by Moges *et al.* (2010a) also showed that 96.4% of villagers had no culture of vaccinating birds against diseases, 71.4% lacked awareness about presence of chicken vaccines, 13.6% of farmers did not give much attention to their birds and 15% complained of low availability of vaccines. Mapiye *et al.* (2008) found that a higher percentage of farmers do not treat their flocks during disease outbreaks and do not concentrate much on their flock's productivity.

Apart from the constraints mentioned above, farmers lose their eggs due to predators; small chicks do not mature to sexual age as they are targeted by wild snakes, thieves, cats, eagles and dogs (Gondwe & Wollny (2007). This is because farmers do not have proper structures for conserving eggs or for layering chickens. Farmers do not have the financial support to build such structures and or are not educated on egg preservation and conservation. Predators are a significant cause of chicken and egg losses (Molla (2010); Moreki *et al.* (2010); Gondwe & Wollny (2007) and Moges *et al.* (2010a). Snakes, ravens, dogs and wild cats eat

the eggs before the farmer can notice or pick up the eggs from the vulnerable places. Mosisi (2010) and Tshikosi (2009) identified lack of poultry production skills, limited access to information about marketing, financial constraints and poor flock and financial management skills as other constraints to effective egg production.

2.5.3 Stability of egg supplies in rural areas

Both food availability and accessibility must be stable. Stability according to food security is when the adequate food is available and accessible 'at all times' meaning that food must always be available throughout the year when needed (FAO 2007). This is a challenge when it comes to small poultry farmers in the rural areas. Seasonal variations and perishability of eggs negatively affect their stable, supply making it impossible for them to be available and accessible at all times year round. According to Broca (2002), a population is still considered food insecure if they have food access for a day but still have inadequate access to food on periodic or seasonal basis, thereby increasing their risk to malnutrition.

Besides seasonal variations, other factors are attributed to instability of egg supplies across the year; some of which are age, breed, feed climate and body weight (Mutayoba *et al.* 2011; Molla 2010). In winter, egg production tends to be lower than in summer (Cherian 2008). As a result of varying egg production patterns, there are periods when households do not have adequate eggs to use as a source of nutrition. In summer when eggs are plenty, a significant proportion of them are lost through deterioration because farmers have little or no knowledge on proper egg handling, storage and preservation. The eggs are lost through spoilage, breaking and or to predators, which affects their stable supply all year round.

2.6 Traditional preservation techniques for maintaining the availability and accessibility of food in rural areas

In African rural areas, several types of foods are eaten fresh, dried or processed into other forms. Fresh foods are normally eaten soon after harvest, while other consumers practise traditional preservation methods such as fermentation, drying and pickling (Ibnouf 2013). Leafy vegetables, fruits, meats and corn, among other crops are eaten fresh in rural areas during their ripening season (Hart 2011). The surplus produce is harvested and dried traditionally through sun drying methods for consumption when they are off-season (Tunde-Akintunde 2010). Indigenous foods have been considered safe and nutritious for rural

households. Moreover, they are inexpensive and most communities depend on them for dietary diversity and when there are food shortages (Ibnouf 2012a)

In South Africa, several traditional leafy vegetables are eaten and preferred fresh by consumers. However, they can also be dried and can be eaten dry (Ndlovu & Afolayan (2008). Popular among South African rural communities are cow peas leaves, amaranth, pumpkins leaves, jute mallow and spider plant (*Cleome gynandra*). In some parts of Africa, cow peas are dried to lengthen their shelf life and they become an important relish throughout the year. In South Africa, grasshoppers, termites, bees, mopane worms, stink-bugs, jewel beetles and white-grubs are also eaten fresh or dry (Teffo *et al.* 2007).

Traditional vegetables are mostly used by households who do not have sufficient income to buy enough meat or other expensive foods (Voster, van Rensburg, van Zijl and Venter 2007a). Thus, traditional vegetables have become important for rural household food security. The traditional drying of wild fruits and vegetables is also practised in other rural areas of Southern Africa (Motlhanka, Motlhanka and Selebatso 2008). It has been found to be a useful technology contributing to food security in Zimbabwe (Maroyi 2011) and Zambia (Nguni & Mwila 2007). Whereas drying has been employed traditionally in most food products in rural areas, it has not been tried on eggs which in rural communities are mostly eaten fresh boiled, scrambled fried or in baked products.

2.7 Drying as a food preservation method in rural areas

Direct sun drying as a method of preserving food has been practised in rural areas for many generations (Bechoff *et al.* 2011). It has been used successfully to dry meat, fish, vegetables, corn and fruits in most African countries. Drying reduces post-harvest losses (Usman (2010).

Reed mats or sacks are the common drying surfaces in rural areas. Drying facilities are placed on raised platforms or are spread on the ground. Putting drying facilities on platforms is done in order to protect vegetables from domestic animals and dust. Some households also dry vegetables on roof tops. Naturally occurring flat stone surfaces are also used for drying if they are available (Nguni & Mwila 2007). Some of the advantages of sun-drying are that the shelf life of the dried food is lengthened. There is less storage space required and minimal nutritional losses. In addition, sun-drying is considered to be the least expensive food preservation method (Samad *et al*. 2009).

2.8 Problems associated with sun-drying of food

Direct sun-drying has some disadvantages: it depends on the weather conditions; during winter and rain seasons and it is difficult to apply this preservation method as the food might take too long to dry. In winter, there is limited insolation and hence the temperatures are lower resulting in the drying process taking long. In summer, the temperatures are high but the rains cause the environment to be humid thereby causing minimal air circulation and vegetables taking long to dry or getting deteriorate (Hart 2011).

Sun drying also requires sizeable exposure surfaces if air circulation is to reach all parts of food items being dried. Sun-dried products are susceptible to microbial contamination by the action of insects, rodents or other small animals (Guiné *et al.* 2007). Ibeanu *et al.* (2010) also cited insect infestation as one of the problems associated with open air sun-drying. A survey done in Zambia, Nguni & Mwila (2007) found that most rural consumers who practised direct sun-drying complained of deteriorated products due to rain, wind, moisture and dust. Consumers also lost produce due to animals. Findings by Bal *et al.* (2011) also indicate that the harvested crops also deteriorate due to decomposition, insect attacks and fungi. In another study by Tunde-Akintunde (2010), consumers complained that the process is labour intensive, time consuming and requires a large area for spreading the produce out to dry.

Appropriate methods of egg storage and preservation (e.g. sun-drying) may improve the food security and nutrition status of rural households in South Africa. Unfortunately, it seems no research has been conducted to investigate whether processing of eggs into powder by sun-drying could be a feasible strategy to enhance rural household food security.

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CHAPTER 3: DESCRIPTION OF THE STUDY AREA

Impendle Local Municipality is one of the seven category B municipalities making up the Umgungundlovu District Municipality. Impendle Local Municipality is located within the western portion of Umgungundlovu District Municipality, which in turn is situated in the west of KwaZulu-Natal Province. The town of Impendle is centrally situated within the local municipality, and about 50 kilometres from central Msunduzi, another local municipality of the Umgungundlovu District Municipality, in which the town of Pietermaritzburg is located.

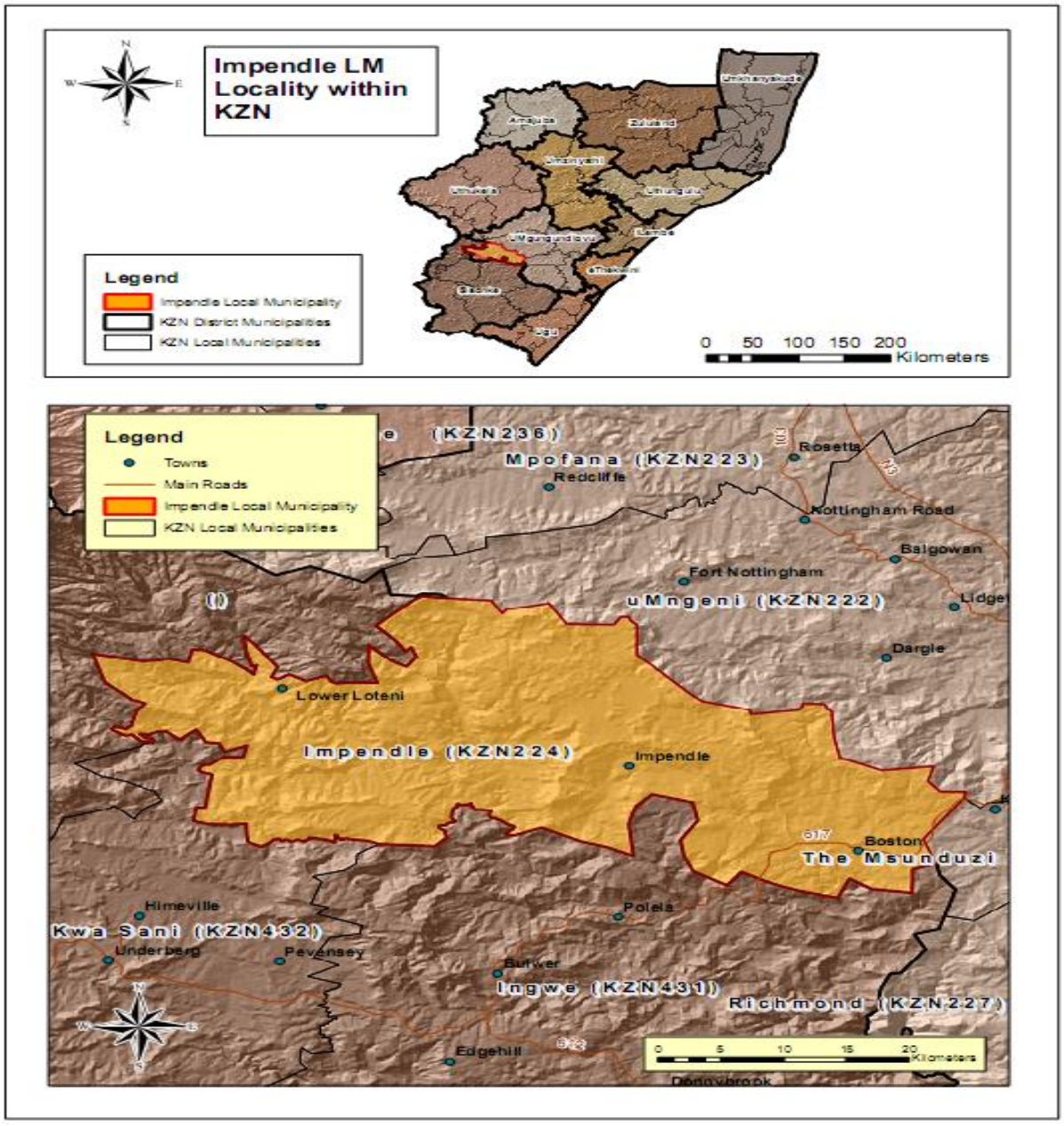

Figure 3.1: Map of Impendle and surrounding areas

The current population of Impendle municipality is about 35 000 people. The Municipality has experienced a population decline since 2001. This may be attributed to a variety of factors, including inaccessibility, poorly developed infrastructure, limited marketing, inability to compete in the regional economy and limited rates base. Through its integrated development programme, it is targeting key infrastructural and economic projects with to the aim of providing a platform for investment in development of the area in agriculture, tourism, services and processing industries.

The Impendle economy is predominantly rural, and highly dependent on agriculture. The municipality includes a large number of people living in poverty, and needs assistance to try and turn around the present downward economic trends. The roads that connect Impendle to the national routes are not direct, which has contributed to Impendle being economically marginalised. A lack of economic development is also reflected by poor service delivery. Road access was listed by the Integrated Development Plan Review (IDPR) as the third most important factor for the success of a business, the most important being the provision of electricity, followed by telephones and potable water. Economic interaction with adjacent municipalities in the uMgungundlovu District is severely hamstrung by poor road connectivity; whilst roads exist, these are generally in poor condition.

Impendle is arguably the least developed and most under-resourced local municipality within the uMgungundlovu District Municipality; however, it does have economically important resources that underpin its importance for economic development in the rest of the District. Economic strategies focusing on nodal development and the retention of the natural resource base are likely to render long term sustainability at the local municipality and district municipality scale (IDPR 2010).

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CHAPTER 4: CONSUMER PERCEPTIONS AND ACCEPTABILITY OF EGG POWDER AS A PRESERVATION TECHNIQUE FOR RURAL HOUSEHOLD FOOD SECURITY IN KWAZULU- NATAL, SOUTH AFRICA

4.0 Abstract

Almost all South African rural households produce chicken eggs with a potential to contribute to food security. Unfortunately, eggs are highly perishable and these households do not have access to modern food preservation technologies. As a result, a large proportion of the eggs are lost through deterioration. Egg powder is currently available commercially and when compared with fresh eggs, it is superior due to its longer shelf life and ease of handling. This study, conducted in a rural area of KwaZulu-Natal, South Africa, aimed to evaluate the acceptability of egg powder to rural households and its potential to improve food security. A structured questionnaire was administered to 120 community members complemented by a series of nine focus group discussions to determine egg production and consumption patterns, egg storage methods and challenges, and consumers' perceptions about egg powder. Sixty five recruits from the focus group were used as a consumer panel to rate the sensory acceptability of a scrambled commercial egg powder as compared to a fresh scrambled egg on a 5-point pictorial hedonic scale. Of the respondents, 88% had egg laying chickens but despite owning egg layers, the respondents indicated that eggs were in short supply due to storage challenges and their lack of egg preservation competence. Thus, mainly commercial eggs were consumed about three times a week. Eggs were valued for health and perceived socio-cultural benefits. Sensory analysis indicated that the egg powder was significantly ($P<0.05$) less acceptable to the panellists relative to the fresh egg. The acceptability of the egg powder was not associated with consumer age and gender. The colour acceptability ratings of the egg powder did not indicate that egg colour highly influenced its acceptability. The participants in general were interested in exploring processing egg powder. Thus, there is an opportunity to explore the sun drying of eggs into powder to improve rural household food security.

4.1 Introduction and background

Eggs can be an important part of the diet since they contain most nutrients required by the human body. Of great importance in eggs is the availability of high quality proteins; which are used as the reference standard against which all other foods are assessed (Tshikosi 2009). Besides proteins, eggs are also an important source of vitamins A, B, D, E and K (Bunchasak & Kachana 2009), as well as fat and minerals (Fisinin *et al.* 2009).

There is however several challenges associated with eggs, which makes it difficult to use them as a constant protein source for families in rural areas. Hendriks *et al.* (2009) indicated that the small-holder farmer is challenged by limited access to markets due to infrastructure, supporting services and manipulation of fresh egg markets by the well-established commercial farmers. Due to these market challenges, small farmers lose some of their eggs to deterioration and/or breakage. Egg production varies seasonally and this presents a further major challenge to farmers in rural areas. In winter, egg production tends to be lower while in summer eggs are plentiful (Cherian 2008). However, while eggs are abundant in summer, they are not stored or preserved for the next leaner season as there is no form of preservation practised by rural farmers. Eggs are highly perishable with a shelf life of up to 14 days when stored at room temperature. A study by Jirangrat *et al.* (2010) shows that after 14 days, eggs becomes runny and subsequently deteriorate. In the hot, humid and wet season, rural farmers lose their eggs due to rapid deterioration and due to diseases and parasites, which also affect other domestic animals (Okeno *et al.* 2012; Moges *et al.* 2010a); Moges *et al.* 2010b; Mosisi 2010). Another challenge is availability of appropriate feed for the chickens meant for egg production. For example, Okeno *et al.* (2012) noted supplementary feeding as one of the constraints in rural areas of Kenya. A lack of constant feed quantity and quality reduce the productivity of indigenous chickens and while supplementary feeding is readily available during the harvesting period, there is little or no supplementation after the harvesting period (Okeno *et al.* 2012; Molla 2010). Furthermore lack of proper nutrition, as experienced in winter, causes a delay in egg production or low productivity levels.

A solution is required that would help farmers to preserve their eggs into the next season to enhance their food security. A preservation method would ensure that there is a stable availability and accessibility of eggs throughout the year, thereby increasing the nutrition and food security of rural communities. Currently, at rural community level there are no

technologies in place for egg preservation. Drying is known for its ability to lengthen the shelf life of foods and has been used successfully in drying meat, cereals, fruits and vegetables by rural households (Sagar & Suresh Kumar 2010). It is both simple to employ in rural areas and require only limited inputs as farmers can use solar energy.

At the industrial level, eggs are preserved by manufacturing egg powder through spray drying. Firstly, the egg shells are removed and the egg is filtered and stored at 4º C. The eggs are then heated to 65º C for 8 to 10 minutes and spray dried, resulting in egg powder (Kumaravel *et al.* 2012; Dixit *et al.* 2010), yields of around 80%. A survey in Nigeria for small and medium enterprises poultry farmers revealed that farmers had adopted the technology of drying eggs into powder and processing the matured poultry birds into chicken parts (Ugwu (2009). These technologies have mitigated the seasonal gluts experienced by poultry farmers in the marketing of products in Lagos State. The processing of eggs into powder has also been successfully adopted by small scale farmers in Asia with small poultry processing units export egg powder and frozen chicken to European countries (Balakrishnan (2004). Egg drying therefore, has the potential to contribute towards household livelihoods and food security. However, it seems that sun-drying is currently not been applied in the processing of egg powder and thus there is a need to explore this technology that might be highly appropriate for rural communities.

The objective of this study was to determine the feasibility of manufacturing egg powder at the rural community level. Egg consumption patterns of people in rural Impendle Kwazulu Natal, South Africa were also assessed. Finally, the sensory acceptability of egg powder compared to fresh egg by the rural community was determined.

4.2 Research methodology

4.2.0 Study area

This investigation was carried out in the rural areas of Impendle in KwaZulu-Natal Province of South Africa. Impendle Local Municipality is in the category B municipalities of Umgungundlovu District Municipality. It is located within the western portion of Umgungundlovu District Municipality, situated in the west of KwaZulu-Natal Province. The town of Impendle is centrally situated within the local municipality, and about 50 kilometres from central Msunduzi, another local municipality of the Umgungundlovu District

Municipality, in which the city of Pietermaritzburg town is located. The current population of Impendle municipality is about 35 000 people. Three villages were chosen, namely Gomane, eSwampu and Nguge. In order to access the community, the researcher consulted with the local municipality office. The researcher was allocated with a municipal official to assist throughout the investigation period. Through the municipal official, the researcher was able to meet with the chief and the councillors to seek permission to do a study in the Impendle area. The councillor acted as the gate keeper and organised respondents as well as venues for the meetings. The participation in the study was voluntary and this was explained to the participants verbally every time before the beginning of each study session.

4.2.1 Sampling technique

The selection of study villages was based on accessibility, availability of egg laying chickens and active small egg layer projects. Purposive and convenience sampling were applied. Purposive sampling is the deliberate choice of an informant due to the qualities the informant possesses (Cochran 2007). It can be used both for qualitative and quantitative data. One of its advantages is that it is a non-random technique that does not need underlying theories or a set number of informants (Tongco 2007). Convenience sampling involves recruiting respondents that are both easily accessible and willing to participate in a study (Teddlie & Yu 2007).

The questionnaire was administered to 120 participants. Out of the 120 questionnaire survey participants, 63 voluntarily participated in a sensory evaluation. The same sensory evaluation panelists participated in the focus group discussions (FGD). The composition of sensory panel was such that it was representative of the community's adult demographic profile. The focus group discussion was used to complement the questionnaire survey in exploring the consumption of eggs, perceptions about egg as a food source and gender dynamics around egg consumption.

4.2.2 Validity, reliability and trustworthiness of the methods

Trained field workers were used to administer the questionnaire. The field workers were proficient in both English and Zulu. The questionnaire was translated from English to Zulu by two of the field workers working together. The field workers piloted the questionnaire on small sample of community members from the study area. The community members used in the pilot study was excluded from the actual study. The focus group discussions were

facilitated by a trained fieldworker who was in both English and Zulu. For sensory evaluation validity and reliability was ensured by using a pictorial scale which was appropriate for these less literate participants. Sensory evaluation was piloted in a similar manner as the survey.

4.2.3 Research procedure

4.2.3.1 Survey

A survey was conducted in the selected study area described above. A questionnaire written in Zulu was administered to 120 respondents. The respondents were made to sit individually; handed with questionnaire and were asked to circle answers. This was done with the assistance of two trained field workers who assisted the respondents individually in filling out the questionnaire. The questionnaire had 14 questions, which inquired about ownership of egg laying chickens, egg consumption, egg acquisition methods, egg preservation methods and storage challenges (Appendix 1).

4.2.3.2 Focus group discussions

Nine focus group discussions were conducted in the study area. Each focus group consisted of between 8 to 12 participants. Three focus group discussions were administered each in Nguge, Gomane and Swampu villages. As already stated, the focus group discussions participants were recruited from the survey participants and their participation was voluntary. The participants were divided into three demographic groups, the youth (16-25 years), adult women and adult men. The division was done to obtain an unbiased perception from each demographic group. A focus group discussion guide (Appendix 2) was used for the discussions. The focus group discussions were conducted in Zulu.

4.2.3.4 Sensory evaluation

4.2.3.4.1 Preparation of scrambled egg from egg powder

The egg powder was reconstituted with water following a method described by Ross (2008). One levelled tablespoonful of commercial egg powder was mixed with two level table spoons of water. The mixture was allowed to stand for about 5 minutes to settle and then prepared into a scrambled egg in the same manner as the fresh egg. The standard method used by the local community of the study area was used to prepare scrambled eggs using fresh eggs and reconstituted egg powder, respectively. A fresh egg was broken into a cup and then thoroughly

beaten using a fork. Three table spoons of oil for each case were added to two individual shallow frying pans and allowed to heat. The beaten fresh egg and reconstituted egg powder were respectively added all at once to the heated oil in the frying pan and then stirred continuously until well cooked.

4.2.3.4.2 Sensory evaluation method

Sixty three panellists were recruited to participate in a consumer acceptance test. The panellists were drawn from the survey (described above) participants and the panel was composed of equal numbers of the youth (16- 25 years), women and men. The panellists were made to sit in a back to back position to avoid interaction. The sensory evaluation questionnaire was in a form of 5-point pictorial hedonic scale, written in Zulu (Appendix 3). The panellists were asked to rate the acceptability of each sensory attribute of the egg samples by marking an 'X' on the face which best described their perception of the sample. Two samples of scrambled egg one made from egg powder and another from fresh egg were prepared and coded with three digit codes obtained from a Table of Random Numbers. The samples were tested in a randomised order from left to right. Randomisation of the serving order of the egg samples was done using a Table of Random Permutations of Nine. Before and after tasting each egg sample, the panellists were required to rinse their mouths. Prior to the testing the panellists were trained on the sensory evaluation procedure. Participants signed a consent form for voluntary participation (Appendix 4). Ethical clearance for the use of human subjects was granted by the University of KwaZulu-Natal Research Office (Appendix 5).

4.3 Data analysis

The survey data were analysed using International Business Machines Statistical Package for Social Sciences (IBM SPSS) version 21. The data were presented graphically showing percentages of the following; i) egg storage challenges ii) egg storage methods and iii) keeping quality of eggs. The focus group discussions data were presented in tables showing verbatim quotes. The data of sensory evaluation were analysed using ANOVA (SPSS) and Chi- square tests. ANOVA was used to determine whether there was a significant difference in the sensory acceptability of the two egg samples. The Chi-square test was used to determine whether there was an association between egg acceptability and consumer gender and age.

4.4 Results and discussion

4.4.1 Demographic information of the participants

A total of 120 respondents were interviewed, of which 54% were female and 46% were male. Forty nine percent of the interviewees were aged 40 years and above. The youth (16-25 years) and the adults (26- 40 years) constituted 26% and 25%, respectively. Figure 4.1 summarises the demographics of the sampled households (respondents).

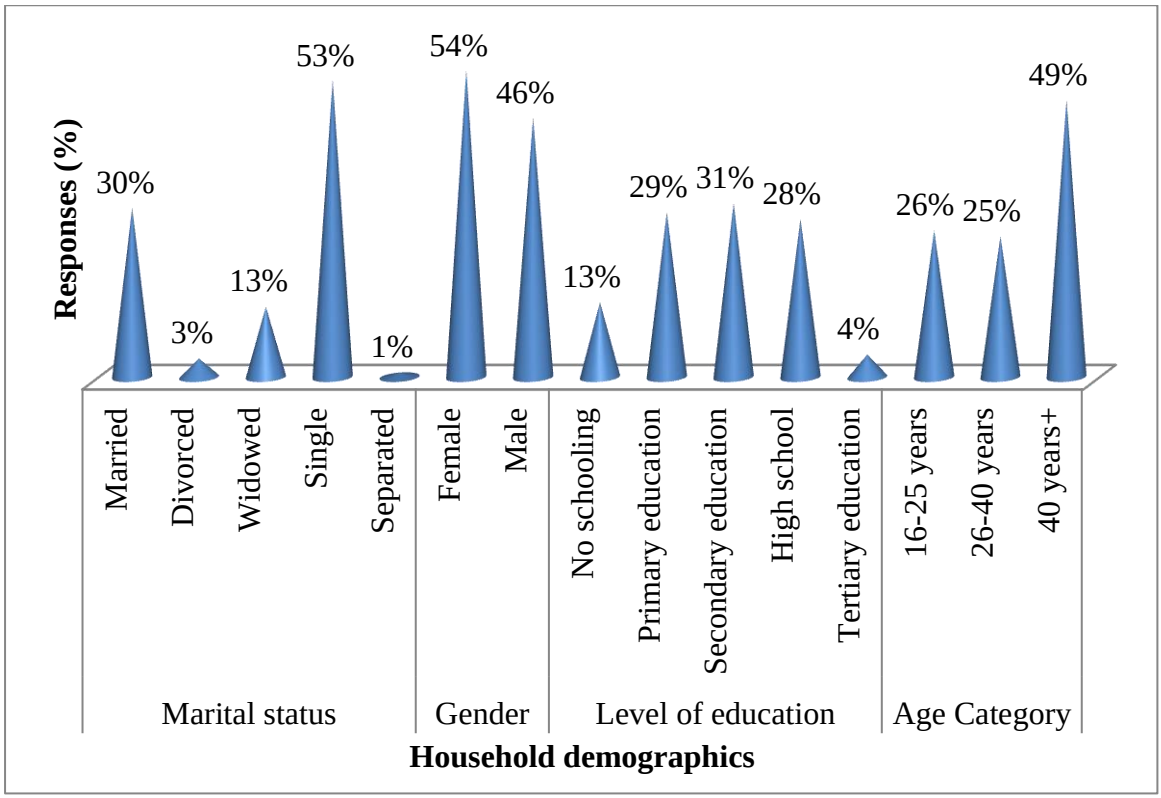


Figure 4.1 Demographics of sampled households

The demographics also showed that most (53%) of the respondents were single, whist 30% were married. The demographics show that there was more or less equal gender distribution. The majority of the respondents were aged 40 years and above. Most of the study participants had primary and secondary school education and few had tertiary education.

4.4.2 Ownership of chicken

Up to 87% of the respondents indicated that they had egg-laying chickens compared to 13 % who did not have. Table 4.1 shows egg-laying chicken ownership statistics of the study area.

Table 4.1 Egg-laying chicken ownership in the study area

Variable	Frequency (N= 120)	Percentage (%)
No chickens	16	13
Less than 5 chickens	43	36
More 5 chickens but less than 10	31	26
More than 10 chickens	30	25

Chickens were owned mainly by women (70%). This concurs with the literature: where mainly women are reported to be the owners of chickens (Leta & Bekana 2010a; Aklilu *et al.* 2008; Mapiye *et al.* 2008). Chickens are a common small-livestock for women and decisions about the use of poultry and poultry products are made by women. In another study, Halima *et al.* (2007) concluded that women, whether in male-headed or female-headed households, were responsible for chicken rearing while the men were responsible for crop cultivation and other off-farm activities. This is mainly because chickens have a low socio-economic value; hence they have a societal attachment to women whose social status if often considered lower than that of men (Walker 2005). As a result, chicken breeding receives minimal family investment, if any, which adversely affect their contribution to household food security.

4.4.3 Importance of eggs in rural households of Impendle

Research findings indicated that each household's food basket contains eggs. Some households partly generate income through selling eggs while others use them for flock multiplication. The focus group discussions confirmed that eggs ensured dietary diversity among households, because households would switch relishes when they wished. This is confirmed by these research findings which indicate the primary reason why the consumers kept eggs was household consumption; with only 23% of the chicken were for breeding. Table 4.2 shows a summary of the most important focus group discussion findings.

Table 4.2: Importance of eggs in rural households of Impendle

Question	Theme	Concept	Quotes	Discussion
Importance of eggs	Basic food basket item	Nutritional benefit	*'We eat eggs because they are nutritious'*	Eggs are included in the food grocery list were not only valued for their health benefits as food but they also carried strong societal cultural values that are grounded from patriarchal and gerontocracy belief systems. Eggs were also important for purposes of flock increase/chicken breeding. Eggs can also be a source of income for the rural communities
	Socio-economic-cultural status	Perceived cultural-value	*'As chickens lay eggs, we leave the eggs to hatch so that they multiply and we also give to our children'*	
		Economic benefits	*'If we have excess sometimes we sell them'*	
	Socio-cultural myths	Beliefs	*'The teenage girls cannot eat eggs; even those who are just married, they should wait to be given permission to eat eggs'*	

Almost all participants from Impendle knew that eggs were important for nutritional reasons. Eggs form an integral part of rural households' food basket and can be utilized for various purposes. In view of this, eggs are important for households since they contribute to household dietary diversity and access to income. Despite the fact that eggs were kept mostly for consumption in Impendle, other researchers found that eggs were kept mainly for chicken breeding (Moreki & Montsho 2011; Moges *et al.* 2010a; Alders & Pym 2009). Leta & Bekana (2010b) found that eggs meant more than gaining nutritional benefits, as it also carried socio-economic-cultural status and beliefs for both men and women. Eggs also contributed towards an increase in household income, household consumption, and were also used for traditional ceremonies and sacrifice. Additionally, an increase in household income can contribute to an improved dietary diversity since it enables households to purchase other food items.

4.4.4 Egg consumption frequency in Impendle

There were no major differences in egg consumption patterns based on gender. About 80.8% of the respondents indicated that eggs were consumed by the whole family, whilst 3.2% to 5.5 % of the respondents indicated that they did not eat eggs due to unstated reasons. Most of the respondents, including girls, consumed eggs about three times a week and most preferred them fried. Participants also added tomatoes and onions to eggs to prepare a relish that would be eaten with *phuthu* (crumbled stiff maize porridge) or rice.

Egg consumption patterns are not uniform across countries. Studies conducted in Zimbabwe, revealed that egg consumption was low and similar across seasons, regardless of the availability of eggs (Muchadeyi *et al.* 2005). Aklilu *et al.* (2008) reported that egg consumption was uncommon among the Ethiopian poor community as it was considered a luxury. In other areas of Ethiopia eggs were consumed for religious and medical reasons, while 2.2% of the study participants reported to not have eaten eggs (Moges *et al.* 2010a). In Impendle, eggs were more frequently consumed relative to other rural areas studied as indicated above.

However, focus group discussions showed that there were conditions preventing the consumption of eggs by certain demographic groups that are based on gender and age. For example, culture discouraged the consumption of eggs by both the girls who are at teenage stage and newly married couples (Table 4.2). Taboos about egg consumption have been also reported by other researchers. According to a study carried out by IRIN (2012) in Mali, there is a belief that children and expectant mothers would have bad luck if they ate too many eggs. Table 4.3 shows a summary of the most important egg consumption beliefs derived from focus group discussions.

Table 4.3: Consumers of eggs in rural households of Impendle

Question	Theme	Concept	Quotes	Discussion
Who should eat eggs	Socio-cultural norms	Gender barriers	*'Men should eat eggs to increase their strength in bed and also to boost fertility'*	There is a correlation between cultural systems and the consumption of eggs. There are two main considered factors; gender and age. Children regardless of gender were allowed to consume eggs however teenage girls and young couples were to be given permission to start consuming eggs.
		Age standards	*'If teenage girls eat eggs they will develop a high sex desire when they are still young'*	

The results indicate that egg consumption restriction on the basis of gender exists especially among women and girls, which deprives them of this valuable protein source. This might compromise their nutritional status. Intervention such as education programmes on egg consumption would be appropriate to impart change on these socio-cultural stereotypes.

4.4.5 Ways in which eggs are acquired for consumption in Impendle

About 80% of the interviewed participants indicated that they bought eggs from local formal market retailers compared to 20% who got them from household rural chickens. This was because eggs from rural chickens were not always available and if available would be often insufficient for the whole family as they still needed to retain some for chicken breeding. There was a concern raised with regard to the quality of indigenous eggs. Some of the respondents believed that eggs from the shops were credible with respect to food safety compared to local eggs. They indicated that the eggs would be *'tested'* for various '*diseases'* before they were sold to them. Participants also preferred eggs from the store because they were bigger. The consumers also pointed that indigenous eggs were not readily available due to the slow maturing rate of egg laying chickens. To support this, Moges *et al.* (2010a) found that low productivity is attributed to the slow maturing rate of local traditional indigenous chickens in Ethiopia. Participants also acquired eggs from the retailers because they preferred to keep the eggs from traditional chickens for flock multiplication. Some participants also felt that taking eggs from chickens stress the chickens the same way a woman would get stressed if their child was stolen.

Several factors limited the consumption of indigenous eggs in rural Impendle and this has resulted in many participants preferring to buy eggs from retailers rather than depending on their own egg production. This has also caused most participants to believe that retailer's eggs are better than the indigenous eggs produced by the rural community. Purchasing of eggs reduces household income, which could be used for other purposes. Additionally, the perceptions reflected by participants indicate that this rural community lacks information about the quality of indigenous eggs compared to commercial eggs, which might be genetically modified. While of the rural community members in Impendle are generally cash strapped, they still buy eggs from formal market retailers to meet their dietary needs because their indigenous chickens do not produce enough for their families.

4.4.6 Egg storage methods in Impendle area

The respondents in the survey indicated that they stored eggs in different ways, of which 57% stored eggs in the fridge, while 32% kept them in a basket in a cool room. The other 7% of the respondents indicated that they used other methods such as putting it on the floor or on sand in the cool room. The remaining 5% of the respondents indicated that they did not store eggs at all. The focus group discussions confirmed the same storage methods listed by the survey respondents. Figure 4.2 presents the egg storage methods used in the three study areas as indicated by respondents in the survey.

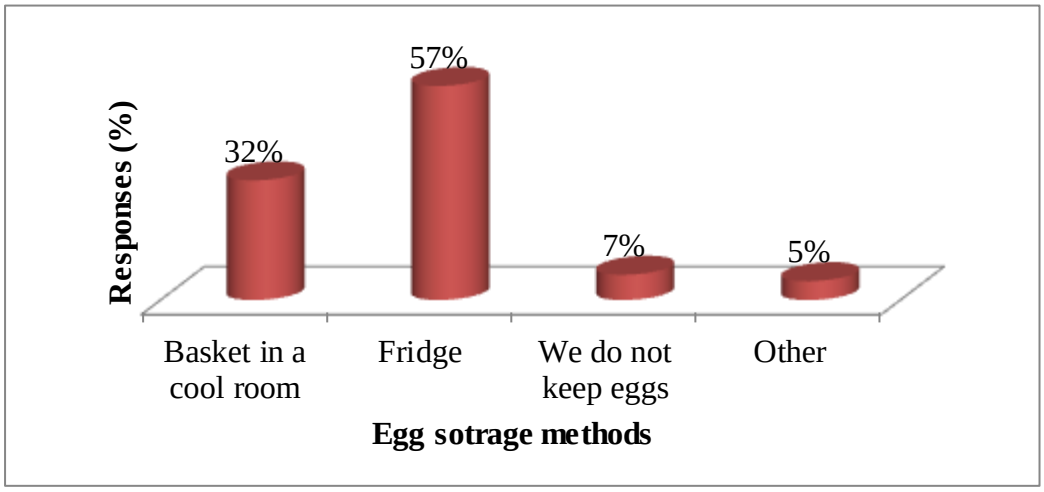
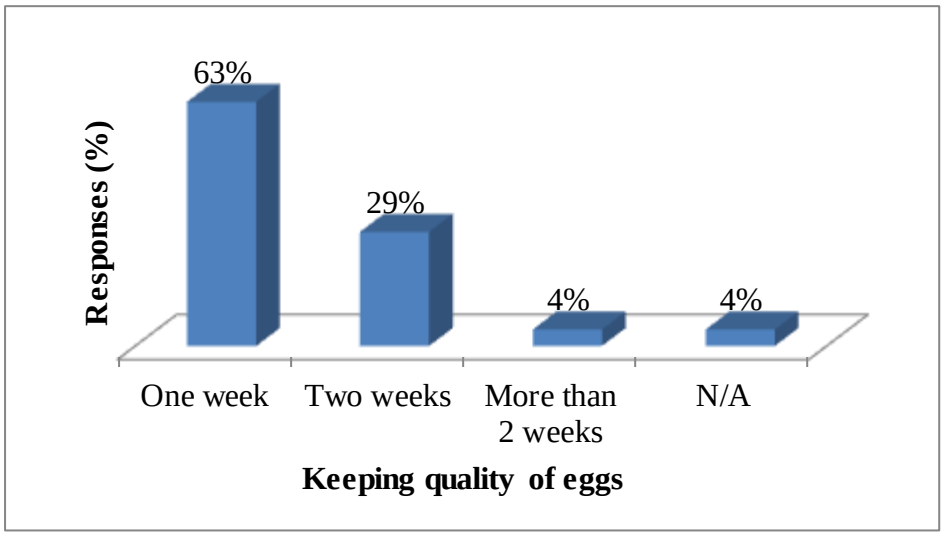


Figure 4.2: Egg storage methods used by rural households of Impendle

Storage methods vary across countries; in a study in Ethiopia, Molla (2010) found that about 57.1% respondents stored eggs on nests, 18.5% in baskets and 5.6% in iron dishes. The

storage methods identified in the present study resulted in the eggs keeping their quality for an average time of one to two weeks (Figure 4.3).



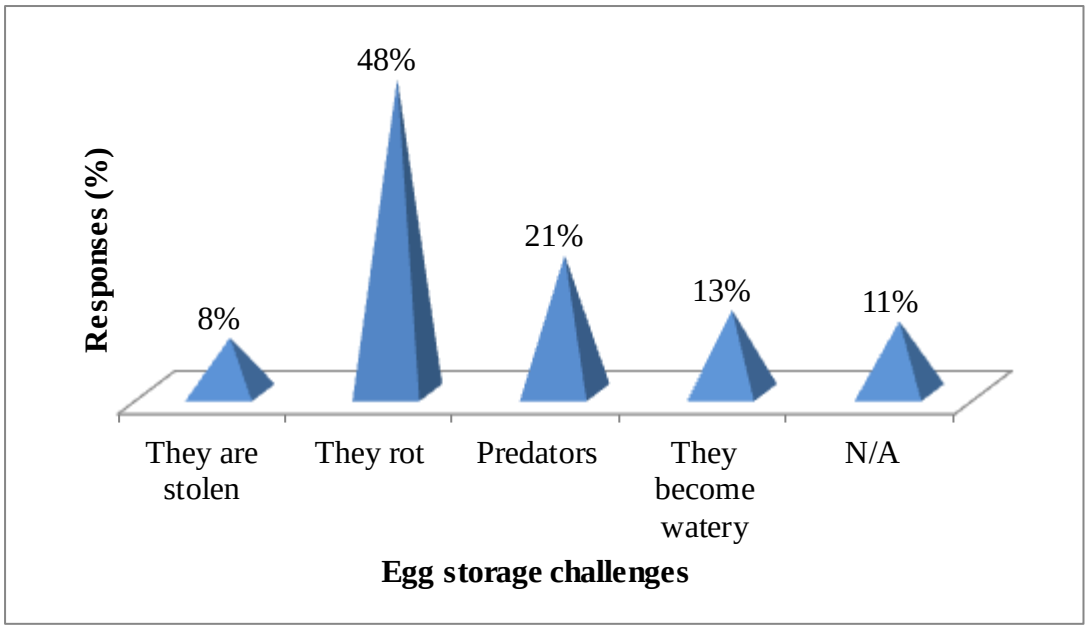
N/A = Not applicable; i.e. participants do not keep eggs or do not eat eggs at all

Figure 4.3: Keeping qualities of eggs in rural Impendle

It is important to note that most of the storage methods resulted in the eggs keeping their quality for a short time. This then reduces household egg availability and calls for alternative user-friendly methods of storing eggs, such as drying, that produces egg powder, which has a long shelf life.

4.4.7 Challenges in egg production and storage in Impendle

There are a number of challenges faced in egg production and storage among Impendle rural households as reflected by the respondents in the survey. According to the study respondents (48%), egg deterioration was the main challenge followed by predators such as dogs, cats and wild birds which was reported by about 21% of the respondents. The respondents reported that the eggs got deteriorated within a short space of time; with 62% of the respondents indicating that the eggs kept their quality for one week, at the most (Figure 4.4).



N/A = Not applicable; i.e. participants do not keep eggs or do not eat eggs at all

Figure 4.4: Egg storage challenges experienced by rural households of Impendle

The focus group discussions showed that the community members perceived commercial eggs carrying less risks compared to indigenous eggs. This perception about the production of indigenous eggs has led partly to the community not focusing on their indigenous eggs and thereby underutilising them. Although the results indicate that commercial eggs were most utilised, participants cited that they were watery and had a weak shell hence they easily broke. This is may be attributed to that small retailers in rural areas who buy from retailers in the cities/towns have poor storage and preservation facilities. Table 4.4 presents the challenges in egg production and storage among households of Impendle according to focus group discussions.

Table 4.4: Challenges in egg production and storage among households of Impendle

Question	Theme	Concept	Quotes	Discussion
Challenges	Commercial eggs	Fragile	*' They are very watery with a pungent smell'*	The participants also preferred to keep the eggs to grow their flock; culturally the wealthy of a rural household is determined by number of animals owned including chickens. Production of indigenous chickens was perceived as costly while egg production was disturbed by predators
			'They break even before we get home because we buy them from very far'	
	Indigenous eggs	Perceived cost maintenance of rearing egg laying chicken	*'The eggs rot even before we see them because our chickens do not have designated places for hatching'*	
			'Wild cats and snakes eat the eggs'	
			'the eggs only last for a week'	
		Preferences influenced by culture	*'We prefer eggs from supermarkets because they are cheaper and bigger'*	
			'we do not like to eat indigenous eggs because we want the chickens to multiply'	
			'we do not take eggs away from the chickens because we will stress them'	
		Impact of limited storage life of eggs	*'The eggs we buy from shops last for a week only'*	
			'even though we keep indigenous eggs they do not last, it is better to eat them all or leave the chickens to hatch'	

4.4.8 Consumer perceptions and acceptability of egg powder

The focus group respondents expressed willingness to learn about egg powder and aspired to start their own egg drying projects. Focus group discussions also revealed that most participants did not have proper means of protecting their indigenous eggs. Very few respondents indicated that they fenced around hatching areas but most of the areas were not seen and would only be discovered later when eggs will be rotten. The findings of the focus group discussions are presented in Table 4.5.

Table 4.5: Consumer perceptions and acceptability of dried egg powder

Question	Theme	Concept	Quotes	Discussion
What is your view of egg powder?	New experience	Excitement	*'I have never seen something like this'* *'It is my first time to see this'* *'I do not believe that you can make an egg a powd*er'	The participants were amazed as this was their first time to see egg powder. The health benefit was not the key factor but the excitement was more about what they could do with the egg powder to start generating cash income as well as improve household food security. Appearance is the most importantly used sensory attribute for egg powder which was associated with the indigenous egg.
Views towards egg powder scrambled egg vs fresh egg scrambled	Sensory acceptability of powdered egg vs fresh egg	Colour	*'This egg looks like a Zulu egg(colour) but the aroma is different from that of eggs'*	Rural areas have a challenge of high rate of unemployment; the egg powder presented an opportunity for entrepreneurship for the youth. The participants showed interest and eagerness to learn more about egg drying preservation technique. As evidence the participants started to talk about how they can organise themselves, suggested who should be targeted and which venue could be used for education and training on this technique. They also thought about the importance of rearing egg layers and how value adding of the egg powder could be done through baking. The findings of this study showed the eagerness and willingness of the participants to gain competence on egg drying and to practice the technique to generate livelihoods for household food security.
Would you like to learn about it?	Livelihoods opportunities	Self-employment for youth Willingness to learn about the egg drying techniques	*'It will help us to generate money for our expenses'* *'It should be a project for the unemployed youths and the orphans so that they help the aged'*	

Sensory attributes are the key determinants influencing the preferences and acceptability of a food. With regard to the scrambled eggs, statistical analysis indicated that there were significant differences between the scrambled eggs made from the fresh egg and egg powder ($P< 0.05$), with fresh eggs scoring better on all attributes. Table 4.6 shows the ratings of the sensory attributes of each egg sample.

Table 4.6: Sensory acceptability rating of scrambled egg made from egg powder compared to fresh egg

	Appearance	Aroma	Taste	Colour	Overall Acceptability
Fresh egg	$4.1^{a} \pm 0.9$	$3.9^{a} \pm 1.1$	$4.3^{a} \pm 0.8$	$4.1^{a} \pm 1.0$	$4.5^{a} \pm 0.8$
Egg powder	$3.5^{b} \pm 1.1$	$3.2^{b} \pm 1.2$	$3.6^{b} \pm 1.3$	$3.7^{b} \pm 1.2$	$3.9^{b} \pm 1.3$

[1] Mean ± SD (N=63).Means with different superscript letters in the same column are significantly different ($P< 0.05$)

Acceptability of scrambled eggs prepared from fresh eggs and egg powder was compared showing how panellists scored or each attribute. The number of people who scored for each attribute (n) is shown as well as the percentage (%) they represent. Generally, higher scores were associated with fresh eggs for all attributes as indicated in Table 4.7.

Table 4.7: Acceptability of scrambled eggs made with egg powder compared to scrambled egg with fresh eggs (N=63)

Sensory attribute	**Rating**	**Egg powder** n (%)	**Fresh Egg** n (%)
	Very Bad	4* (6.3)**	0* (0)**
Overall acceptability	Bad	8 (12.7)	3 (4.8)
	Neutral	4 (6.3)	3 (4.8)
	Good	19 (30.0)	15 (23.8)
	Very good	28 (44.4)	42(66.7)
Appearance	Very bad	3 (4.7)	0(0)
	Bad	9(14.3)	0 (0)
	Neutral	14 (22.2)	5 (7.9)
	Good	27 (42.9)	12(19.0)
	Very good	10 (15.9)	46 (73)
Aroma	Very bad	27(42.9)	1 (1.9)
	Bad	14 (22.2)	9 (14.3)
	Neutral	9 (14.3)	10 (15.9)
	Good	6 (9.5)	19 (30.2)
	Very good	7 (11.1)	24 (38.1)
Taste	Very bad	7 (11.1)	0 (0)
	Bad	8 (12.7)	2 (3.2)
	Neutral	4 (6.3)	8 (12.7)
	Good	29 (46.0)	20 (31.7)
	Very good	15 (23.8)	33 (52.4)
Colour	Very bad	3 (4.8)	1 (1.6)
	Bad	10 (15.9)	4 (6.3)
	Neutral	6 (9.5)	8 (12.7)
	Good	29 (46.0)	23 (36.5)
	Very good	15 (23.8)	27 (42.9)

* Number of respondents who gave the rating; ** % of respondents who gave the rating

For the sensory attributes evaluated, the scrambled egg made with egg powder was less acceptable than that made with the fresh egg. The highest differences in acceptability were in the appearance and aroma acceptability of the two egg samples. According to the results in the table the aroma of egg powder was scored as ‘very bad’ compared to any other attributes. The panellists commented that the scrambled egg powder had an unusual aroma, which was not present in the scrambled fresh egg. This made most panellists prefer the sample

scrambled fresh egg. The odd aroma from the egg powder could have been produced during the processing of fresh eggs into egg powder. The aroma of the egg powder may be improved by adding other ingredients, such as tomatoes, onions and spices, to the egg powder to mask the unusual aroma.

Panellists also commented that the colour of the sample made with the egg powder resembled that of a Zulu egg (dark yellow; Figure 4.5). From the focus group discussions, it was established that the participants were interested in learning how to make the egg powder as they believed that it could be a good substitute for fresh eggs. Participants also believed that when blended with other ingredients, the egg powder could be processed into a relish that was the same as that of fresh eggs; the unusual aroma of the egg powder would be presumably masked by the other ingredients.

Figure 4.5: Differences in the colour of scrambled eggs, sample 769 (egg powder) has a darker colour compared to sample 831(fresh egg).

The Chi square test revealed that there was no association (Table 4.8) between egg acceptability and gender ($P<0.05$). The findings showed that if the egg powder was to be introduced in rural households it will be accepted since there will not be barriers associated with gender. Mothers are known to influence choice of foods for a household, but that could not be confirmed in this particular study.

Table 4.8 Association between gender and acceptability of eggs

	Variable	Chi square value	P value
Gender	Appearance	0.8	0.9 ^{ns}
	Aroma	5.1	0.3 ^{ns}
	Taste	2.9	0.6 ^{ns}
	Colour	5.1	0.3 ^{ns}
	Overall Acceptability	4.7	0.3 ^{ns}

^{ns} = not significant at P< 0.05

4.5 Conclusion

This study showed that eggs formed an integral part of the household food basket. Generally, eggs were consumed on an average of three days per week and were used as part of dietary diversification. Regardless of the socio-cultural beliefs, the majority of households, including girls, were readily consuming eggs and were more than keen to explore egg drying and learn innovative egg preservation technologies, such as sun drying. This highlights the opportunity to introduce egg drying in this particular area. The community of the study area believes that eggs are a symbol of a high socio-economic status for the household; hence this community needs education on the importance of eggs as a nutritive food source. There are challenges in egg production due to seasonal gluts. There is a need to improve the capacity of this rural community to produce sufficient eggs to meet their consumption needs and if possible a surplus for sale. Capacity building may include training on poultry husbandry and management. Although the results showed that egg powder was less acceptable than fresh egg, there is an opportunity to improve its acceptability by processing into other egg food forms in which the less acceptable sensory attributes are masked. It is imperative to address the currently existing egg storage and preservation challenges through the introduction of sun drying as preservation method to ensure that eggs are well utilised by rural communities and thereby improve household food security.

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CHAPTER 5: MICROBIOLOGICAL AND OTHER QUALITY ATTRIBUTES AND SAFETY OF SUN-DRIED AND OVEN-DRIED EGG POWDERS

5.0 Abstract

Although eggs have been successfully dried into powder at industrial level no evidence is available that sun-drying or oven drying has been tried on eggs in the rural areas. This study conducted in the rural areas of Impendle in the KwaZulu-Natal Province of South Africa determined the microbiological quality and safety of sun dried eggs. A sample of eggs was oven-dried at 35^0 C over a period of 3 hours. Another sample was sun-dried over a period of 72 hours. When observed over a period of 8 weeks, both sun-dried and oven-dried eggs developed a rancid flavour. The dried egg samples were subjected to microbiological analysis: *Salmonella spp., E. coli, Coliforms, Listeria monocytogenes* and Total Bacterial Count. The results showed that the egg samples had little or no growth of these microorganisms suggesting that they were safe for consumption. The study demonstrates the potential for processing eggs into egg powder in rural areas to improve household food security.

5.1 Introduction

In African rural areas, many types of foods are eaten fresh, dried or in other processed forms. Fresh foods are normally eaten soon after harvest, but some of the fresh foods can be preserved using traditional preservation methods, such as fermentation, drying and pickling (Ibnouf 2013). Leafy vegetables, fruits, meats and corn, among other crops are eaten fresh in rural areas during their ripening season (Hart 2011). Towards the end of the ripening season they are harvested and dried traditionally through sun drying methods for consumption in another season. Indigenous foods have been considered safe and nutritious for rural households. Moreover, they are inexpensive and most communities depend on them for dietary diversity during their on-and off season, as well as when there are food shortages (Ibnouf 2012a). Traditional vegetables are a significant food source for households who do not have sufficient income to buy meat or other expensive foods for their large families (Voster *et al.* 2007). The traditional drying of wild fruits and vegetables is also practised in other rural areas of Southern Africa (Motlhanka *et al.* 2008). Dried foods have been found useful for food security in Zimbabwe (Maroyi 2011) and Zambia (Nguni & Mwila 2007).

The preservation a of food has been practised in rural areas since ancient times (Bechoff *et al.* 2011). Usman (2010) concluded that drying reduces post-harvest losses.

Preservation of food by sun-drying has several advantages. The dried food has a long shelf life; the food requires less storage space; there are minimal nutritional losses; and sun-drying is considered one of the least expensive preservation methods (Samad *et al.* 2009).

Direct sun drying practised in rural areas also has some disadvantages. It depends on the weather conditions; during winter and rain seasons, it is difficult to practise as the food takes longer to dry. In summer, the temperatures are high and the humid environment cause prolongs drying process or causes food deteriorating (Hart 2011).

Sun drying also requires sizeable exposure areas if air circulation is to reach all parts of food items being dried. Sun dried products are susceptible to microbial contamination by the action of insects, rodents or other small animals (Guiné *et al.* 2007). In a survey done in Zambia, Nguni & Mwila (2007) found that most rural consumers who practised direct sun drying complained of product deterioration due to rain, wind, moisture and dust; and loss of produce due to animals. In another study, consumers complained that the sun-drying process is labour intensive, time consuming and required a large surface area to spread the produce out (Tunde-Akintunde 2010).

Whereas drying has been employed traditionally in most food products in rural areas, it seems it has not been tried on eggs. Eggs in rural communities are eaten fresh in the form of boiled, scrambled and fried eggs or in baked products. A high proportion of the eggs not eaten immediately after hatching are lost through deterioration and/or breakage. This reduces the nutritional value and food security of the rural communities and hence there is a need to try innovative egg preservation methods, such as sun-drying.

5.2 Research methodology

The eggs were dried using traditional methods practised in the rural areas. For this study, oven drying and sun drying were used. Sun drying was used because it is one of the simplest methods used for drying other forms of food in rural areas. Oven drying was also used because the peri-urban households have access to electricity and hence could explore oven drying.

5.2.1 Method for drying of eggs

5.2.1.1 Sun drying

Large sized eggs (50 g) were broken and whisked in a porcelain bowl. From the whisked portion, 100 g of whisked egg was spread in a 15 cm x 25 cm glass tray, covered with cotton voile and put on an elevated position where there was unhindered insolation and where there was free air circulation. The eggs were left to dry until they had a crispy feel for 72 hours. The dried eggs were spread on a cutting board and crushed into powder using a wooden roller.

5.2.1.2 Oven drying

Large sized eggs (50 g) were broken and whisked in a porcelain bowl. A portion of whisked eggs (100 g) was spread in a 15 cm x 25 cm glass tray. The product was in an oven at 50^0 C for 3 hours until it had a crispy texture. The dried eggs were spread on a cutting board and crushed into powder using a wooden roller. The dried egg samples (both oven- and sun-dried) were kept in tightly sealed containers and observed weekly for any visible physical deterioration for 8 weeks.

5.2.2 Microbiological quality and safety analysis of dried eggs

Total Plate Count, *Coliforms, E. coli* and *Samonella* were determined according to SABS ISO standards methods, which are briefly described below.

5.2.2.1 Preparation of serial dilutions

The method followed for preparation of serial dilutions was the same for all bacterial analyses. Accurately, 25 g of egg samples were transferred into 250 ml of distilled water. The samples were thoroughly mixed on a platform shaker. Exactly 1 ml aliquots of the samples were drawn using separate sterile pipettes into test tubes containing 0.9% of saline water. Serial dilutions were prepared from this up to 10^{-4}. The diluted samples were shaken thoroughly before plating.

5.2.2.2 Total Plate Count

Total plate count was done following the SABS method, (SABS ISO 4833:1991). Exactly 0.1 ml of each of the serially diluted samples was pipetted into separate, duplicate, appropriately marked petri dishes. Twelve to fifteen ml of plate count agar were added (cooled to 45 ± 1° C) to each plate within 15 min of the original dilution. Sample dilutions and agar medium were mixed thoroughly and uniformly by alternate rotation and back-and-forth motion of plates on flat level surface and left to solidify. The plates were incubated promptly for 48 ± 2 h at 35° C (Anon 1991b).

5.2.2.3 Total Coliform Count

Total Coliforms and the presence of *E. coli* were determined following the SABS method, (SABS ISO 4832:1991). The diluted samples (described above) were plated by the pour-plate method, in duplicate, using violet-red bile agar (VRB) and incubated at 37° C for 24 hours. *E. coli* was differentiated from other coliforms using standard microbiological tests. A positive indole test and the presence of short Gram-negative rods was taken as positive for the presence of *E. Coli* (Anon 1991a).

5.2.2.4 Presence of *Salmonella* spp

The presence of *Salmonella spp.* was analysed for following the ISO method (ISO 6579:2002). The pre-enrichment was carried out by adding 25 g egg samples to 225 ml buffered peptone water (Difco, East Molesy, UK/Merck, Amsterdam; the Netherlands) followed by incubation at 37 °C for 18 ± 2 h. From the pre-enrichment culture, 1 ml was inoculated in 9 ml RV broth (Oxoid, Haarlem; the Netherlands). After an incubation of 24 ± 1 h at 42 °C the RV culture was streaked onto brilliant green agar (BGA; Oxoid). If suspect colonies were not found on BGA after incubation, the RV culture was again streaked onto BGA after a second incubation period of 24 ± 1 h at 42° C (Anon 1993).

5.2.2.5 Presence of *L. monocytogenes*

Serial dilutions for each homogenised egg sample were made in 0.9% saline water up to 10^{-4}. To determine *L. monocytogenes* the method of Taormina & Beuchat (2001) was followed, which involved surface plating on *Listeria* selective agar (PALCAM, Oxoid, Basingstoke,

UK) with modified *Listeria* selective supplement (Oxoid). Typical colonies were selected and counted after incubation at 37° C for 24 h.

5.2.3 Other quality analyses

5.2.3.1 Determination of moisture content

The moisture content was determined by measuring the mass of an egg sample before and after the water had been removed by evaporation. The moisture content was calculated as follows:

5.2.3.2 Determination of colour variation and odours

The dried eggs were monitored for colour changes and development of unusual odours. Every week, a small portion of each egg powder sample was taken and compared with the other egg powder and also with commercial egg powder. Approx. 10 g of oven dried, sun dried and commercial egg powder were each placed, separately, in a white plate and hipped. The researcher then visually analysed the samples for colour changes. The changes in the smell of the eggs were monitored by placing 10 g of each egg powder sample in a measuring cylinder and the presence of pungent smells or odours examined by the researcher using her sense of smell.

5.3 Statistical analysis

Means of duplicate plates were calculated using IBM SPSS 21.

5.4 Results and Discussion

5.4.1 Microbiological quality and safety of the dried eggs

Table 5.1 shows that the total plate counts of the egg powders were more than that of the fresh egg (control), but less than that of the standard. Total coliforms in the egg powders were less than the standard. There were no growths observed for *L. monocytogenes, E. coli, and Salmonella* spp.

Table 5.1: Bacterial counts for fresh egg, oven dried egg and sun dried eggs (Units = cfu/g)

Test	Oven dried	Fresh egg	Sun dried	Water	Standard
Total Plate Count	1.55×10^3	1.28×10^2	5×10^3	Nil	<20000 per gram
Total Coliforms	< 10	<10	<10	Nil	< 50 per gram
E. coli	ND	ND	ND	Nil	0
Salmonella	ND	ND	ND	Nil	0
Listeria monocytogenes	ND	ND	ND	Nil	0

ND= Not detected (<) is less than

The total plate count of a food samples is indicative of its total microbial load and hence the general microbiological quality of the food (Annon 2001). The microbial loads of the egg powders were acceptable as they were less than the standard (Table 5.1) and were not exceeding the standards reflected in the South African regulation as shown in the table. Total coliforms are used as a specific indicator of the microbiological quality of the food and the hygienic conditions under which it was processed. The results of this study indicate that the egg powders were of acceptable microbiological quality, because their total coliform counts were below the standard. *L. monocytogenes* and *Salmonella spp.*, and certain *E. coli* strains are pathogenic to humans; food safety standards require that they be absent from food (Annon 2001). The results (Table 5.1) of the counts (0) of these bacterial species indicate that the egg powders were microbiologically safe with respect to the pathogenic microorganisms analysed for.

There is, however, a need to analyse for other microbial pathogens, include food-borne pathogenic fungi. However, the total bacterial counts were the highest in sun dried eggs. Figure 5.1- 5.3 shows representative plates for the microbiological analysis (total plate count only). These results confirm the challenges of sun drying as documented in the literature (Bal *et al.* 2011; Guiné *et al.* 2007; Nguni & Mwila 2007). The environmental factors, such as temperature and air circulation are not controlled during the sun drying of food. On the other hand, people in rural areas have been traditionally using sun drying to preserve vegetables, fruits and meat. If improved, sun drying can also be used effectively for egg drying.

Figure 5.1 Total Plate Count Fresh egg 10^{-1} dilutions

Figure 5.2: Total Plate Count Sun dried eggs 10^{-1} dilution

Figure 5.3: Total Plate Count 10^{-1} dilution oven dried eggs

5.4.2 Other quality attributes of dried eggs

5.4.2.1 Moisture content

Eggs were successfully dried to a moisture content of 5.3% for sun dried eggs and 3.9% for oven dried eggs. Studies have shown that the rate of egg powder deterioration increases with increase in the moisture content (Koç *et al.* 2012; Koç *et al.* 2011b; Koç *et al.* 2011c; Koc *et al.* 2011). To maintain quality during storage and transport, dried egg should contain no more than 5% moisture and preferably 2% or less (Koc *et al.* 2011). High moisture content also promotes growth of microorganisms which would accelerate deterioration.

5.4.2.2 Odours

At day 16 the egg powders developed an unpleasant odour that is not associated with fresh eggs. This observation is similar to that reported by Rannou *et al.* (2013). Other researchers have attributed the development of odour and off flavours to rancidity**.** Rancidity is one of the major causes of food deterioration. It is caused by oxidative and/or hydrolytic deterioration of lipids in foods (Viuda-Martos *et al.* 2010). Studies show that egg yolk lipids are oxidised during storage and the oxidation is influenced by storage time and temperature and the degree of unsaturation of the yolk fatty acids (Rocha *et al.* 2010). In another study Bonazzi & Dumoulin (2011) mentioned that lipid oxidation is responsible for rancidity, development of off-flavours, and the loss of fat-soluble vitamins and pigments in dehydrated foods.

According to Perera (2005), lipid oxidation is initiated by heat, light or free radicals and peroxides, activated by metal ions, and enhanced at higher dehydration temperatures. Moisture content also plays an important role in the rate of oxidation. At high moisture

contents, lipids can undergo enzymatic hydrolysis, which may cause off-flavour formation, such as soapy tastes, depending on the type of lipids; at a low water activity of a_w<0.2, auto-oxidation of unsaturated fatty acids causes off-flavours such as rancidity. The porosity of the dried product can have an impact on oxygen concentration and affect the susceptibility to oxygen, which is, for example, higher for freeze-dried products. Broncano *et al.* (2009) found that high temperature treatment was responsible for oxidative rancidity. For sun drying and oven drying to work effectively in rural areas, methods for preventing the rancidity of the eggs should be developed.

5.4.2.3 Colour of dried eggs

The colour of oven dried and sun dried egg powders varied significantly from the commercial egg powder (Figure 5.4). However, no colour differences were noted between sun dried and oven dried eggs (Figure 5.5).

Figure 5.4: Colour of oven dried, commercial dried and sun dried egg powders

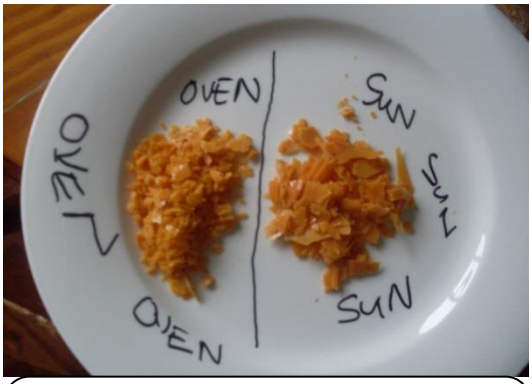

Figure 5.5: Colour of oven dried and sun dried egg powders

Colour differences could be attributed to pre- treatment steps taken to commercial egg powder and treatment temperatures (Ndife *et al.* 2010). The colour of egg powders plays an important role if the powder is to be used as a colouring agent in baking industries. The colour of dried egg powder can be maintained by preventing mouldiness and lump formation that are due to an increase in the moisture content of the product. The colour of oven dried egg powders may also be controlled by drying the eggs at temperatures that do not have a detrimental effect on colour. The colour of egg powder affects consumer acceptance of the product. However, colour variations are not an issue in the rural areas as the egg powder resembles the traditional Zulu egg (Mnyandu 2012, personal observation).

5.5 Conclusion

The results of this investigation indicate that sun drying and oven drying could be used to preserve eggs in rural areas. Due to its much lower moisture content, the egg powder so produced would have a longer shelf life compared to fresh eggs. If practised hygienically, in a home setting, the egg powder produced using these methods would be microbiologically safe for human consumption. To prevent oxidative deterioration suspected in the egg powders of this study, proper storage methods can be practised. The investigation demonstrates a potential for the preservation of eggs by sun- or oven-drying them into egg powder in rural areas to contribute to food security. However, if not carefully practised, sun drying or oven drying can result in high microbial loads, including microbial pathogens, such as the deadly bacterium *Salmonella*, which commonly contaminates poultry products. It is paramount to train the rural community on safe and hygienic processing of eggs before the sun-drying method is adopted. Further research can be conducted also to find out how to reduce rancidity in sun dried eggs.

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CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.0 Conclusions

The study findings indicated that, particularly in rural areas of Impendle, poultry has been viewed more as a socio economic asset rather than a food source. There were some myths associated with egg consumption in Impendle. However, eggs were consumed regularly regardless of age and gender. Most egg-laying chickens were owned by women and most families in Impendle consume eggs in a fried form; occasionally the eggs are consumed in the boiled form. They also used eggs as a relish, as well as an ingredient in baked foods. The egg participants said that the major reason for consuming eggs was for their nutritional value. The findings showed that eggs form an important part of everyday meals among the people of Impendle. Their constant availability is paramount to ensure their full utilisation. Although there were still myths about egg consumption, the findings also showed that the myths were weakening- quite a number of girls and young women were shifting towards eating eggs more than three times per day and most respondents indicated that eggs were consumed by the whole family.

Due to inconsistence of rural egg availability, most families in rural Impendle purchase eggs from formal market retailers. When purchased, the eggs were mostly stored in a fridge or other storage facilities such as a cool room. The consumers indicated that they had egg storage challenges associated with both their traditional eggs and purchased eggs. The major storage challenge faced by consumers was egg deterioration. It was revealed that when stored in a fridge the eggs lasted for at most two weeks and then began to show signs of deterioration. Other storage challenges cited by the study participants were losses due to breakage and also due to predators. Limited access to eggs and storage challenges have contributed to the underutilisation of eggs in Impendle community and therefore preservation and storage solutions are needed.

Results of the acceptability test conducted showed that participants preferred an egg product made from fresh eggs; they cited an unusual odour in the egg powder product as the major problem. However, the participants suggested that, if mixed with other ingredients, the egg powder products could equally substitute fresh egg. Results of microbiological analysis of the dried egg samples indicated that all the samples were microbiologically safe, but the relatively higher microbial load (Total Plate Count) and moisture content of the sun-dried

product highlighted the need to further improve the effectiveness of the sun-drying technique. In terms of other quality attributes the egg powders developed a rancid flavour at the 16th day of storage. No colour changes or any other signs of deterioration were observed in the entire eight weeks. Therefore, this study suggests that microbiologically safe egg powder can be obtained through sun-drying and oven-drying. The rural community can use these preservation technologies but they must be taught on proper food handling practices to ensure that the dried eggs are of acceptable quality and safety. The egg powder can be used in combination with other ingredients such as spices, tomatoes and onions to mask the unwanted aroma.

The study findings showed that, instead of viewing poultry as a source of protein, the studied rural community of Impendle believed that poultry was an asset associated with people of low socio economic status particularly women. Increased consumer knowledge of the nutritional value of eggs could change these mind sets and ensure the proper utilisation of poultry. Through this study, it was established that participants were willing to learn new technologies. Participants also expressed interest in commercial egg powder processing and were willing to adopt it. Participants were also willing to learn how to preserve eggs for income generation; they would also use the preserved eggs for their own consumption when egg supply falls. Overall, this study demonstrates that preservation of eggs through drying can be achieved at rural community level.

6.1 Recommendations

Further research may be pursued to find possible solutions to improve egg drying methods for rural communities for household consumption and for commercialisation. Sun drying is simple to implement in rural areas as it is already being used for other food products. However, it may not be on a sufficient scale for commercialisation if not coupled with other methods such as solar drying. Most participants own egg laying chickens, but have little knowledge of maintaining a healthy flock and increasing it. Education on egg production skills, management and the value of eggs may also be provided to improve the availability and utilisation of eggs by these households. Further studies may also look into possible methods of reducing the fat content of the eggs as is done in commercial egg powder processing and the use of ingredients that would mask the unusual flavour of the egg powder.

APPENDICES

APPENDIX 1: EGG CONSUMPTION AND KNOWLEDGE QUESTIONNAIRE (ENGLISH & ZULU)

Name Elizabeth Mnyandu
Student Number 211560561
Programme Master of Science in Food Security

Egg consumption and knowledge Questionnaire

Ward Code |___|___|___|

Questionnaire Number |___|___|___|

Questionnaire Code ……..…./……..…/…..……/

Interviewer's Name ……..

Date ……

Guidance for introducing yourself and the purpose of the interview

1. My name is _____ and I am a student at the University of Kwazulu Natal
2. You have been selected at random from individuals in the area for this interview. The purpose of this interview is to obtain information on whether the public know the importance of eggs in their diet
3. The survey is voluntary and the information that you give will be treated confidentially and if there is any question that you do not wish to answer you are free to do so. The information will be used to prepare reports, but will not include any specific names. There will be no way of identifying you or your information.
4. Please spare some time for the interview.

A: Household demographics		
1	Gender of respondent	**1** = Male **2** = Female
2	When where you born	|__||__||__||__|
3	Status of respondent	**1**=Married/partnership **2**=Divorced **3**=Widowed **4**=Single **5**=Separated
4	What is your highest level of education?	**1**=No schooling **2**=Primary education **3**=Secondary Education **4**= High school education **5**=Tertiary education (degree / diploma)
5	House hold size	0-12 years ….. 13-21 years…. 22 and above…..
6	Household income	---------- per month

B: Egg Consumption and utilization		
7	How many egg laying chickens do you have?	**1=** I don't have **2 =** Less than 5 **3=** More than 5 **4=** More than 10
7a	Why do you own egg laying chickens?	**1=** Egg production for consumption **2**= Egg production for sale **3** = traditional purposes **4**= other **5**= N/A
7b	Who owns these chickens?	**1**= Mother **2**= Father **3**= Children **4**= Other
7c	What do you use the eggs for?	**1**= consumption **2**= selling **3**= we do not have eggs **4**= other
8	Did you eat eggs in the last 30 days	**0**= No **(skip to Q 8b) 1**= Yes
8a	If yes, how often	**1**= once a week **2**= twice a week **3**= more than 3 times a week **4**= N/A
8b	Why did you not eat eggs in the past 30 days?	**1**=had no eggs **2**= we do not eat them **3**= cultural beliefs **4**= health concerns **5**= no reason **6**= N/A
8c	Where do you get the eggs that you eat?	**1**= own village chickens **2**= own layer chickens **3**= purchase the eggs
9	Who normally eats eggs in your household	**1** = all adults **2**= children **3**= pregnant women **4**= men only **5**= women only **6**= all of us **(skip to Q10)**
9a	Why does the person mentioned above eat eggs?	**1**= Not enough for all **2**= Culture **3**= Don't know **4**= N/A

10	How do you prepare your eggs for consumption?	**1**= boil them **2**= fry them **3**= use for baking **4**= use as relish **5**= other
11	What is the importance of eggs in one's diet	**1**= have nutrients **2**= we just eat them **3**= Don't know **4**= tasty **5**= other

C: Egg storage processes		
12	How do you store your eggs	**1** = Basket **2** = Fridge **3** = We do not keep eggs **4**= other
12a	How long do they last stored like that	**1**= 1 week **2**= 2 weeks **3**= More than 3 weeks **4**=N/A
12b	What challenges do you face with egg storage	**1**= stolen **2**= they rot **3**= predators **4**= they get watery **5**= other
Knowledge and willingness to learn about egg powder		
13	Have you ever heard about egg powder before?	**0** =No **(skip to Q14)** **1**= Yes
13a	have you used it before	**0**= No **1**= Yes **2**= N/A
13b	What has the egg powder been used for?	**1**=Baking **2**= Reconstituted **3**= Sold as egg powder **4**= N/A
14	Would you like to learn about egg powder and its uses	**0**= No **1**= Yes
14a	What would you like to learn about (products which you feel egg powder can be used for)	……..

Thank you very much for your responses. Do you have any questions you would like to ask?

Name Elizabeth Mnyandu
Student Number 211560561
Programme Master of Science in Food Security

Egg consumption and knowledge questionnaire

Interviewer's Name
……..
Date ……

Ward Code |___|___|___|
Questionnaire Number |___|___|___|
Questionnaire
Code ……..…./……..…/…..……/

Guidance for introducing yourself and the purpose of the interview

1. Igama lami ngingu _____ ngingumfundi e University of Kwazulu Natal
2. Ukhethiwe kwabanye endaweni ukwenza le interview (inhlolokhono). Inhloso ya le interview ukuthola ulwazi ulwazi emphakathini ukhuthi wazi kangakanani ngokubaluleka kwamaqanda
3. uziphendulela ngokwako kanti ulwazi osinika lona luzoba imfihlo, futhi uma kukhona umbuzo ongathandi ukuwuphendula ungakwenza lokho. Ulwazi luzosetshenziswa ukwenza izethulo, kodwa ngeke kubalwe amagama abantu.
4. ngicela ungiphe isikhashana sale interview

A: Household demographics		
1	Ubulili	**1** = Owesilisa **2** = Owesifazane
2	Uzelwe nini?	|__||__||__||__|
3	Ubudlelwano bezothando	**1**= Ushadile **2**= Uhlukanisile **3**= Washonelwa **4**= Akekho othandana naye **5**= Nihlala nokuhlukana
4	Wagcina kubani esikoleni	**1**= Awuyanga esikoleni **2**= Ezingeni eliphansi **3**= Ezingeni elithuthukile **4**= Ezingeni eliphakeme **5**= Uqeqeshiwe
5	Nibangaki ekhaya	0-12 years ….. 13-21 years…. 22 kusiya phezulu…….
6	Malini engenayo ekhaya ngenyanga	----------

B: Egg Consumption		
7	Zingaki inkukukhazi onazo?	**1=** Anginazo **2**= Ngaphansi kuka 5 **3**= ngaphezulu kuka5 **4**= Ngaphezulu kuku 10
7a	Uzifuyeleni inkukukhazi?	**1=** Siyawedla amaqanda azo **2**= Sidayisa amaqanda **3** = Siyenzela isintu **4**= Okunye **5** = N/A
7b	Ubani umnikazi wezinkukhu?	**1**= Umama **2**= Ubaba **3**= Children **4**= Abanye
7c	Ngokujwayelekile niwasebenzisela ukwenza ini amaqanda?	**1**= Siyawedla **2**= Siyawadayisa **3**= Asinawo amaqanda **4**= Okunye
8	Uwadlile amaqanda ezinsukwini eziwu 30 ezidlulile?	**0**= Ca **(skip to Q 8b)** **1**= Yebo
8a	Uwadle kangaki?	**1**= Kanye ngesonto **2**= Kabili kabili ngesonto **3**= Ngaphezulu kokhuthathu ngesonto **4**= N/A

8b	Kungani ungawedlanga ezinsukwini eziwu 30 ezidlulile?	**1**=Besingenawo **2**= Asiwadli **3**= Usiko **4**= Impilo ebuthaka **5**= Asikho isizathu **6**= N/A
8c	Niwathola kuphi amaqanda eniwadlayo?	**1**= Amaqanda ezinkukhu zasemakhaya **2**= Amaqanda ezinkuku zamaqanda **3**= Nithenga amaqanda
9	Ubani ojwayele ukudla amaqanda ekhaya?	**1**= Abadala **2**= Ingane **3**= Okhulelwe **4**= Abesilisa **5**= Abesifazane **6** = Sonke **(skip to Q10)**
9a	Kungani yena ejayele ukudla amaqanda?	**1**= Awenele **2**= Usiko **3**= Angazi **4**= N/A
10	Uwapheka kanjani amaqanda ozowadla?	**1**= Siyawabilisa **2**= Siyenza isishebo **3**= Siyawathosa
11	Abaluleke ngani amaqanda ekudleni kwako?	**1**= Anomsoco **2**= Siwadlela ukhusutha **3**= Angazi **4**= Amnandi **5**= Okunye

C	Egg storage processes	
12	Uwagcina kanjani amaqanda akho?	1= Ubhasikidi **2** = Isiqandisi **3** = Asiwagcini amaqanda **4**= Okunye
12a	Uwagcina isikhathi esinganani?	**1**= Isonto elilodwa **2**= 2 Amasonto amabili **3**= Ngaphezulu kwamasonto amabili **4**=N/A
12b	Ngabe yiziphi izinkinga onazo nokugcinwa kwamaqanda?	**1**= Ayatshonshwa **2**= Ayabola **3**= Izilwane ziyawadla **4**= Aba namanzi **5**= Okunye
Knowledge and willingness to learn about egg powder		
13	Usuke wezwa ngempushana yamaqanda?	**0** =Ca **(skip to Q14)** **1**= Yebo
13a	Sewake wayisebenzisa impushana yeqanda	**0**= Ca **(skip to Q14)** **1**= Yebo **2**= N/A
13b	Isetshenziselwa ukwenza ini lephushana?	**1**=Ukubhaka **2**= Siyenza iqanda **3**= Ukuyidayisa impushana **4**= N/A
14	Ungathanda ukufunda ngalempushana nokuthi isetshenziselwani?	**0**= Ca **1**= Yebo
14a	Yini ongathanda ukuyazi ngayo?	……..

Ngiyabonga ngokungisiza

APPENDIX 2: FOCUS GROUP DISCUSSION QUESTIONS

Focus group discussion questions

Area	Youth	Women	Men
What is the importance of eggs?			
Who should eat eggs?			
Forms of preparation of eggs?			
Forms of acquiring eggs?			
Challenges associated with egg storage			
Which eggs do you prefer?			
What do you do to preserve the eggs?			
What do you do to protect your eggs?			

APPENDIX 3: 5 POINT PICTORIAL HEDONIC SCALE

Sensory evaluation questionnaire

Gender: Male Female

Age: ____

Number: _____

Sample number: _____

TASTE

Very bad Bad Average Good Very good

TEXTURE

Very bad Bad Average Good Very good

AROMA

Very bad Bad Average Good Very good

COLOUR

Very bad Bad Average Good Very good

OVERALL ACCEPTABILITY

Very bad Bad Average Good Very good

Ubulili: Owesilisa Owesifazane

Iminyaka: ____

Number: _____

Sample number: ___769_

Besicela uzwe ukunambitheka kwalokhu kudla okuphambi kwakho.
Emuva kokuzwa besicela utshengise ngalezizimpawu ezilandelayo ukuthi kubukeka kanjani, iphunga, ukunambitheka, nohlobo kanye nesinqumo jikelele ngokubeka uphawu ezithombeni ezilandelayo

UKUBUKEKA

Kubi impela | Kubi | Mhlawumbe Kumnandi Noma Mhlawumbe kubi | Kumnandi | Kumnandi impela

IPHUNGA

Kubi impela | Kubi | Mhlawumbe Kumnandi Noma Mhlawumbe kubi | Kumnandi | Kumnandi impela

UKUNAMBITHEKA

Kubi impela | Kubi | Mhlawumbe Kumnandi Noma Mhlawumbe kubi | Kumnandi | Kumnandi impela

UHLOBO

Kubi impela | Kubi | Mhlawumbe Kumnandi Noma Mhlawumbe kubi | Kumnandi | Kumnandi impela

ISINQUMO JIKELELE

Kubi impela | Kubi | Mhlawumbe Kumnandi Noma Mhlawumbe kubi | Kumnandi | Kumnandi impela

APPENDIX 4: PANELIST CONSENT FORM FOR PARTICIPATION IN THE SENSORY EVALUATION EXERCISE

Consent Form

Sensory evaluation panel of foods prepared from commercial egg powder

You are requested to participate in a scrambled egg testing section. One of the samples you will test is prepared from commercial egg powder. The other sample is prepared from a fresh egg. The eggs are prepared from a home setting under hygienic conditions following the household method for preparing scrambled eggs. The ingredients added are salt and water only. There is no risk associated with consumption of these products, however if you are allergic to eggs you are advised not to participate.

Participation

Your participation in this exercise is voluntary. You can choose not to participate or you may withdraw at any point without any consequences. However we request that you commit yourself throughout the entire period of the study.

Questions

If you have any questions about the study, please ask the researcher now or call Elizabeth on 0780248617 or email to mketiwae@yahoo.com.

Consent

I have had the opportunity to discuss this study and my questions have been answered to my satisfaction. I consent to take part in the study with the understanding that I may withdraw at any time although the researcher would love if I were available for the entire study period. I have received a signed copy of this consent form. I voluntarily consent to participate in this study

_____ _____ _____

Participant Name (Please print) Signature Date

I confirm that I have explained the nature and purpose of the study to the subject named above. I have answered all questions.

_____ _____ _____

Researcher Sign Date

APPENDIX 5: ETHICAL CLEARANCE NOTIFICATION FROM THE UNIVERSITY OF KWAZULU NATAL FOR THE USE OF HUMAN SUBJECTS IN THE SENSORY EVALUATION OF COMMERCIAL EGG POWDER

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

16 July 2012

Mrs Mnyandu (211560561)
School of Agriculture, Earth & Environmental Sciences

Dear Mrs Mnyandu

Protocol reference number: HSS/0461/012M

Project title: Assessing the feasibility of making egg powder at rural community level

In response to your application dated 15 June 2012, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number. Please note: Research data should be securely stored in the school/department for a period of 5 years.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

.....
Professor Steven Collings (Chair)
Humanities & Social Science Research Ethics Committee
/ms

cc Supervisors: Dr U Kolanisi and Dr M Chimonyo
cc Academic Leader: Professor D Jaganyi
cc Ms Michelle Francis

Professor S Collings (Chair)
Humanities & Social SC Research Ethics Committee
Westville Campus, Govan Mbheki Building
Postal Address: Private Bag X54001, Durban, 4000, South Africa
Telephone: +27 (0)31 260 3587/8350 **Facsimile:** +27 (0)31 260 4609 **Email:** ximbap@ukzn.ac.za / snymanm@ukzn.ac.za

APPENDIX 6: LABORATORY REPORTS FOR TESTS PERFORMED ON SUN DRIED AND OVEN DRIED EGGS

Document No: BST28COA.1

Bio-Science Technologies (Pty) Ltd

Founded in 2003, Reg. no. 2012/029072/07
In association with ISO/IEC 17025 accredited Chem-Science Laboratories (Pty Ltd
Food Technologists & Microbiologists, Hygiene Auditors & HACCP Consultants
Sole South African distributors for Technical Service Consultants, UK and EnZtek, USA

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LAB T0161

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Republic of South Africa

Telephone: +27 (0) 31 205 1216
Fax2email: +27 (0) 88 031 206 0518
Cellphones +27 (0) 82 444 9401 (Director)
+27 (0) 83 427 3023 (Manager)
E-mail: microlab@biosciencetechnologies.com
Website: www.biosciencetechnologies.com

Our certificate number: B131217.4
Your order / reference number: *190413*

Page 1 of 1
Our Quote number: Q – BT219

Certificate of Analysis

One sample received on the 19 April 2013 at 15h00, ***sampled by yourselves***.

Sample Markings: No Markings
Sample Description: Water Sample
Condition of sample as received: Unsatisfactory (±25°C)
Date testing commenced: 22 April 2013
Date testing completed: 29 April 2013

The microbiological examination showed the following:

Test	Sample Result	Units
Total Plate Count*	**Nil**	**cfu/ml**
Total Coliform Count*	**Nil**	**per 100ml**
Total *E.coli* Count*	**Nil**	**per 100ml**

Key: < = Less than; > = Greater than; ND = Not Detected ie. indicates the absence of the organism; **P** = Indicates the **Presence** of the organism

Comments:

1. Temperature of sample upon receipt at our laboratory = **±25°C.**
2. All Internal Laboratory QC Controls conform to documents BST08QCC and BST09QCC.
3. All laboratory tests carried out as per client's instructions, Agreement of Service Form dated 18 February 13, and email dated 2013/08/27.
4. Sterile sampling bottle supplied by ourselves.
5. **We recommend that microbiologically sensitive samples should be kept cool (ideally below 10°C) during transit to our laboratory. Cooler boxes with ice packs can be provided, if requested.**

Methods: (Lab T0275)

Total Plate Count* - PC agar at 35°C for 48 hours (SANS 5221: 2006) (Test Method BST/F1.2)
Total Coliform Count* - M-Endo Agar at 35°C for 24 hours (SANS 5221:2006) (Test method BST/W1)
Total *E.coli and Faecal Coliform* count* - M-Fc Agar at 42°C for 24 hours (SANS 5221:2006) (Test method BST/W2)

Note: Only original reports are considered official. Electronic documents are transmitted "WITHOUT PREJUDICE"

Approved signatures signed electronically

Signed ……VAS…… this 3rd day of May 2013
VA Soffiantini, Chartered Chemist
C.Chem.M.R.S.C. Pr.Sci.Nat.

……NR……
N. Ramparsad; BSc Micro & Biochem
Technical Signatory (Microbiology)

……LP……
L. Pillay; Nat. Dip. Biotechnology
Microbiologist

To: University of KwaZulu Natal
Private Bag X01
Scottville
3209

Requested by: Elizabeth Mnyandu
E-mail: mketiwae@yahoo.com

Reported to: Dr.M. Kolanisi
kolanisi@ukzn.ac.za

Document No: BST28COA.1

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Cellphones +27 (0) 82 444 9401 (Director)
+27 (0) 83 427 3023 (Manager)
E-mail: microlab@biosciencetechnologies.com
Website: www.biosciencetechnologies.com

Our certificate number: B131217.2
Your order / reference number: 190413

Our Quote Number: Q – BT219

Certificate of Analysis

One sample received on the 19 April 2013 at 15h00, ***sampled by yourselves.***

Markings: Oven Dried Egg
Sample Description: Yellow Powder
Condition of sample as received: Satisfactory (±25°C)
Date testing commenced: 22 April 2013
Date testing completed: 29 April 2013

The microbiological examination showed the following:

Test	Sample A Result	Sample B Result	Units
Total Plate Count*	**$13x10^2$**	**$18x10^2$**	**cfu/g**
Total Coliform Count*	**<10**	**<10**	**cfu/g**
Presence of *E.coli**	**ND**	**ND**	**per 10g**
Presence of *Salmonella spp**	**ND**	**ND**	**per 10g**
Total *L.monocytogenes* Count*	**ND**	**ND**	**per 10g**

Key: < = Less than
> = Greater than
ND = Not Detected ie. indicates the absence of the organism
P = Indicates the Presence of the organism

Comments :
1. Temperature of the cooler box upon receipt at the laboratory = ±25°C (Ambient).
2. All Internal Laboratory QC Controls conform to documents BST08QCC and BST09QCC.
3. All laboratory tests carried out as per client's instructions, Agreement of Service Form dated 18 February 13 and email dated 2012/08/27.
4. Samples was tested in duplicate.

Methods: (Lab T0275)

Total Plate Count*	- PC Agar at 30°C for 72 hours (SABS ISO 4833:1991) (Test method BST/F1.1).
Total Coliform Count* & Presence of *E.coli**	- VRB- Mug Agar at 37°C for 24 hours (SABS ISO 4832:1991; Biolab Catalogue & Manual, 2004) (Test method BST/F2.1).
Presence of *Salmonella* spp*	- BPW/RV/MKTTn/XLD at 37°/42°/37°/37°C for 18/24/24/24 hours respectively (ISO 6579:2002) (Test method BST/F4)
Presence of *L.monocytogenes*	- ½ Frasers/Fraser Broth/Chromogenic agar at 35°/35°/37° for 24/24/24 hours (Test method BST/F9) (Test method BST/F2.1).

Note: Only original reports are considered official. Electronic documents are transmitted "WITHOUT PREJUDICE"

Signed.....VAS.....this day of 3rd day of May2013.
V A Soffiantini, Chartered Chemist
C.Chem., M.R.S.C., Pr.Sci.Nat.
Approved signatures signed electronically

.....NR.....
N Ramparsad; BSc Microbiology & Biochemistry
Technical Signatory (Microbiology)

.....LP.....
L. Pillay, Nat. Dip. Biotechnology
Microbiologist

To: University of KwaZulu Natal
Private Bag X01
Scottville
3209

Requested by: Elizabeth Mnyandu
E-mail: mketiwae@yahoo.com

Reported to: Dr.M. Kolanisi
kolanisi@ukzn.ac.za

Document No: BST28COA.1

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E-mail: microlab@biosciencetechnologies.com
Website: www.biosciencetechnologies.com

Our certificate number: *B131217.3* *Page 1 of 1*
Your order / reference number: *190413* *Our Quote Number: Q – BT219*

Certificate of Analysis

One sample received on the 19 April 2013 at 15h00, ***sampled by yourselves.***

Markings: Fresh Egg
Sample Description: Whole Hens Egg
Condition of sample as received: Satisfactory (±25°C)
Date testing commenced: 22 April 2013
Date testing completed: 29 April 2013

The microbiological examination showed the following:

Test	Sample A Result	Sample B Result	Units
Total Plate Count*	**110**	**145**	**cfu/g**
Total Coliform Count*	**<10**	**<10**	**cfu/g**
Presence of *E.coli**	**ND**	**ND**	**per 10g**
Presence of *Salmonella spp**	**ND**	**ND**	**per 10g**
Total *L.monocytogenes* Count*	**ND**	**ND**	**per 10g**

Key: < = Less than; > = Greater than
ND = Not Detected ie. indicates the absence of the organism
P = Indicates the Presence of the organism

Comments :
1. Temperature of the cooler box upon receipt at the laboratory = ±25°C (Ambient).
2. All Internal Laboratory QC Controls conform to documents BST08QCC and BST09QCC.
3. All laboratory tests carried out as per client's instructions. Agreement of Service Form dated 18 February 13 and email dated 2012/08/27.
4. The egg yolk and albumin were tested by aseptically blending to make a composite of the contents of the egg in a sterile bottle.

Methods: (Lab T0275)

Total Plate Count*	- PC Agar at 30°C for 72 hours (SABS ISO 4833:1991) (Test method BST/F1.1).
Total Coliform Count* & Presence of *E.coli**	- VRB- Mug Agar at 37°C for 24 hours (SABS ISO 4832:1991; Biolab Catalogue & Manual, 2004) (Test method BST/F2.1).
Presence of *Salmonella* spp*	- BPW/RV/MKTTn/XLD at 37°/42°/37°/37°C for 18/24/24/24 hours respectively (ISO 6579:2002) (Test method BST/F4)
Presence of *L.monocytogenes*	- ½ Frasers/Fraser Broth/Chromogenic agar at 35°/35°/37° for 24/24/24 hours (Test method BST/F9) (Test method BST/F2.1).

Note: Only original reports are considered official. Electronic documents are transmitted "WITHOUT PREJUDICE"

Signed.....VAS.....this day of 3rd day of May2013.
V A Soffiantini, Chartered Chemist
C.Chem.,M.R.S.C.,Pr.Sci.Nat.
Approved signatures signed electronically

.....NR.....
N Ramparsad; BSc Microbiology & Biochemistry
Technical Signatory (Microbiology)

.....LP.....
L. Pillay, Nat. Dip. Biotechnology
Microbiologist

To: University of KwaZulu Natal
Private Bag X01
Scottville
3209

Requested by: **Elizabeth Mnyandu**
E-mail: mketiwae@yahoo.com

Reported to: **Dr.M. Kolanisi**
kolanisi@ukzn.ac.za

Document No: BST28COA.1

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Cellphones +27 (0) 82 444 9401 (Director)
+27 (0) 83 427 3023 (Manager)
E-mail: microlab@biosciencetechnologies.com
Website: www.biosciencetechnologies.com

Our certificate number: B131217.1 *Page 1 of 1*
Your order / reference number: 190413 *Our Quote Number: Q – BT219*

Certificate of Analysis

One sample received on the 19 April 2013 at 15h00, ***sampled by yourselves.***

Markings: Sun Dried Egg
Sample Description: Yellow Powder
Condition of sample as received: Satisfactory (±25°C)
Date testing commenced: 22 April 2013
Date testing completed: 29 April 2013

The microbiological examination showed the following:

Test	Sample A Result	Sample B Result	Units
Total Plate Count*	**$37x10^2$**	**$62x10^2$**	**cfu/g**
Total Coliform Count*	**<10**	**<10**	**cfu/g**
Presence of *E.coli**	**ND**	**ND**	**per 10g**
Presence of *Salmonella spp**	**ND**	**ND**	**per 10g**
Total *L.monocytogenes* Count*	**ND**	**ND**	**per 10g**

Key: < = Less than; > = Greater than
ND = Not Detected ie. indicates the absence of the organism
P = Indicates the Presence of the organism

Comments :
1. Temperature of the cooler box upon receipt at the laboratory = ±25°C (Ambient).
2. All Internal Laboratory QC Controls conform to documents BST08QCC and BST09QCC.
3. All laboratory tests carried out as per client's instructions, Agreement of Service Form dated 18 February 13 and email dated 2012/08/27.
4. Sample tested in duplicate.

Methods: (Lab T0275)
Total Plate Count* - PC Agar at 30°C for 72 hours (SABS ISO 4833:1991) (Test method BST/F1.1).
Total Coliform Count* & Presence of *E.coli** - VRB-Mug Agar at 37°C for 24 hours (SABS ISO 4832:1991; Biolab Catalogue & Manual, 2004) (Test method BST/F2.1).
Presence of *Salmonella* spp* - BPW/RV/MKTTn/XLD at 37°/42°/37°/37°C for 18/24/24/24 hours respectively (ISO 6579:2002) (Test method BST/F4)
Presence of *L.monocytogenes* - ½ Frasers/Fraser Broth/Chromogenic agar at 35°/35°/37° for 24/24/24 hours (Test method BST/F9) (Test method BST/F2.1).

Note: Only original reports are considered official. Electronic documents are transmitted "WITHOUT PREJUDICE"

Signed.....VAS.....this day of 3rd day of May 2013.
V A Soffiantini, Chartered Chemist
C.Chem.,M.R.S.C.,Pr.Sci.Nat.
Approved signatures signed electronically

.....NR.....
N Ramparsad; BSc Microbiology & Biochemistry
Technical Signatory (Microbiology)

.....LP.....
L. Pillay, Nat. Dip. Biotechnology
Microbiologist

To: University of KwaZulu Natal
Private Bag X01
Scottville
3209

Requested by: Elizabeth Mnyandu
E-mail: mketiwac@yahoo.com

Reported to: Dr.M. Kolanisi
kolanisi@ukzn.ac.za

APPENDIX 7: REGULATIONS CONCERNING MICROBIOLOGICAL SAFETY OF FOODS

(updated)
REGULATIONS GOVERNING MICROBIOLOGAL STANDARDS FOR FOODSTUFFS AND RELATED MATTERS

Published under Government Notice No. R. 692 of 16 May 1997
As corrected by:
Government Notice No. R. 1296 of 16 October 1998
Government Notice No. R. 491 of 8 June 2001
As amended by:
Government Notice No. R. 427 of 5 May 2000
Government Notice No. R.490 of 8 June 2001

The Minister of Health has, in terms of section 15(1) of the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act No. 54 of 1972), made the regulations in the Schedule.

SCHEDULE

Definitions

1. In these regulations any expression to which a meaning has been assigned in the Act shall bear such meaning and, unless the context otherwise indicates -

"Annex" means an annex to these regulations;

"bottled water" means any water other than natural mineral water prepacked in a container made from glass, a plastic material, tin plate or other suitable material which is capable of being sealed with a closure;

"coconut" means the fruit of the coconut palm in *Cocus nucifera*;

"edible gelatin" means clean, wholesome protein obtainable by extraction from collagenous material;

"edible ices" means the sweetened product obtained either from an emulsion of fat and protein with the addition of other ingredients and substances or from a mixture of water, sugars and other ingredients and substances which have been treated by freezing and are intended for storage, sale and human consumption in the frozen or partially frozen state;

"egg product" means the product from the contents of an egg of the species *Gallus domesticus*: Provided that such an egg, the yolk thereof, the albumen thereof or a mixture of the yolk and albumen of such an egg in liquid, frozen or dried form has not been subjected to an incubation process;

"natural mineral water" means water which contains certain mineral salts in various proportions and which is characterized by the presence of trace elements and other substances such as calcium, magnesium, sodium and potassium and is obtained directly from natural or drilled sources from underground waterbearing strata;

"poultry" means any chicken, duck, goose, guinea fowl, ostrich, partridge, pheasant pigeon, quail, turkey, and the chicks thereof;

"spices and dried aromatic plants" means natural dried components or mixtures of spices and aromatic plants used in foodstuffs for flavouring , seasoning and imparting aroma, and includes the whole, broken or ground form;

"sugars" means dextrose, dextrose syrup, fructose, fructose syrup, glucose, glucose syrup, invert sugar, lactose, maltose, maltose syrup, sucrose and xylose; and

"the Act" means the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act No. 54 of 1972).

Microbiological specifications

2. The analysis or examination of a foodstuff referred to in these regulations for determining the presence of bacteria or other micro-organisms listed in column 1 of Annex A shall take place in accordance with the method listed opposite thereto in column 2 of the said Annex

3. Desicated coconut shall not contain any pathogenic organisms of the genera *Salmonella* and *Shigella* nor any coagulase-positive *Staphylococcus aureus* per gram.

4. Sugars that are used for the canning of vegetables or other products liable to thermophilic spoilage shall comply with the following bacteriological standards:
   (a) The total number of thermophilic organisms shall not exceed 100 per 10 grams of sugar;
   (b) *Escherichia coli* shall be absent in 20 grams of sugar;
   (c) *Clostridium* species shall be absent in 20 grams of sugar; and
   (d) The total number of sulphide spoilage shall not exceed 10 per 100 grams of sugar.

5. Edible gelating shall comply with the following microbiological specifications:
   (a) The total bacteriological count shall not be greater than 1 000 per gram when gelatin is tested according to SABS method 756, modified by using an incubation temperature of 37°C;
   (b) *Escherichia coli* shall be absent in 0,1 gram;
   (c) *Clostridium* species shall be absent in 0,1 gram when gelatin is tested according to SABS method 762, modified by adding sodium sulphite and ferric citrate to the reinforced clostridial agar and the formation of black colonies shall indicate the presence of *Clostridium* bacteria; and
   (d) *Salmonella* species shall be absent in 1 gram.

6. (1) In the case of partly cooked or uncooked sea-water and freshwater foods such as prawns, shrimps, crayfish, lobsters, crab meat, oysters, mussels, clams, eels or fish-
      (a) a histamine content of more than 10 mg per 100 grams of the foodstuffs, when tested according to AOAC (Association of OfficialAnalytical Chemists) method 977.13 (1990), shall indicate decomposition of the foodstuff, and more than 20 mg per 100 grams shall render the foodstuff unsafe for human consumption;
      (b) no antibiotics shall be present;

(c) no organisms of the genera *Salmonella* and *Shigella* and no species of *Vibrio cholerae* and *V.parahaemolyticus* shall be present in 20 grams;
(d) no coagulase-positive *Staphylococcus aureus* shall be present in 20 grams-
(e) (i) except in the case of oysters, mussels and clams, the number of *Escherichia coli* Type 1 organisms shall not exceed 10 per 100 grams; and
(ii) in the case of oysters, mussels or clams, the number of *Escherichia coli* Tpe 1 shall not exceed 500 per 100 gram; and
(f) the total colony count for organisms shall not exceed 1 million per gram when such foodstuff is tested by the pour-plate method on plate count agar at 30°C for 72 hours and, in the case of oysters, mussels or clams, the total colony count shall not apply.

(2) In the case of cooked sea-water and freshwater foods such as prawns, shrimps, crayfish, lobsters, crab meat, oysters, mussels, clams, eels or fish -
(a) a histamine content of more than 10 mg per 100 grams of the foodstuff, when tested according to AOAC (Association of Official Analytical Chemists) method 977.13 (1990), shall indicate decomposition of the foodstuff, and more than 20 mg per 100 grams shall render the foodstuff unsafe for human consumption;
(b) no antibiotics shall be present;
(c) no organisms of the genera *Salmonella* and *Shigella* and no species of *Escherichia coli* Type 1, *Vibrio cholerae* and *V.parahaemolyticus* shall be present in 20 grams;
(d) no coagulase-positive *Staphylococcus aureus* shall be present in 20 grams;
(e) the number of coliform organisms other than *Escherichia coli* Tpe 1 shall not exceed 1 000 per 100 grams; and
(f) the total colony count of organisms shall not exceed 100 000 per gram when such a foodstuff is tested by the pour-plate method on plate-count agar at 30°C for 72 hours.

7. No person shall sell cooked poultry -
(a) which contains the following:
(i) Antibiotics and other antimicrobial substances in amounts that exceed the maximum levels determined in the regulations governing maximum limits for veterinary medicine and stock remedy residues that may be present in foodstuffs, published by Government Notice No. R. 1809 of 3 July 1992;
(ii) Organisms of the genera *Salmonella*, *Shigella* and *Escherichia coli* in 20 grams
(iii) *Staphylococcus aureus* in 20 grams;
(iv) *Clostridium perfringens* in 20 grams; and
(b) of which the total colony count of organisms exceeds 10 000 per gram when such foodstuff is tested by the pour-plate method on plate-count agar at 30°C for 72 hours.

8. In the case of natural mineral water or bottled water which is sold as a foodstuff -
(a) it shall be free from -
(i) parasites and pathogenic organisms which may render such product unfit for human consumption;

(ii) *Escherichia coli* and other coliforms, and faecal streptococci in a sampleof 250 millilitres;
(iii) *Clostridium* species in a sample of 50 millilitres; and
(iv) *Pseudomonas aeruginosa* in a sample of 250 millilitres;

(b) the total viable count of organisms when sampled within 12 hours of bottling shall not exceed 100 per milliliter when measured at 20-22°C in 72 hours on agar-agar medium or an agar-gelatin medium and 20 per milliliter when measured at 37°C within 24 hours on agar-agar medium.

9. Dried species ad aromatic plants (including but not exclusively those listed in Annex B) or a mixture thereof, with or without the addition of other foodstuffs, which are sold to the consumer or to the food industry shall be deemed to be contaminated, impure, decayed or harmful or injurious to human health if any such product contains -

(a) the following bacteria in a sample of 20 grams of the product:
(i) *Bacillus cereus*;
(ii) *Clostridium perfringens*;
(iii) *Escherichia coli*;
(iv) *Staphylococcus aureus*; and

(b) more than the following amounts of micro-organisms in 1 gram of the product:
(i) Total aerobic bacteria: 10^6 per gram of the product;
(ii) yeasts and moulds: 10^4 per gram of the product; and
(iii) coliforms: 10^3 gram of the product.

(c) bacteria of the *Salmonella* species in a sample of 25 grams of the product.

10. In the case of edible ices -

(a) it shall be free from -
(i) pathogenic organisms; and
(ii) *Escherichia coli* Type 1 in 0,1 ml;

(b) the total colony count of organisms shall not exceed 50 000 per milliliter.

11. An egg product after pasteurization or irradiation shall comply with the following microbiological specifications:

(a) *Salmonella* organisms shall be absent in 25 ml or g of an egg product;
(b) *Staphylococcus aureus* shall be absent in 1 ml or g of an egg product;
(c) mesophilic aerobic bacteria shall not exceed 20 000 colony forming units per gram or milliliter;
(d) coliforms shall not exceed 50 per gram or milliliter of an egg product; and
(e) yeast and moulds shall not exceed 200 per gram or milliliter of an egg product.

Repeal

12. The following regulations are hereby repealed:

(f) Regulation 11 of the regulations regarding ice cream promulgated in terms of the repealed Foods, Drugs and Disinfectants Act, 1929 (Act No. 13 of 1929), as published by Government Notice No. 2518 o 10 December 1954 and amended by Government Notices Nos. 515 of 14 April 1967, 850 of 16 June 1967 and 1484 of 25 August 1972, in so far as it relates to microbiological standards;
(g) regulation 21*bis* of the regulations regarding desiccated coconut promulgated in terms of the repealed Foods, Drugs and Disinfectants Act, 1929 (Act No. 13 of 1929), as published by Government Notice No. 1291 of 25 August 1967;

(h) regulation 7(1)(e) of the regulations regarding food, drugs and disinfectants in terms of the repealed Foods, Drugs and Disinfectants Act, 1929 (Act No. 13 of 1929), as published by Government Notice No. 575 of 28 March 1930 and amended by Government Notice No. 739 of 29 May 1935, substituted by Government Notice No. 2401 of 26 November 1954 and amended by Government Notices. 837 of 7 June 1957, 1913 of 6 December 1957 and 418 of 19 March 1971;

(i) regulation 39*bis* (1), (4), (5) and (6) of the regulation regarding edible gelatine promulgated in terms of the repealed Foods, Drugs and Disinfectants Act, 1929 (Act No. 13 of 1929), as published by Government Notice No. 941 of 8 May 1953 and amended by Government Notice No. 837 of 7 June 1957;

(j) subregulations (3)(a) to (g), (4)(a) to (g) and (5) of the regulations regarding marine food promulgated in terms of the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act No. 54 of 1972), as published by Government Notice No. R. 2064 of 2 November 1073;

(k) the regulations governing the microbiological standards for cooked poultry promulgated in terms of the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act No. 54 of 1972), as published by Government Notice No. R. 106 of 18 January 1985; and

(l) the regulations relating to herbs and spices promulgated in terms of the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act No. 54 of 1972), a published by Government Notice No. R. 1468 of 13 August 1993.

ANNEXURE A
MICROBIOLOGICAL METODS

COLUMN 1	**COLUMN 2**
Micro-organisms	**Standard test methods**
Bacillus cereus……	ISO Test Method 7932*
Viable *Clostridium perfringens*……	ISO Test Method 7937
Coliforms ……..	SABS Method 757
Escherichia coli ……..	SABS Method 758**
Viable *Salmonella* ……	SABS Method 759
Total plate count (total aerobic bacteria)……..	SABS Method 756
Staphylococcus aureus ……..	SABS Method 760
Shigella ……..	SABS Method 1195
Vibrio cholerae ……..	SABS Method 1196
Faecal streptococci……..	ISO Method 7899
Yeast and mould count ……..	ISO Method 7954

* Microbiology – general guidelines for enumeration of *Bacillus cereus* colony count techniques at 30°C

** Use the PMN technique for the enumeration of *Escherichia coli* using the media described by this ethod.

SABS: South African Bureau of Standards

ISO: International Standards Organisaion

ANNEXURE B

Herb/Spices	Botanical name
Allspice…….……..	*Pimenta dioica* *Pimenta officinalis* (Berg)
Aniseed……..	*Pimpinella anisum* L.
Anise star ……..	*Illicium verum* L.
Bay leaf ……..	*Laurus nobilis* L.
Caraway…….……..	*Carum carvi* L.
Cardamom……..	*Elettaria cardamomum* (Maton)
Cassia (wild cinnamon, sena leafes)……..	*Cinnamomum burmanii* L. *Cinnaomum cassia* L. *Cinnamomum loureirii* (Nees) *Cinnamomum zeylanicum* (Nees)
Cayenne pepper (chilli) …….……..	*Capsicum annum* L. *Capsicum baccatum* L. *Capsicum frutescens* L. and others
Celery (seed) ……..	*Apium graveolens* L.
Chervil…….…….……..	*Anthriscus cerefoliom* (Hoffm.)
Chives…….……..	*Allium schoenoprasum* L.
Cinnamon…….……..	See cassia
Cloves…….……	*Eugenia caryophyllus* *Caryophyllus aomaricus* L.
Coriander…….……..	*Coriandrum sativum* L.
Cumin…….……..	*Cuminun cyminum* L.
Dill seed…….……..	*Anethum graveolens* L.
Fennel…….……..	*Foeniculum vulgare* L.
Fenugreek (Greek hay)…….……	*Trigonella foenum-graecum* L.
Garlic…….……..	*Allium sativum* L.
Ginger…….……..	*Zingiber officinale* L.
Horseradish…….……..	*Cochlearia armoracia* L.
Mace (seed coat)…….……..	*Myristica fragans* (Houtt.)
Marjoram (motherwort)…….……..	*Majora hortensis* *Origanum* spp. *Origanum majorana* L. *Origanum nitex*
Mustard (black)…….……..	*Brassica juncea* L. *Brassica nigra* L.
Mustard (white)……..	*Brassica hirta*
Nutmeg (limed or unlimed)…….……	*Myristica fragrans* (Houtt.)
Onion…….…….……..	*Allium cepa* L.
Origanum…….……	*Origanum vulgare* L.
Paprika…….…….……	*Capsicum annuum* L. *Capsicum fragrans* L. *Capsicum frutescens* L.
Parsley……	*Petroselinum carum* *Petroselinum crispum* (Hoffm.)
Pepper (black)……	*Piper nigrum* L.
Pepper (white)……	*Piper nigrum* L.
Peppermint……..	*Mentha piperita* L.

Poppy seed……..	*Papaver somniferum* L.
Rosemary……	*Rosmarinus officinalis* L.
Saffron……	*Crocus sativus* L.
Sage……	*Salvia officinalis* L.
Savory (bean wort)…….….	*Satureja hortensis* L. *Satureja indicum* L.
Sesame ……..…….…….…….…….……..	*Sesamum indicum* L.
Shallot……..……..	*Allium ascolonicom*
Spearmint (garden mint)…….…….……	*Mentha spicata* L. *Mentha viridus*
Sweet basil (basil wort)……..……..	*Ocimum basilicum* L.
Tarragon…….……..	*Artemisia dracunculus* L.
Thyme……..……..	*Thymus vulgaris* L.
Tumeric (curcuma root)……..	*Curcuma longa* L.