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A Quality Assessment of Home-Made Baby Foods and Their Impact on the Health of Babies

Philip John Kanu[1], Fatmata Bintu Dumbuya[2], Alhaji Ibrahim Sankoh[1*]

[1]Milton Margai Technical University, Freetown, Sierra Leone
[2]Freetown Polytechnic, Freetown, Sierra Leone
Email: *aisanks3049@gmail.com, dumbuyaf3@gmail.com, philipkanu@yahoo.com

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Abstract

Food is vital for the growth of humans especially children. Irregular growth in children can lead to many health hazards ranging from physical impairment to death. In Sierra Leone, poor Infant and Young Child feeding practices are predominant, with only 32% of children being exclusively breastfed and 42% appropriately fed with complementary foods, some of which are produced home-made. This study aimed to assess the quality of home-made produced baby foods and their impact on the health of infants. The objectives of the study are to, 1) investigate the weaning process and identify the types of food mothers/caregivers use to introduce the child to weaning food, 2) interview parents in the community that feed their children with home-made produced baby foods to understand, the health and developmental problems affecting their children in relation to the food, 3) observe and assess the production and processing methods of home-made produced baby foods and 4) relate these processes to the quality of the food and analyse home-made produced baby foods. Using laboratory techniques the food quality and possible contamination were assessed and possible amendments for the benefit of the child were suggested. Interviews were conducted using a structured interview schedule and food was analysed in the laboratory for macronutrient levels, and microorganisms. It was discovered that babies are introduced to weaning foods before three months and 100% both production and preparation observed have the tendency to contaminate the food. Not all the food tested have the required levels of nutrients. Microorganisms that can be pathogens were found in the food. It was concluded that home-made produced foods are often not safe weaning foods since they have the potential to cause food borne in children.

Keywords

Mother/Caregivers, Contamination, Health Hazards, Weaning

1. Introduction

1.1. Background

According to [1], food is a substance consisting essentially of protein, carbohydrate, fat, and other nutrients that are used by the body of an organism to sustain growth and carry out vital processes and furnish energy. Food also includes substances such as mineral, vitamins and other food nutrients. For food to be used by the body, it has to be digested, absorbed and assimilated. This process of digestion, absorption and assimilation is a complex system which develops in human as one grows from an infant to an adult.

Food is vital for the growth of humans especially children. Irregular growth in children can lead to many health hazards ranging from physical impairment to death [2]. Poor infant feeding practices, such as infrequent feeding, coupled with high rate of diseases such as malaria, pneumonia, diarrhoea are the major courses of inadequate growth in children [3]. Poor infant feeding practices can lead to malnutrition especially when the food lacks some of the major food nutrients or too much of one or more types of nutrients. Malnutrition could be under nutrition where the child does not have sufficient food to support normal growth or over nutrition, where the child is fed with too much of one type of nutrient. Over nutrition could lead to obesity and other over growth issues such heart diseases, kidney malfunctioning and giantism.

According Likhar and Patil (2022) [4], most under nutrition happens during pregnancy and the first two years of life and most of this early damage cannot be reversed. Exclusive breast feeding is recommended for the first six months of life and to introduce solid food at the sixth month but not earlier than 17 weeks [5]. Breast feeding is the optimal method of infant feeding as it ensures babies have the best start in life and provides all energy and nutrients the baby needs, as well as growth factors and immunological component that help protect the baby for infection. However, most mothers do not adhere to this recommendation. Despite the well published benefits of breast feeding for short- and long-term health benefit, the UK still has one of the lowest rates in Europe. An infant feeding survey carried in 2005 showed that, 45% of all mothers in the UK were exclusively breast feeding in one week while 21% at six weeks and at four months the figure went down to 7%. At six months the proportion of mothers who were breast feeding was negligible [6].

If a mother is unable to breast feed or chooses not to, then infant formula should be given as an alternative. Strict criteria on the composition of and permitted ingredient in infant formulas are set out by the European Commission, to ensure that infant formulas contain recommended amount of nutrient and that additions are carefully regulated. This means that the vitamins and mineral content of different brands of formulas are very similar, although they may differ in source of protein or the addition of novel ingredients as in the case of home-made processed baby foods.

Quality assessment of baby food made of different pre-processed organic

material under industrial processing conditions targets the satisfaction of consumers. The market for processed foods is rapidly growing [7]. The industry needs methods for processing with care leading to high quality products in order to meet consumers' expectations. Processing influences the quality of finished products through various factors. Statistically significant differences are found for sensory attributes among three puree samples [7]. Bio crystallization identifies changes between replication of the cooking pre-treatment of material have a significant influence on the final influence of the baby food [7].

1.2. Statements of the Problem

Breast milk is the best meal for new-borns [8]. Babies' natural food is breast milk. It gives the baby all the energy and nourishment they require, particularly during the first six months of life [8]. Breast milk is proven to promote healthy growth in children, which lowers infant mortality [9]. Over 10 million children die before turning five every year, primarily from avoidable causes, and nearly all of these deaths take place in developing nations like Sierra Leone [9] [10]. Furthermore, according to Australian Institute of Health & Welfare (2003) [11], around 41% of these deaths take place in sub-Saharan Africa alone. According to reports, the majority of these deaths take place in the newborn stages, with the majority also occurring in the infantile phases. The significance of improper food and undernutrition is one of the important factors to take into account while attempting to reduce the issue of child mortality. One of the root causes of infectious disease-related child fatalities has been found to be undernutrition. Compared to infants who are exclusively breastfed, infants aged 0 - 5 months who are fed baby food have a seven-fold higher risk of dying from pneumonia and diarrhea [12] [13]. According to the World Health Organization (WHO), breastfeeding could have prevented the deaths of an estimated 1.5 million newborns annually [9].

In spite of the benefits of breast-feeding, and all the interventions and provisions initiated to promote, support and protect breastfeeding, the rate of breast feeding in Sierra Leone is still generally low. This has partly been attributed to socio-economic and demographic trends, lactation problems as well as the fact that breast feeding is still not as protected as it should be because mothers still believe in the traditional ways of child caring [14]-[16]. In Sierra Leone, poor Infant and Young Child feeding practices are predominant, with only 32% of children being exclusively breastfed and 42% appropriately fed with complementary foods (solid/semi solid/soft foods) at 6 - 23 months [17]. There are traditional beliefs that when a child cry too much it means the child needs food which could be either liquid of semi-liquid. The perception of parents/caregivers that breast milk is not enough for the satisfaction of the child. Therefore, majority of children are given baby food. Such food could be industrially manufactured or home-made produced. In most cases the introduction of baby food leads to the deterioration of the health of the baby. This often leads to mothers changing the type of food.

This makes most of the mothers who introduce their babies to early feeding using industrially manufactured food changes to home-made produced foods which are relatively cheaper.

The Baby Food market has been reported to be growing consistently, however it is said to have experienced phenomenal growth since the year 2003 [18]. Studies have shown that the complexity of factors that affect breastfeeding include the aggressive marketing of breast milk substitutes, practices at health facility levels that have the potential to undermine breastfeeding, cultural feeding practices, economics of feeding, convenience, socio economic and demographic factors, availability as well as employment concerns [15] [19] [20]. Of all these, two key factors that have been identified to contribute largely to the entrenchment of bottle feeding are commercial promotion of infant food products and health care practices that encourage the use of these products [19]. In Sierra Leone, the worsening economic trends make it difficult for poor parents who are in the majority, to afford buying industrially manufactured foods for their babies. Due to the cost and allergy associated with processed foods most mothers in Sierra Leone tend to prepare their own baby food using home-made available foods within their localities. This makes home-made produced baby foods more popular in Sierra Leone. The common home-made produced baby foods in Sierra Leone include but not limited to; Corn meal, foofoo porridge, Home-made bennimix, porridge made from rice crust, porridge made from powdered rice, plantain, banana and carrot. The problem is that not much is known about the food quality of these baby foods. Both the processing and the production are not standardised and the food is liable to contamination. No research has ever reported the level of contamination and how this impacts the health of babies. Even those mothers feeding their children with different types of foods differ in methods of preparation. This is because there is limited access to written document which serves as guide for the preparation and processing of such foods by most mothers and or caregivers in Sierra Leone [21]. Handling, processing and storage could affect the quality of food and most times introduce contaminants which may be harmful to infants and children. Most parents or care givers use mortars and pestles to pound the food during production. This could contaminate the food with fungal toxins such as aflatoxins that could cause diseases in babies. These instruments could also be infested with bacteria and other contaminants. One grinding method that is becoming increasingly popular in Sierra Leone is the use of grinding machines in local markets which are used for grinding a variety of other materials. This could introduce heavy metals and also have the potential to introduce germs to the produced baby food. Handling, preparation, and processing are all liable to contaminate and destroy the food quality of the baby food. Some of the questions one would be asking is that, how safe is this food? What is the quality of the various foods prepared for children? Do they meet the standard nutrient requirement for proper growth? No research has ever been done to address these issues

1.3. Aims and Objectives of the Study

1.3.1. Aim

The aim of this study is to assess the quality of home-made produced baby foods and their impact on the health of infants.

1.3.2. Objectives

The objectives of the study are as follows;

- To investigate the weaning process and identify the types of food mothers/caregivers use to introduce the child to weaning food.
- To interview parents who bring their babies for treatment at the Iscon Health Centre in the Portee community that feed their children with home-made produced baby foods to know the health and developmental problems affecting their children in relation to the food.
- To observe and assess the production and processing methods of home-made produced baby foods and relate these processes to the quality of the food.
- To analyse home-made produced baby foods using laboratory techniques to determine the food quality and possible contamination and suggest possible amendments for the benefit of the child.

1.4. Justification of the Study

It is an established fact that most parents in Sierra Leone either at the early (2 months) or mid-stage (3 - 4 months) end up giving their children home-made baby food. Food in general can have a significant impact on the health of children depending on its safety and food quality. A study which quantifies the nutrient level in various home-made produced foods are important in the process of good health care delivery and reduction of child mortality.

2. Research Methodology

2.1. Introduction

The research methodology was multidisciplinary in approach. The first section involved a social type of data collection which employed the use of questionnaires for key informant interviews and focus group discussions. The other section was observations and the final section was laboratory analytical methods which were used to analyse the baby food samples. The research is both qualitative and quantitative.

2.2. Study Area

Portee is located between Brima Lane and Rokupa going towards Wellington, East-End of Freetown in the Western Urban Area of Sierra Leone. Portee community is a densely populated community inhabited by all the major ethnic groups in Sierra Leone. There are also foreign inhabitants such as the Guineans, Liberians, Nigerians, Ghanaians and Lebanese. This makes this community a diversified community with an integration of different cultural practices which also

reflects on the feeding habits and patterns.

The Iscon Community Health Post is located at 10, William Street which is about 100 m from Portee junction.

2.3. Research Population and Sample Selection

The study targeted mothers/caregivers with children within 2 - 24 months which is the common age bracket when mothers often introduce home-made produced baby food to babies in Sierra Leone. Respondents were drawn from mothers/caregivers who visit the Iscon Community Health Post.

According to the hospital management, the hospital services 100 children per week within that community. About 85% of cases reported for children in the health centre are food related. The most common among these are cases of malnutrition as classified by ASPEN (2024) [22].

The target population was about 100 mothers/caregivers since this is the estimated number of mothers/caregivers that visits the health centre per week. From this population a sample size of 20 mothers/caregivers was selected at random using a ballot system. The sample size was determined using an online sample size calculator (survey system 2019) at 95% confidence level.

2.4. Research Instrument and Implementation (Interviews and Focus Group Discussions)

A semi-structure questionnaire was prepared and used to form a structured interview schedule. Five focus group discussions were also held using the interview schedule as a guide and in addition thought stimulating questions were used to stimulate discussion. Before participating, respondents were informed about the research using an information sheet. After a clear understanding, the respondents were asked to fill a consent form. This was done to respect research ethics.

2.5. Observation Procedure

Homes of selected respondents were visited at the time when they produce their baby foods. The processes involved were observed. The hygienic conditions such as proximity toilets, conditions of the equipment used, the cleanliness of the producers and the nature of the environment surrounding the production area and that of the producers were also observed. The preparation processes would be observed. Findings were recorded on paper and photographs were taken using a smart phone as supportive evidence.

2.6. Sample Collection and Preservation

Samples of baby foods prepared during the time of visit were collected from the stock mothers/caregivers produced or stored for the preparation of baby food. These samples were packaged in polythene bags and sealed using a vacuum sealer. The samples were stored at 4˚C in a refrigerator until ready for analysis.

2.7. Analytical Procedures

2.7.1. Determination of Protein Content in Selected Baby Food Using the Bradford Method

1. Sample Homogenization

About 0.5 ml of the sample was transferred into a potter Elvejhem homogenizer and 5 ml of chilled homogenization buffer was added and the homogenized using a mortar and pestle. The homogenate was transferred to a 15 ml centrifuge tube and then centrifuged at 3000 rpm for 5 minutes. After centrifugation the supernatant was transferred to a labelled cryoscopy storage vial held in an ice bucket.

2. Standard and Sample Preparation

BSA assay tubes were prepared at room temperature at the same time for all samples. The homogenate was diluted to ensure that the absorbance reading falls within the standard curve where necessary. The six tubes to receive the BSA Standard 0.2, 0.4, 0.6, 0.8, 1.0 mg/ml were labelled. The tubes receiving the sample were labelled using the name codes of the various samples and a blank was added.

3. Standard and Sample Analysis

The BSA Standards were analysed to produce a standard curve and then the absorbance of the food sample would be determined. From this the concentration of protein in the sample was obtained.

2.7.2. Determination of Carbohydrate Content

The Ruiz-Matute *et al.* (2008) [23] method was followed. About 70:30 ethanol water: mixture was used to extract carbohydrate at 40˚C and sunicated for 30 minutes. The supernatant was filtered after centrifuging. To the residue 1:99 ethanol water/water mixture was added and sunicated for 5 minutes and a second 50:50 ethanol/water sunicated for 10 minutes. The mixture was centrifuged then stored for analysis. The supernatant was analysed using a Nabi spectrophotometer under a VV Spectrum.

2.7.3. Determination of Fats and Oils Content

As an alternative to the solvent extraction methods, hydrolytic procedures were used. This involved a two-step process by which the sample is first treated with concentrated sulphuric acid (H_2SO_4) in order to breakdown the matrix prior for extraction with solvent. Hydrolytic procedures enable the disruption of lipid-carbohydrate bonds, proteins, polysaccharides, and plant cell walls. Such sample pretreatment is particularly necessary for baby food in order to facilitate extraction of neutral lipids contained within the milk fat globule membranes [24]. A complete digestion or hydrolysis of the test material enabled the extraction solvent to come in contact with all lipids contained within the test material. Thus, an exhaustive and quantitative extraction of total lipids was expected. Total lipids were extracted by addition of chloroform, methanol, and water to cause separation of the aqueous and organic phases. The chloroform layer was transferred to a weighed 100-ml beaker and evaporated to dryness.

2.7.4 Determination of Aflatoxins in Home-Made Produced Baby Food

The biosensors method was used to analyse home-made produced food for aflatoxins. This technique refers generally to an analytical device called an ELISA whose analysis is based on the combination of recognition biomolecules with an appropriate transducer, and able of detecting chemical or biological materials selectively and with a high sensitivity [25]. Its principle of detection is the specific binding of the analyte of interest to the complementary biorecongnition element immobilized on a suitable support medium. When the analyte binds the element, there happens a specific interaction which results in a change of one or more physico-chemical properties. Such properties may be pH, electron transfer, mass, or heat transfer that are detected and can be measured by a transducer. In the case of aflatoxin detection, electrochemical and optical are the most commonly used [26].

The sample was mixed with Reverse Osmosis purified water, shaken for 5 minutes using a mechanical shaker and then filtered through a column containing sepharosa beads to which the polyclonal aflatoxin-specific antibodies were joined. The beads with attached aflatoxins were subsequently rinsed with distilled water to remove any impurities and interference. Posterior, an eluant solution was passed through the beads causing antibodies to release the bound aflatoxins. The analyte was collected and placed in an ELISA plate. The plate was heated for 5 minutes using a bio-san heater and was washed with distilled water. The plate was analysed using an ELISA analyser.

2.7.5. Bacteriological Determination

Baby food samples were analysed by using a culture method. The food was moistened with Reverse Osmosis water. This was used to swab on prepared ager broth plates. Four ager broths were prepared these were MacConkey, blood, nutrient and shigella agers. The blood ager was prepared by transferring a known weight of Columbia ager into an Erlenmeyer flask and a known volume of distilled water was added and heated in a microwave to boiling point for 2 seconds to allow the ager to dissolve. The content was allowed to cool to about 57˚C. A sheep's blood was added to the dissolved ager stirred using a magnetic stirrer and then transferred to Petri dishes. The ager was allowed to solidify at room temperature. The other agers were prepared using the same method but there was no added blood on these agers. The samples were added to the prepared plates using a swab and then spread to the rest of the plate using loops. The plates were incubated at 37˚C for 24 hours. Bacteria colonies were observed on the plates. Colonies were smeared on microscope slides slightly heated and then stained with safranine. The stained slides were observed in a light microscope to identify the type of bacteria found. The colonies were also incubated in entero test tubes to identify the bacteria using a code chart.

2.7.6. Determination of Moisture Content in Produced Food

To determine the moisture content of the food, 5 g of sample was placed in a porcelain crucible of known weight. The samples were placed in an oven at 85˚C for 12

hours or overnight. The samples were cooled in a desiccator and then weighed using an electronic balance. The value obtained was expressed as a percentage of the moist sample. This was used determine the moisture correction factor.

2.8. Data Analysis

Data collected from laboratory analysis was presented using pie and bar charts. ANOVA and t-tests was used at 95% confidence level to compare the nutrient levels to internationally recommended values. Cross tabulation and chi-squared analysis were used to compare the food quality and the health of the babies.

3. Results and Discussion

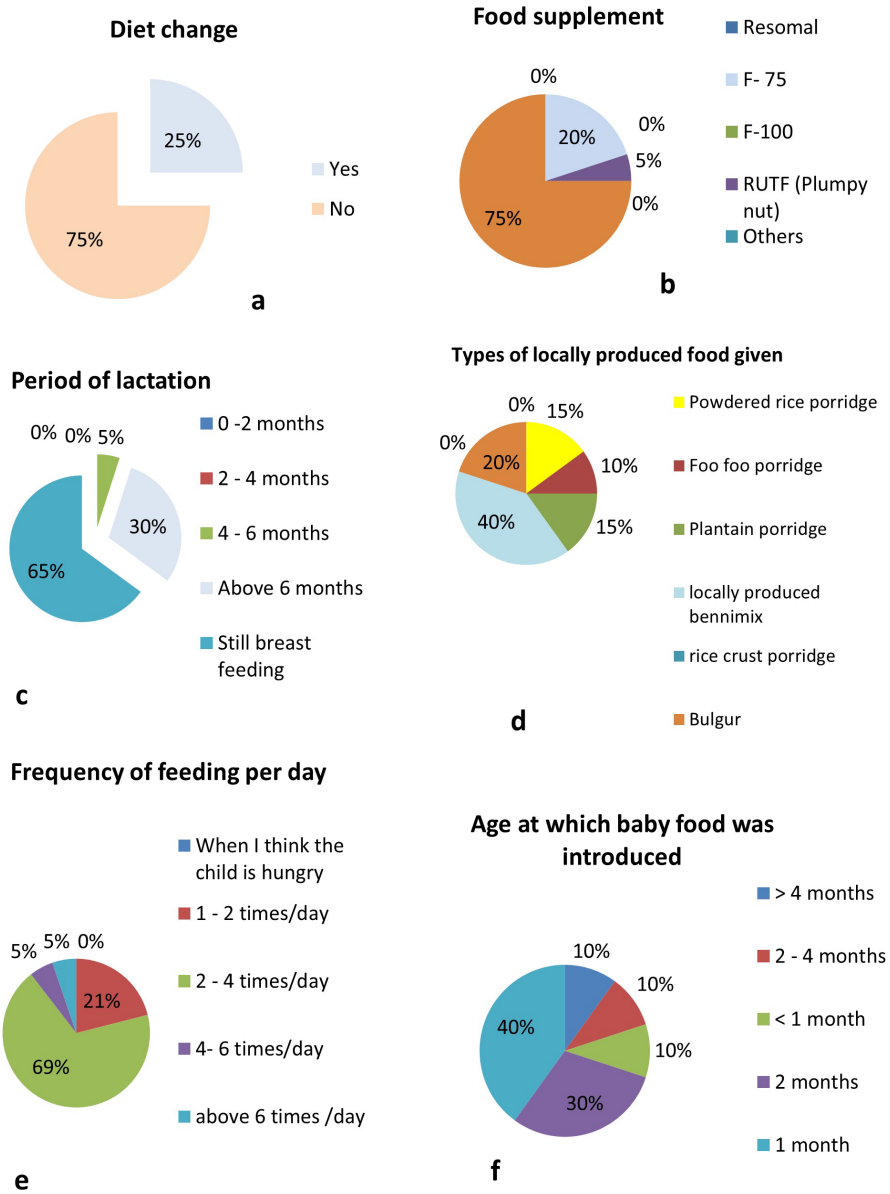
3.1. Introduction

The first sub-section looked in the data collected from the interviews, focus group discussion and observation which was done to determine the health and developmental problems affecting children in relation to home-made produced baby food. This was followed by the presentation analysis and discussion of data obtained from the laboratory analysis of macronutrients. The final section discussed the microbiological contamination data.

3.2. Weaning Processes and the Types of Home-Made Produced Weaning Foods Introduced to Children in the Portee Community

The results obtained for the weaning process carried out by the respondents are displayed in **Figures 1(a)-(f)**.

Form the interview, it was found that 65% of the respondents are still breast-feeding their babies (**Figure 1(c)**). All the respondents stated that they give their babies baby food. Respondents also indicated that 80% introduce their babies to early weaning food (**Figure 1(f)**) despite the exclusive breast feeding for the first 6 months sensitization given to them in clinics [27]. Sometimes this early introduction leads health problems which often lead to diarrhoea, vomiting and/or malnutrition [28]. In some cases, this makes the parent/caregivers change the food. In the research, 25% of the respondents reported that they have changed their baby food at least one time for health-related problems the child developed (**Figure 1(a)**). Some children are allergic to some of the food or they are just too young for that type of food as some of the foods may require mastication which the children cannot do. About 25% of the respondents give their babies F-75 (20%) and plumpy nuts (5%) as supplements to avoid or treat malnutrition (**Figure 1(b)**). The others do not use these supplements because they could not afford or access them [27]. About 70% of the parents use both home-made produced food and industrially produced food to feed their babies especially during the first month baby food is introduced. The local weaning foods introduced to babies in the Portee community include home-made produced Home-made bennimix (40%), Bulgur (20%), rice (15%), plantain (15%) and foofoo 10% (**Figure 1 (d)**). This food is given to the child at least four times a day (**Figure 1(c)**).



Figures 1. The weaning processes of mothers/caregivers at the Iscon Health Centre.

According to [29], babies introduced to early baby food feeding are more likely to develop health problems than those who are breast fed exclusively for 6 months. This implies that babies in the Portee community are more susceptible to encounter health problems. Some of these problems could come from home-made produced food.

3.3. The Production and Processing Methods of Home-Made Produced Baby Foods and Its Impact on the Child's Health

3.3.1. Production of Home-Made Baby Food

According to the respondents, the production method depends on the type of food been produced. However, most of the methods involve washing (**Figure 2**), soaking, grinding/pounding, sieving and roasting. All of these methods have the

potential to contaminate the food. From observation, most parents used tap water or well water with no form of purification for washing and soaking the grains for softening. Research has shown that untreated water could contain pathogens and other life-threatening contaminants which could cause health problems to consumers [30].

Figure 2. A parent washing the sesame for the production of Home-made bennimix.

Some of the respondents grind the food with public grinding machines. Most of these machines are used for multi-purpose grinding with extremely poor hygienic practices. This could be a possible source of contamination and hence a potential threat to the health of the baby. From the focus group discussion, it was revealed that most of the areas where grinding is done is filthy and it is full of flies. The water used to wash the machine is highly contaminated environmental pollutants such as faecal waste. However, the parents are aware of the potential harm that this practice might have on their children but the challenge of producing rice flour from parboiled rice makes them use the machines for this process. Some of the parents/caregivers use mortar and pestle to do the grinding. The major challenge is fungal contamination which can easily grow on the instruments. This type of contamination could lead to mycotoxin related infections when consumed. Poor handling and multipurpose use of the mortar and pestle could also be a source of contamination.

Sieving is also a potential source of contamination. It was observed that parents/caregivers use their bare hands during sieving. In all the sieving processes observed no parent/caregiver use protective gears during sieving. Some were seen not washing their hands before handling their baby's food. This could be a potential source of bacterial contamination. According to [31], the human hands are well known for bacterial contamination. This implies exposed hands especially when not washed properly could lead microbial contamination.

Roasting (Figure 3) is another common practice use in the local production of baby food. This method is good for the elimination of thermo-phobic microbes and it can also help in preserving the food as it reduces the moisture contents and hence prolong the shelf life of the food. However, the environment in which this process is often done could be a source of contamination (Figure 4).

Figure 3. Roasting process in the production of Home-made bennimix.

Figure 4. The nature of an environment on which baby food is home-made produced.

By Roasting at more or less high temperatures, some components may be inactivated (e.g., microorganisms) or their formation can be prevented (e.g., toxins). The food industry often employs processes of homogenization, heating and cooking under hygienic conditions such as preventing flies from sitting on the food to obtain safe and less perishable products. At the same time, numerous reactions can occur during thermal processes leading to the loss of thermolabile substances, such as vitamins and some essential amino acids and resulting in a reduction of the nutritional value of the finished food product. In addition, also particular

chemical-physical mechanisms may be triggered, such as caramelization, lipid oxidation, and Maillard reaction, which can lead to the formation of harmful compounds. In particular, in the Maillard reaction substances such as acrylamide, 5-hydroxymethylfurfural (HMF) and aromatic heterocyclic amines are formed. The products obtained from this reaction have multiple effects: some can be carcinogenic; others seem to be related to diabetes and Alzheimer's, whereas others instead show positive effects such as a high antioxidant and antimutagenic activity

Some parents/caregivers produce foods using materials which cannot be roasted such as plantain (**Table 1**). Some of these are dried in the sun and most do not cover the food during the drying process. This could lead to contamination which could have some health effects on the child that consume such food.

According to [32], homemade baby foods are more likely to be contaminated than industrially produced foods. Results obtained from this research revealed that most of the production processes are associated to possible contamination. This implies the findings are supported by related research by [28], done. In Sierra Leone, most of the parents in Freetown prefer to feed their children with industrially produced food rather than home-made produced food. This is not because of the contamination associated with home-made produced baby food but because of the challenges involved in the production.

3.3.2. Processing Baby Food

All the preparation methods involve heating and boiling which could lead to over cooking. When food is over cooked some important nutrients might be lost and hence reduces the food value. This could lead to malnutrition effects. A major advantage this type of food processing might have is the destruction of microbes especially those that cannot withstand elevated temperatures. This could to a reduction in the risk of ingesting pathogens which might have some health implication. The possible sources of some of these microbes include, water, food production, cooking utensils, the surrounding environment and the person processing the food. Condiments added during processing can also affect the food quality.

According to the respondents the health problems encountered by their babies caused by food that has led to death include; Malnutrition (5%), diarrhoea (15%) and Constipation (6%) (**Figure 5**).

3.4. The Food Quality (Macronutrient Only) of Home-Made Produced Baby Foods

This section will discuss results from the laboratory analysis of baby food samples collected from some respondents. The nutrients analysed include carbohydrate, protein and fats and oil (total lipids).

3.4.1. Protein

Average concentrations of nitrates in all samples are summarized in **Figure 6**. Values obtained varied considerably according to the composition and type of the food.

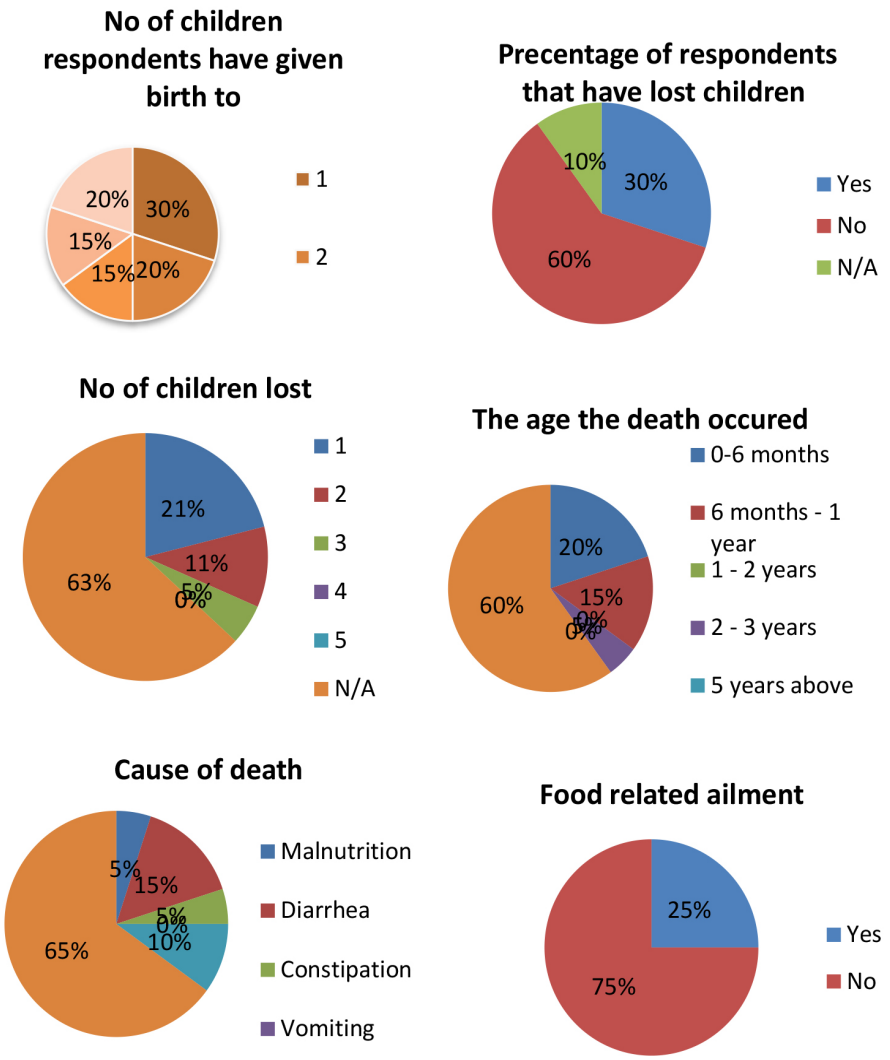


Figure 5. Infant mortality experienced by respondents (data source—Interviews).

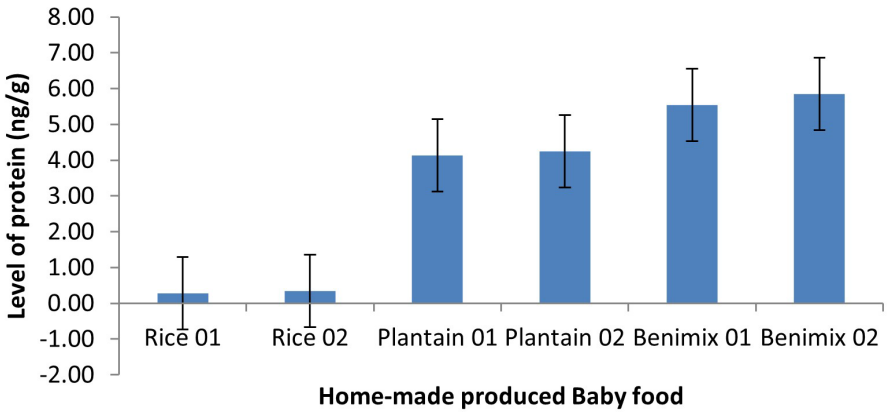


Figure 6. The levels of nitrates (protein) in baby food samples (±SE). Source data from research findings.

Nitrites content in the rice samples was below the detection limit of applied method (<0.9 mg/kg). Consequently, the samples mass of the samples was increased

five times and the values obtained were divided accordingly to obtain the displayed results. Considering the levels obtained which are 0.27 ng/g for white rice and 0.34 ng/g for parboiled rice (Rice 01 and Rice 02 respectively; **Figure 6**), the consumption of 200 g portion of this food would provide 5.4×10^{-3} and 6.8×10^{-3} mg respectively. According to [33], a daily limit 0.56 mg of nitrates is required for the proper development of the baby. Therefore, according to legislation limits levels of nitrates consist of values that can be perceived as unsafe. Such food should be administered with protein supplement such as milk. However, considering the economic status of most parents/caregivers in Sierra Leone, most parents will not be able to afford the required quantity of nitrate supplement for the normal growth of the child.

For the two plantains and two Home-made bennimix samples the levels are within the detection limits (**Figure 4**). For the plantain, the consumption of 200 g portion of plantain 01 and plantain 02 per day will provide 8.26×10^{-2} and 8.5×10^{-2} mg of nitrates respectively. These are still below the minimum [33] recommended value of 0.56 mg but are significantly higher than that of the rice samples ($p = 0.001$). Although the nitrate supplements content required is lower, parents/caregivers find it still too high to afford in Sierra Leone.

The Home-made bennimix samples have higher nitrate levels. The levels in Home-made bennimix 01 and Home-made bennimix 02 are 0.11 and 0.12 mg /200 g respectively. This is also below the WHO recommended value of 0.59 mg per day. It contains the highest quantities of nitrates as compared to rice and plantain. However, this could only give 19% and 20% respectively of the nutrient requirement set by [33]. This implies food supplement for nitrates is also important for home-made produced Home-made bennimix. Home-made produced Home-made bennimix foods differ in composition especially the variety of beans used. That is responsible for the differences in nitrate levels between different samples. Some of the parents/caregivers add fish when producing Home-made bennimix. This might increase the protein content but this might introduce other effects that would not be good for the development of the baby.

In Sierra Leone, Home-made bennimix food is traditionally produced at a large scale as a winning baby food for the period of 6 - 20 months. It is also produced industrially using almost the same components such as sesame seeds (15%), rice (55%), cowpea beans (25%) and sugar (5%). This formula has been recommended by [34], as good winning food that can help babies to grow healthily. However, in the local production of Home-made bennimix, these proportions are not considered. This implies the food quality is not certain.

Nitrates contents in commercial products ranged from 9.1 mg/kg to 38.1 mg/kg. In homemade meals values extended from 26.6 mg/kg to 118.8 mg/kg being much more diversified than in jarred foods. Levels in all samples were lower than legislation limit of 200 mg/kg [34]. Home-made produced baby foods in Sierra Leone do not follow this trend. This is probably because of the poor quality of the raw materials and the inadequacy of the materials as a result of the economic

challenges.

In the UK both within commercial alike in homemade foods maximum contents of nitrates were found for the meal containing potatoes and spinach. This is consistent with common observation that spinach is classified as one of the most nitrates-accumulating vegetable, causing health risks for infants [35]. This is an indication that high levels of nitrates in baby foods could have some health problems for babies. These health problems are not expected when rice, Home-made bennimix and plantain are used to produce home-made baby foods. Brown's [36], investigation revealed that homemade variant of spinach-potato dish contained approximately three times more nitrates than its commercial counterpart. Comparison of nitrates contents revealed visible differences between both types of foods in favour of the industrially produced ones. The most significant difference was observed between jarred vegetable meal and its homemade equivalent. Results obtained reveal that less attention is paid to safety of home-made produced baby foods. Low values of nitrites and nitrates in those products prove proper selection of raw materials but the processing is not well monitored or controlled. It is of great interest that the highest levels of nitrates in any investigated meal did not provide more than regulations' limit. Hence in terms of the protein content of the home-made produced baby food it is better to use these foods for their safety levels rather than use supplements that could lead to overdose.

From the interview conducted all the respondents agreed that they are adding milk to the baby's food when preparing it. The quantity added per meal is not known but 55% of the respondents stated that they are using sachet milk which is known to have high sugar content which might pose some problems to the child.

Table 1. The distribution of milk used in the preparation of baby food by the respondents (data sourced field survey).

Type of milk	No of respondents	Percentage (%)
Sachet milk	11	55
Lactogen	1	5
Guigoz 2	3	15
Nan 2	1	5
Peak milk powder	4	20

Sachet milk could be dairy or non-dairy. From the focus group discussions, it was revealed that parents do not stick to one type of milk. To most parents the cheaper the better. The few that give their children baby milk such as Lactogen, Guigoz 2 and Nan 2 cannot afford to buy enough and therefore in most cases ends up using insufficient milk to meet the nutritional requirement of the baby. However, this is just 25% of the total number of respondents (**Table 1**). Adding milk supplement to the food is good but the way it is done at the Portee community is not safe. The situation is similar to exposure of non-standard milk reported in Korea 2008. This situation was associated with endocrine disrupting effects,

impaired growth, mental and motor development, and increased risk for heart defects [37]-[40]. Such conditions could also lead to kidney impairment and dehydration [41].

Apart from comparing the concentration of nitrates with the maximum European legislation, significant assessment of potential health hazards for children was obtained by calculating nitrates intake deriving from a portion of a meal and comparing each amount set by international organizations: for nitrates 0 - 3.7 mg/kg bw/day [39]. According to the FAO/WHO data estimated daily nitrates intake limit for a baby of body weight 8 kg amounts 29.6 mg. In this analysis assumption of a 200 g portion was taken into consideration. Although any of determined nitrates content was not near legislation limit, some alarming issues can be observed within obtained percentage values of home-made produced baby foods. Ingestion none of a single 200 g portion of examined meal would have been cause of malnutrition. Nevertheless. problem can occur when consuming more servings per day, which contain the recommended levels of nitrates.

3.4.2. Carbohydrate

The carbohydrate levels in home-made produced baby food samples collected from some respondents are shown in **Figure 7**.

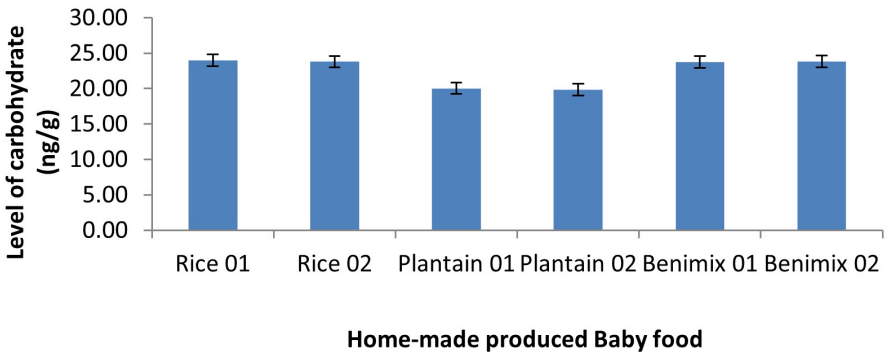


Figure 7. The levels of carbohydrate in baby food samples (± SE). Source data from laboratory analysis.

All the samples analysed have high levels of carbohydrates. However, the expected values are much higher than the actual amount. This is as a result of the presences of other components such as fibre in the matrix of the food. The results focused only on digestible carbohydrates. Results found that the levels of carbohydrates found in the analysed baby food range from 19.80 to 23.97 ng/g of sample. There is no significant difference between all the samples but rice and Home-made bennimix have higher levels of carbohydrates as compared to plantain.

It can be noted that, as regards the foods highest in carbohydrates, the concentrations are far below the above-mentioned threshold values for the normal functioning of the body. As can be seen in **Figure 7**, for cereal-based baby foods analysed at 266 nm the values vary between a minimum of 23.75 ng/g for a cereal mixed with other materials and a maximum of 23.95 ng/g for the same type of

cereal not mixed. According to [42], the daily intake of digestible carbohydrates by infants should be between 0.9 to 10 mg per day. Considering a daily serving of 200 g of food per day, the digestible carbohydrate intake per day when home-made produced food tested is consumed will be between 3.9 and 4.8 mg/200 g of food. This is within the recommended level. This implies the consumption of such food is not expected to cause health problems. However, the addition of other supplements such as sugars could lead to overdose and hence health effects such as diabetes, teeth cavities and obesity are expected. Under feeding which is a common phenomenon in Sierra Leone could also cause diseases as a result of insufficient intake of the nutrient. From the interview, 35% [7] of the respondents indicated that they add sugar to their baby's while 65% [13] do not add sugar. Adding sugar to food that is rich in carbohydrates is likely to cause overdose for babies. The results do not indicate that those parents who do not add sugar to their baby's food are giving their babies sugar free food. Probably the other supplementary foods added to their babies' food contains sugar.

3.4.3. Fats and Oil

Results obtained from the analysis of home-made produced baby food are displayed in **Figure 8**. Fats and oils constitute the lipid content of food. They can either be saturated or unsaturated. However, since the samples do not contain animal material, the results only reflect lipids from unsaturated oils.

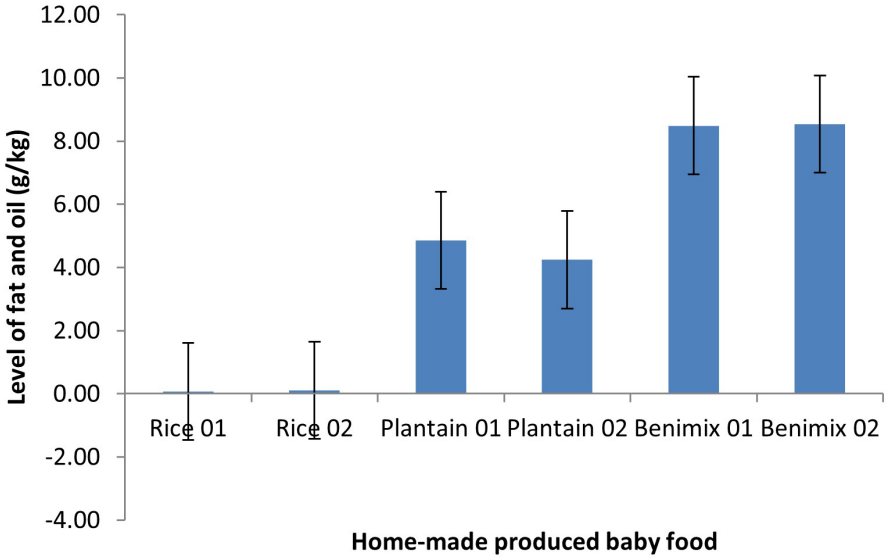


Figure 8. The levels of fat and oil (lipids) in home-made produced baby food samples (±SE). Source data from laboratory analysis.

All the samples were found to contain lipids but the levels in rice is extremely low (**Figure 8**). To obtain these values the sample mass analysed was increased by 10. After obtaining the actual levels were calculated. In both white and parboiled rice the lipid level did not exceed 0.11 g. Plantains has a significantly higher levels of lipid content than rice ($p = 0.0001$) but have significantly lower levels of lipids

than Home-made bennimix ($p = 0.004$). The Sesame in the Home-made bennimix are seeds that are rich in oil. This explains why this type of baby food is rich in oil.

When the composition is 15% the oil in Home-made bennimix is good for the normal development of the baby. However, when over utilised, this could lead to obesity which might occur with some other side effects. From the focus group discussion, it was revealed that parents do not even know the proportion of the components they use to make their baby foods. This uncertainty is a recipe for overdose. In Sierra Leone, obesity occurs at an early age, the parents associate to rapid growth of the child. It has been reported that too much fats and oil in baby food would lead to obesity and some other ailments [43] [44].

Production of baby food without using the right proportion or the right procedure is known as adulteration. Adulteration has been associated to different health problems in children. It is estimated that more than 300,000 infants were exposed to such adulterated formula, with tens of thousands of hospitalizations and several deaths [45] [46]. This is a common phenomenon in the Portee community especially in the production of a multi-component baby food such as Home-made bennimix.

Foods with low lipid levels have negative effects to the normal development of the baby. This implies feeding the child with rice flour is risking some of these effects especially if the appropriate food supplement is not added during preparation.

3.5. Home-Made Produced Baby Food Contamination by Microorganisms

This research considered two types of microbial contaminations. These are bacterial and fungal (Aflatoxins) contamination.

3.5.1. Bacteria Contamination

Bacterial contamination was detected using agar plates and entero test tubes (**Figure 9(a)**, and **Figure 9(b)**).

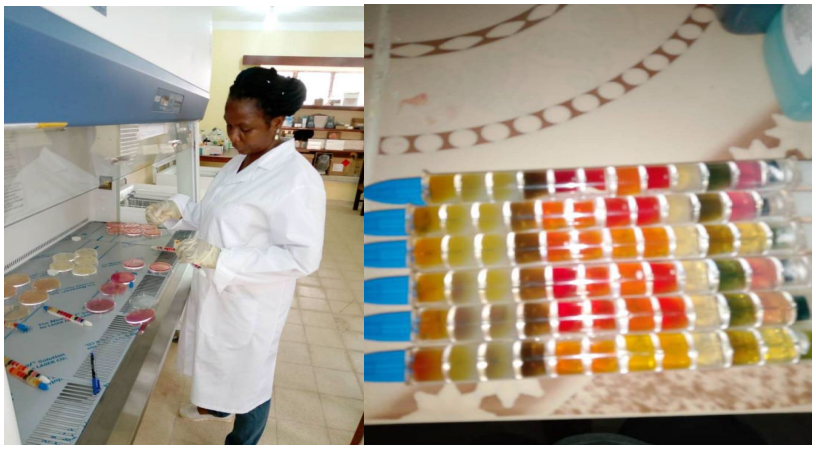


Figure 9. (a) Agar plates with bacteria colonies; (b) Entero test tubes with colour changed by bacteria.

Four agar plates were used for each sample to culture the bacteria. The entero test tubes were used to identify the colonies. The results obtained are displayed in Table 2.

Table 2. The bacteria found in home-made produced baby food analysed.

Sample	Type of sample	Bacteria colonies present
Rice 01	White rice	None was detected
Rice 02	Parboiled rice	None was detected
Plantain 01	Plantain	*Escherichia coli*, *Salmonella sp* and *Proteus mirabilis*
Plantain 02	Plantain	*Escherichia coli* and *Proteus mirabilis*
Benimix 01	Home-made bennimix with cowpea	*Escherichia coli*, *Pantoea agglamerans*, and *Klebsiella pneumonia*
Home-made bennimix 02	Home-made bennimix with broad beans	*Proteus mirabilis*, and *Klebsiella pneumoniae*

There was no colony of bacteria detected in both of the rice samples (Table 2). This is not an indication that baby food produced with rice was not contaminated. Probably the samples were prepared more precautions or the portion that was swabbed was free of bacteria. Most of the bacteria detected are as a result of contamination either as a result of material, the environment or the person that produced the food. *Escherichia coli* is an indication that there is faecal contamination. This could be as a result of the utilization of faecal contaminated water or directly from the hands of the producer.

Food products, including powdered infant formulae, are not sterile but may contain viable microorganisms, including pathogens such as Salmonella *enterica*, Salmonella *typhi*, Shigella *dysenteriae* or *Cronobacter sakazakii* [47]-[49] that can cause serious infections in infants. In recent years, there have been numerous recurrences of invasive infections with *Cronobacter sakazakii* that led to bacteraemia, necrotizing enterocolitis and meningitis—predominantly in premature infants—which were related to the consumption of infant formula reconstituted from powder contaminated with these bacteria [50]-[53]. Occurrence of invasive infections occurred after prolonged storage of reconstituted formula at warm temperatures which can lead to a marked increase in bacterial numbers and hence reach an infective dose [54] [55]. Reij *et al.* [56] recently estimated the burden of disease of Cronobacter infections in infants to the Dutch population as 19 - 24 disability-adjusted life years (DALYs) per year, of which 95% are due to meningitis. Based on these estimates, Cronobacter infections represent 0.5% - 2.4% of the total estimated burden of food-borne infections and intoxications and would be responsible for 0.5% - 0.7% of the meningitis burden to the entire Dutch population. Due to such concerns, numerous product recalls of powdered infant formulae batches in which *Cronobacter sakazakii* had been detected, even at low numbers, have occurred [57]. Some experts and authorities have also recommended the preparation of all infant formulae with water heated to at least 70˚C to inactivate live bacteria. However, it is unclear whether this measure reduces infection risks in newborn, term or older infants if prolonged formula storage is avoided. At the same time, preparation of infant formula with water heated to at least 70˚C will definitely reduce its nutritional quality [56] [58] and increases the risk of scalding injuries from hot water which frequently

occur in infants [59]. Safety concerns due to microbial contamination are not limited to commercial infant foods [60]. Human breast milk and homemade complementary foods may bear significant contamination with microorganisms and aflatoxins, particularly in low-income countries [61]-[64], whereas commercial baby foods generally contain very low amounts of mycotoxins [65].

3.5.2. Mycotoxin (Aflatoxin) Contamination

Aflatoxin contamination in home-made produced baby food samples was determined using a Capture 95 Elisa analyser. Results obtained are displayed in **Figure 10**.

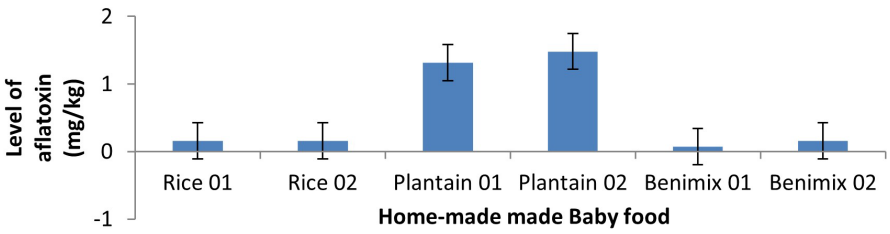


Figure 10. Levels of aflatoxins in home-made produced baby food collected from the Portee community (±SE). Source data.

Aflatoxin contamination is occurring as a result of fungal growth on the food. This could be during prolong storage (more than a month) or from utensils such as wooden mortars and pestles. From the samples tested the plantain samples showed the highest levels of aflatoxin contamination (**Figure 10**). Both rice and Home-made bennimix showed relatively low levels of aflatoxin contamination and there is no significant difference between. Plantain has a significant difference in the levels of aflatoxin ($p = 0.001$ for rice and 0.003 for Home-made bennimix). Rice and Home-made bennimix have an average of 0.15 mg/kg of baby food while the plantain samples have an average of 1.40 mg/kg of baby food sample. The production of rice and Home-made bennimix baby food involves roasting. According to Agostoni *et al.* [54], heating can reduce aflatoxin contamination. This is probably why rice and Home-made bennimix have lower levels of aflatoxin. On the other hand, Plantain is dried in the sun instead of roasted. It is possible that during the long drying period at a relatively lower temperature, fungi can grow on the food. This could lead to elevated aflatoxin levels.

Fungi can easily grow on food under favourable conditions like those that exist during poor storage period (one or more weeks). Interviews, focus group discussion and personal observation, revealed that most of the home-made produced baby food is not stored in appropriate containers. The storage time could be another concern. The shortest storage time is a week. Parents store the baby food they produce for one week (15%), two weeks (30%), three weeks (10%) and one month (45%). This storage time is long enough for fungal growth. Although the aflatoxin levels are low in the rice and Home-made bennimix samples, the storage of the food could lead to rapid growth. Hence all the samples have the potential to cause harm to consumers.

Aflatoxin contamination of foods contributes a significant public health burden in low-income countries due to their carcinogenicity and their growth-impairing effects in children [66].

4. Summary, Conclusion and Recommendation

4.1. Summary

From the first section it was discussed that the introduction of weaning food to babies is not done appropriately. Children are exposed to weaning food too early. There have been reports of babies getting sick or even dying with food related conditions. The most commonly used home-made weaning food is Home-made bennimix.

Production varies and it depends on the type of baby food being produced. The most common production processes include soaking to soften, roasting, pounding/machine grinding, sieving and panning. All of these processes can impact the quality of the produced food. For instance, roasting could lead to the denaturing of proteins and some vitamins

Most of the food processing methods are similar and this includes stirring powder in cold water, adding to boiled water and cooking for 30 minutes. This process also has its challenges in terms of food quality and the safety of babies who consume this food.

The babies of parents/caregivers encounter health problems that are related to food and have led to death these include Malnutrition, diarrhoea and Constipation.

Although any of determined nitrate content was not near legislation limit, some alarming issues can be observed within obtained percentage values of home-made produced baby foods. Ingestion none of a single 200 g portion of examined meal would have been cause of malnutrition. Nevertheless, problem can occur when consuming more servings per day, which contain the recommended levels of nitrates. All the parents use milk to supplement for protein but the quantity of milk added per serving does not take cognisance of what is really needed. Most of the milk used is not appropriate for babies.

Carbohydrates levels in all the food samples are within the recommended threshold. However, the addition of sugar either directly or indirectly could lead to over dose and hence health problems.

All the samples were found to contain lipids but the levels in rice are extremely low. The consumption of rice baby food without using oil or fat supplements could lead to deficiency of this nutrient in babies.

Rice baby foods were found to be bacteria free probably because of roasting or low moisture content. Plantain and Home-made bennimix baby food were found to contain bacteria some of which could cause health problems directly and others give an indication of contamination that might lead to diseases.

Aflatoxins are in all the baby foods sampled although they are in lower concentrations in rice and Home-made bennimix baby food samples. Because of the long storage time and poor storage condition, there is a tendency of fungi to grow in the samples. Hence food stored for a long time would not be safe for consumption.

4.2. Conclusion

From the findings of this research, the following conclusions were made:

- The weaning process in the Portee community is not in accordance with the recommended standards and the types of food mothers/caregivers use to introduce the child to weaning food are not appropriate.
- From the interviews, parents stated that their babies between two to six months are

affected by the type of food they gave to their babies. It was therefore concluded that home-made produced food can cause health and developmental problems that will affect babies if not handled properly.

- The production and processing methods of home-made produced baby foods are faced with challenges which can have negative impacts on the quality of the food.
- The food quality and possible contamination levels according to the laboratory results, have some major challenges although this vary depending on the type of food source and production processes. Roasting at 218˚C could be a good method to help reduce microbial contamination.

The quality of home-made produced baby foods is on the average if devoid of contamination. Rice is rich in carbohydrates but low in protein and fats and oil. This means that consumption of rice baby food needs to be supplemented otherwise the consuming baby will suffer from protein and fat/oil syndromes such as kwashiorkor. Plantain and Home-made bennimix showed relatively higher levels in all the nutrients but did not reach the international recommended levels. However, these baby foods can be consumed without food supplements such as iron and vitamins A and D.

4.3. Recommendations

Based on the findings and experience gained in this research, the following recommendations were suggested:

- Parents/caregivers should avoid the introduction of weaning food to their babies at an early age. The first six months should be exclusive breast feeding [27]. This can be achieved by more public sensitization and awareness campaigns.
- Parents/caregivers should be careful when preparing baby foods to avoid contamination. They should learn to practice good hygiene practices such as wearing clean and appropriate clothing, use clean and sterilised equipment and prepare it in a clean environment.
- Government should fund more sensitization programmes to raise awareness among parents/caregivers about food safety and its impact on the health of babies. Sensitization can educate caregivers about the nutritional needs of babies, emphasizing the role of safe and balanced diets in preventing malnutrition and boosting immunity. Preventing foodborne illnesses reduces healthcare costs for families and the government. A healthy child is also more likely to succeed in education and contribute to society in the long term. Tailoring programs to local contexts ensures the message resonates with communities, addressing specific risks and behaviours unique to their environment. Governments can utilize diverse channels such as social media, community workshops, and collaborations with healthcare providers to reach a broader audience.

More research should be done on home-made produced baby food and this should increase the sample size and the analysis of more food quality parameters such as vitamins and minerals. A comparative study on industrially manufactured and home-made produced baby foods.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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