ANALYSIS OF SOME ESSENTIAL MINERAL ELEMENTS AND PROXIMATE COMPOSITION OF SELECTED COMMERCIAL BABY FOODS AND RECONSTITUTED FRUIT JUICES

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Declaration

I declare that the work in this dissertation entitled "ANALYSIS OF SOME ESSENTIAL MINERAL ELEMENTS AND PROXIMATE COMPOSITIONIN SELECTED COMMERCIAL BABY FOODS AND RECONSTITUTED FRUIT JUICES" has been carried out by me in the Department of Chemistry. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma in this or any other institution.

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Certification

This dissertation entitled **ANALYSIS OF SOME ESSENTIAL MINERAL ELEMENTS AND PROXIMATE COMPOSITION IN SELECTED COMMERCIAL BABY FOODS AND RECONSTITUTED FRUIT JUICES**byAsifauIdris meets the regulation governing the award of degree of Masters in Analytical Chemistry of the Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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Dedication

This piece of work is dedicated to my children and lovely husband.

Acknowledgement

My deepest gratitude goes to Almighty Allah who by his infinite mercy sustained me throughout my study.

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Abstract

This research reports the concentrations of essential elements in commercial baby foods and reconstituted fruit juices obtained from Kaduna and Abuja, Nigeria.The concentrations of mineral elements except calcium were determined using a direct reading spectrophotometer while calcium concentration was determined using titrimetric analysis. The values for proximate analysis carried out on six (6)selected classes of commercial baby food samples showed that the moisture content ranged from 1.39 to 3.19%; Ash contentranged from1.04% to 3.15%. Crude protein ranged from 5.25% to 8.75% whereas crude fibrevaried from 0.97% to 4.73%. The crude fat/lipid of the samples ranged from 3.40% to 5.90%. Carbohydrate content ranged from 81.51% to 86.65%..The highest mean value for the concentration of fluoride in the reconstituted fruit juices samples was 0.0030mg/Lwhile the lowest fluoride concentration was 0.0003mg/L.Fluoride concentration inthe baby food samples ranged from 0.0004mg/kg to 0.0033m/kg. However,fluoride was not detected in four samples of the reconstituted fruit juice and three baby food samples. The concentration of potassium determined in the fruit juice samples ranged from 10.33mg/L to 450.04mg/L,while potassium inthe baby foods samples ranged from579.25mg/kg to 4250.00mg/kg. The concentration of calcium in the fruit juice samples ranged from 124.42mg/L to 442.50mg/L. The baby foods samples had calcium concentrations in the range of5445.92mg/kg to 5368.85mg/kg. Magnesium concentration in the fruit juice samples ranged from78.70mg/L to 141.56mg/L. However, its concentration in the baby

foodsamples were higher, ranging from566.08mg/kg to 1150.73mg/kg. The concentration of phosphorus in the fruit juice samples ranged from 272.73mg/L to 795.46mg/L. A higher

concentration of phosphorus was present in baby food samples rangingfrom 2301mg/kg to 9943.46mg/kg. The concentration of iron in the baby food and reconstituted fruit juice samples were low compared to the concentrations of other mineral elements.Iron in the fruit juice samples ranged from3.09mg/L to 34.50mg/L and from 31.25mg/kg to 549.11mg/kg in the baby food. The concentration of zinc was also low in baby food samples, ranging from 2.87mg/kg to 171.49 mg/kg. Zinc was not detected in all the fruit juices and baby foods except in one sample of the reconstituted juice.Positive significant correlations were obtained between F^- and Zn (0.770^{**}), NO_3^- and Mg (0.744^{**}); between K and Ca(0.605^{*}), Mg(0.474^{*}), P(0.548^{*}), Fe(0.580^{*}) in the selected reconstituted fruit juice samples. Positive significant correlations were obtained between pH and NO_3^-(0.502^{*}) at (95%) confidence level where as negative correlations were obtained between Cl^- and P (-0.615^{*}) and between Mg and Fe (-0.675^{**}) respectively in the baby food samples. Theconcentrations of the studied elements were within safe limits recommended by National Institute of Health and the Institute of Medicine, for foods. Therefore, the commercial baby foods produced from mixed cereals have higher concentration of calcium, potassium and iron.

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Abbreviations and Symbols

AAP	American Association of Pediatrics
ADA	American Dental Association
AJCN	American Journal of Clinical Nutrition
A I	Adequate Intake
AOAC	Association of Official Analytical Chemists
ATP	Adenosine Triphosphate
CA	Crude Ash
C F	Crude Fats/Lipids
CFBBF	Cereal Based Fruit baby Food
CP	Crude Protein
CW	Crude Water
DNA	Deoxyribonucliec Acid
DRI	Daily Required Intake
EBT	Eriochrome Black T
EDTA	Ethylene diamine tetra acetic acid
EGTA	Ethylene glycol tetra acetic acid
FAO	Food and Agriculture Organization
H M D	Hexamethyldisiloxane
ICP- OES	Inductive Coupled Plasma Optical Emmision Spectroscopy
IDA	Iron Deficiency Anaemia
IM, FNB	Institute of Medicine, Food and Nutrition Board
IOM	Institute of Medicine
INAA	Instrumental Neutron Activation Analysis
LPI	Linus Pauling Institute

LSRO Life Science Research Office

MBBF Maize Based Baby Food

MCBBF Mixed Cereal Based Baby Food

MSBBF Modified Starch Based Baby Food

NAS National Academy of Science

NCCD PHP National Center For Chronic Disease Prevention and Health Promotion

NFE Nitrogen Free Extracts

NHMRC National Health and Medical Research Council

NIH National Institute of Health

NIHCC National Institute of Health Clinical Center

NRC National Research Council

NHANES National Health and Nutrition Examination Survey

PBBF Protein Based Baby Food

ppmParts per million

RDI Recommended Dietary Intake

SCF Scientific Committee on Food

SON Standard Organization of Nigeria

SPADNS 2-(P sulfophenylazo)-1-8-dihydroxy-3-naphtalene diphosphate

TISAB Total Ionic Strength Adjustment Buffer Solution

UNICEF United Nations Children's Fund

USEPA United States Environmental Protection Agency

USDA United State Department of Agriculture

WBBF Wheat based Baby Food

WHOWorld Health Organization

ZINCON 1-(2-Hydroxycarbonylphenyl)-5-(2-hydroxy-5-sulfophenyl phenylformazan, monosodium salt

CHAPTER ONE

INTRODUCTION

1.1 BabyFoods

Scientific study has proven that breast milk is the perfect food for babies during the first six months of life. It is recommended as the sole source of babies nutrition for the first six months of life as it contains all the nutrients and immunological factors that babies require to maintain optimal health and growth. However, less than 35% of the world's infants are exclusively breast fed for the first six months and it is recommended that breastfeeding should continue along with complementary feeding until two years of age (WHO, 2009). This is not always possible due to the fact that not all mothers are able to produce sufficient amounts of milk for their babies (Angel *et al*., 2014). It has been observed that as from six to 12 months, older infants can meet their nutrition requirements with a combination of breastmilk and complementary foods (Butte *et al*., 2004). Complimentary feeding becomes necessary in order to meet the nutritional needs of the child (Monte and Glugilani, 2004).

An estimated one third of a young child's energy can come from breastfeeding and the remaining two thirds from complementary foods (WHO, 2009; PAHO, 2003).Nutritious complementary foods, also known as baby foods are therefore introduced. Poor nutrition during this critical period of life may increase the risk of growth faltering and micronutrient deficiencies, and may have adverse effects on health and mental development. Hence, improved complementary foods are essential for the child's normal growth and cognitive development.

In recent years, the increase in commercial availability of several types of reconstituted fruit juices and baby foods has resulted in a moderate price reduction of these products thereby leading to an increase in consumption of various baby foods by infants and fruit juices by children. The composition of commercial baby foods and reconstituted fruit juices can be very different from the foods that make up the diet of the general population and therefore information is needed on the nutritional adequacy in terms of the levels of many mineral and elements in these foods. These mineral ions and or trace elements can be divided from a dietary point of view into three groups; the essential trace elements (micronutrients) which are constituents of hormones, vitamins and catalysts required by enzyme for metabolic processes in the cells; the possibly essential trace elements and the non-essential trace elements, made up of the toxic and the non-toxic elements which have no metabolic functions in the living organism (Schrauzer, 1994).

Commercial baby foods can be described as any soft, easily chewed and digested food prepared from a powder formula(processed grains, modified starch, fruits and vegetables) into a liquid paste made specifically for babies/children between the ages of four to six months and two to three years or above of age (WHO, 2009) . These foods are usually made mainly from processed grains; usually milk or any form of protein such as soybeans powder is added during preparation before consumption in order to provide a complete protein meal needed by children. These baby foods comes in multiple varieties, textures and tastes; it may be home made, or it can be purchased from markets or retail outlets.Commercial baby foods can be classified according to the type of grains used for its formulation, such as wheat based, rice, corn or maize, guinea corn, millets, barley, a combination of two or three of types of grains, a combination of grains and fruits(banana,

apples etc), modified starch, a combination of any grain with protein powder (soy beans, groundnuts). All commercially available baby foods are to provide the required nutrients as recommended dietary intake (RDI) of minerals for babies and young children (Bermejo *et al*., 2000).

1.1.1 Classification of commercial baby foods

Commercial baby foods are usually prepared mainly from a variety of starchy grains (cereals) as the base ingredient. Classification is therefore based on the type of cereal (milled grain or combination of grains) used. This should constitute at least 50% of the final mixture on a dry weight basis.

The foods are fortified with sufficient amount of nutrient supplements or other adjuvants that make them suitable to be consumed by infants and young children who are over 6 months old.These cereal-based commercial baby foods meant for infants and young children have to be prepared for consumption with milk or other appropriate nutritious liquids. The most familiar grains used for making a category of baby food cereals include maize or corn, rice, wheat, millet, oats and barley.

Wheat based baby food is a type of baby food made primarily from wheat grains(whole or processed). Wheat cereal typically contains more fiber than most other types of cereal. This key nutritional ingredient can help children feel full between meals on a lower amount of calories(Baublis*et al*., 2000).Rice based baby foodare primarily made from rice grain which are either whole or processed. A rice based baby food is usually easy to digest, gluten free and are therefore the least likely to cause allergies in children. They also serve as a good option for kids with sensitive digestive system. Maize or corn based baby foods are also manufactured from maize (whole or processed). Mixed cereal based baby foods are usually a combination of two or more varieties of grains to produce a unique flavor, texture and nutritional

quality for the kids.High protein cereal-based baby foods are a combination of any grain (maize, wheat, rice) with a high amount of protein such as soybeans, milk, peanuts that form the bases for this type of foods which are or have to be prepared with water or other appropriate protein -free liquid to be consumed by babies and young children.Modified starch based baby food are most often referred to as corn starch that has been chemically treated or altered to produce a thick smooth paste when prepared for consumption. Most of these baby food products prepared from modified starch are gluten free.

Fruit based baby foods are a blend of dried, preserved fruits processed into powder form added to any cereal of choice(maize, wheat or rice) by the manufacturer to produce a blended meal for babies and young children(Siega*et al.,* 2010).

1.1.2 Composition and nutrient value of cereal grains used in the manufacture of commercial baby foods

Cereals belonging to the complex carbohydrates food group are rich sources of minerals, vitamins, carbohydrates, oils, proteins and fats. Whole cereal grains have an outer bran coat, a starchy endosperm, and a germ. Cereals are enriched with niacin, iron, riboflavin and thiamine, and most cereals have abundant fiber contents, especially barley, oat, and wheat. Cereal consumption also means an intake of high amounts of protein, for infants and children, baby food cereals that are iron fortified are often eaten with milk that makes for a protein-rich meal and also said to be the premium solid foods for infants (Rampersaud *et al*., 2005).

1.2. Reconstituted Fruit Juicesand Drinks

These are nutritious foods which offer great taste and are of health benefits because they are important source of mineral elements (Gililands*et al.*, 2003). Baby foods and reconstituted fruit juices that are beneficial to both babies and young children's diet should contain significant amounts of vitamins A, B, C, and D, and mineral elements such as Fe, Ca, Mg, K, and accepted recommended doses of Na, F^-, Mn, Zn, P and Cu (Marzec and Zareba, 2005).

However, these products contain varying amount of these minerals and hence are of varying qualities. The content of these mineral elements has become an issue of growing concern (Njenga and Kariuki, 2004).Diet is the main source of trace element (Dim *et al.*, 2004). Many elements are present in foods naturally, or through human activities, such as processing, storage, farming activities and industrial emission (Fein and Falci, 1999). To maintain the physiological and metabolic processes of the body, it is recommended to take appropriate amounts of these mineral elements, since deprivation can lead to diseases; whereas excessive intakes may adversely affect the human metabolic function (Orkason and Sandstoerm, 1995). At high concentrations, these essential elements can lead to poisoning of human body (USEPA, 2004).

1.3. Mineral Elements

1.3.1. Fluorine

Thisis naturally found in water as fluoride in varying amounts, depending on the geological, chemical, and physical characteristics of the aquifer. It is also present in various environmental and food samples. Small amounts of fluoride are vital for the human body and beneficial in the prevention of dental caries but it is toxic in larger amounts.

According to guidelines published by the World Health Organization (WHO, 1984), fluoride is an effective agent for preventing dental caries if taken in optimal amounts. However a single optimal level for daily intake cannot be agreed because of the nutritional status of individuals which varies greatly and influences the rate at which fluoride is absorbed by the body. A diet poor in calcium, for example, increases the body's retention of fluoride.The lethal dose for adults is 0.20-0.35g per kg body weight, (Tokaliogl*u et al.*, 2004). Excessive amounts of fluoride can enter the human body by means of polluted air, water and through the food chain, (Tokaliogl*u et al*., 2004). An additional source of fluoride for human is toothpaste containing 0.1% fluoride and water fluoridation (addition of fluoride in the form of NaF to drinking water).

Water is a major source of fluoride intake. The WHO (1984) guidelines suggested that in areas with a warm climate, the optimal fluoride concentration in drinking water should remain below 1 mg/litre (1ppm), while in cooler climates it could go up to 1.2 mg/L. The differentiation is derived from the fact that perspiration is more in hot weather and consequently more water is consumed. The WHO guideline value for fluoride in water is not universal, for example, India lowered its permissible upper limit from 1.5 mg/L to 1.0 mg/L in 1998. In many countries, fluoride is purposely added to the water supply, toothpaste and sometimes other products to promote dental health. It should be noted that fluoride is also found in some foodstuffs and in the air (mostly from production of phosphate fertilizers or burning of fluoride-containing fuels) so the amount of fluoride people actually ingest may be higher than assumed. It has long been known that excessive fluoride intake carries serious toxic effects. Scientists are now debating whether fluoride confers any benefit to humans at all (Poureslami*et al*., 2008).

1.3.2. Calcium

Calcium is the most abundant mineral in the human body. The body stores about 99% of its calcium in the skeleton (bones and teeth), where it serves both structural and physiological roles. It is very important in human metabolism, making up about 1-2% of an adult human's body weight. In addition to its widely known role in bone structure, calcium is used to help control muscle and nerve function, as well as to manage acid/base balance in our blood stream. Calcium-rich foods therefore play important roles in many aspects of our health that extend far beyond the specific area of bone health (Barba and Russo, 2006).

The most obvious need for calcium is to help build and maintain strong bones. However, calcium is also important for blood clotting, muscle contraction, nerve transmission, and maintenance of normal blood pressure. This explains the importance of calcium intake to human life. Calcium requirements are affected substantially by genetic and other dietary constituents. The interactions of these factors make identification of a single unique number for calcium requirement for all children impossible (NIHCC, 1994; IMFNB, 1997). Calcium is an absolutely critical nutrient in regulating acid/alkaline balance in the blood. When blood pH starts getting low (down to 7.35 from a baseline of 7.4), calcium is released from the bones to regulate the acid / base balance. A complex set of hormonal interactions manages this process, and it is tightly regulated. The pH of blood is of critical importance to sustain life, and controls processes as varied as breathing rate and the ability to transport oxygen in blood cells (Cook and Friday, 2003). It is recognized that a very low calcium intake can contribute to the development of rickets in infants and children,

especially those consuming very restrictive diets such as macrobiotic diets (Dagnelie*et al.*, 1990) even though there are no reliable data on the lowest calcium intake needed to prevent rickets or on the relationship among ethnicity, Vitamin D status, physical activity, and diet in the causation of rickets in children fed with low-calcium diet (Legius*et al*., 1989). There is also some evidence that calcium supplements may be helpful in reducing the risk of colon cancer, regulating heart rhythms and treating premenstrual syndrome. The daily intake for calcium is between 200mg/day to1300mg for babies of months through to children of 16years of age (IOM, 2004/2007). Calcium is usually well tolerated if the stated doses are not exceeded.

1.3.4 Potassium

Potassium is necessary for the function of all living cell, potassium ion diffusion is a key mechanism in nerve transmission and potassium ion depletion in human body results in various cardiac dysfunctions (Murray, 2006). Potassium is an essential mineral that works to maintain the body's water and acid balance. As an important electrolyte, it plays a role in transmitting nerve signals to muscles, muscle contractions, fluid balance, various chemical reactions and in the maintenance of normal blood pressure (Webster *et al.*, 2010). Most of the ingested potassium (80-90%) is excreted in urine, the rest being excreted in faeces and sweat (Holbrook *et al*., 1984; Pietinen, 1982). Potassium filtered in the glomeruli of the kidney is mostly reabsorbed. The potassium in urine results from secretion into the cortical collecting duct, under control of the hormone, aldosterone. High plasma levels of potassium stimulate release of aldosterone to increase the secretion of potassium.Potassium requirements can be affected by climate and physical activity, the use

of diuretics, and the intake of other electrolytes, notably sodium. Potassium blunts the effect of sodium chloride on blood pressure, mitigating salt sensitivity and lowering urinary calcium excretion (Su *et al*., 2001). Given this interrelatedness, requirement for potassium depends to some extent on dietary sodium. However, the ideal sodium: potassium intake ratio is not sufficiently established to use in setting requirements. Its deficiency is usually rare but since many brands of baby foods and reconstituted fruit juices are now fortified with potassium and calcium to increase their nutritional value, there is concern that high intake of potassium poses a risk factor for chronic diseases (Webster *et al.*,2010)**.** High potassium intakes can cause gastrointestinal discomfort and stress that may include ulceration and perforation (Lambert and Newman 1980; Pietro and Davidson, 1990).

High level of potassium can cause a condition known as hyperkalemia**.** The concentration of potassium in blood is more than the kidneys can eliminate. Based on research by the Linus Pauling Institute (LPI, 2007) ingestion of more than 18 grams of potassium per day can cause this mineral to accumulate, resulting in kidney failure. People with hyperkalemia may experience tingling of their extremities, weakness or cardiac arrhythmia, or abnormal heart rhythm that can be deadly. Arrhythmia can also arise from the resulting hyperkalaemia, (Su*et al*., 2001, Ray *et al*.,1999).

1.3.6 Magnesium

Magnesium is one of the most abundant minerals in our body, which needs it for over 300 chemical processes. About half of the magnesium in the body is locatedin the bones. For children whose bones are still growing and developing rapidly, it is crucial that their diets

provide enough magnesium to help them grow healthy and strong(Rude and Shils,2006).According to the L P I (2007), magnesium is used in a variety of functions, especially in the metabolism of energy from food. This is important for children who are very active and need plenty of energy. Magnesium is also important for DNA synthesis, which enables cells to reproduce, helping children's growing tissues. Finally, magnesium works with vitamin D and calcium to help build strong bones. Vitamin D helps aid the absorption of magnesium into the blood, which then travels to our bones.

1.3.7 Iron

Iron is a nutrient that is essential to babies and young children's growth and development. Iron helps move oxygen from the lungs to the rest of the body and helps muscles store and use oxygen. Babies are born with iron stored in their bodies, but a steady amount of additional iron is needed to fuel a child's rapid growth and development (WHO, 1997).

1.3.8 Phosphorus

Phosphorus is a mineral that makes up 1% of a person's total body weight. It is present in every cell of the body. Most of the phosphorus in the body is found in the bones and teeth.The main function of phosphorus is in the formation of bones and teeth. It plays an important role in how the body uses carbohydrates and fats. It is also needed for the body to makeproteinfor the growth, maintenance, and repair of cells and tissues. Phosphorus also helps the body make ATP; a molecule the body uses to store energy (Mason,2011).Phosphorus works with the B vitamins. It also helps with the following; kidney function, muscle contractions, normal heartbeat.

1.3.9 Zinc

Zinc is an essential nutrient, important for proper growth and development in children. Zinc is also needed for enzyme and immune function, wound healing and protein synthesis. According to IOM (2001), it is important to consume zinc every day since the body does not efficiently store it. The amount of zinc a child requires is based on his or her age and gender. Zinc deficiency can lead to developmental delays. Zinc is a trace element essential to the health and formation of a child's brain (AJCN, 2001). The amount of protein in a child's diet is a contributing factor to the efficiency of zinc absorption as zinc binds to protein.

1.4 Proximate Analysis (Crudenutrientanalysis)

The proximate or Weende analysis of food is a quantitative method to determine different macronutrients in food stuff, however it also gives us an idea of its nutritional value. Basically it is the partition of food compounds into six categories by means of common chemical properties. The categories are moisture (crude water), crude ash (CA), crude protein (CP), ether extracts (Crude fats or lipids; EE), crude fiber (CF) and carbohydrate (nitrogen free extracts (NFE).

1.5 Justification of Study

Commercial baby formulas/foods, bottled water, and beverages such as reconstituted fruit juices are sometimes low in essential mineral elements quality and also contain higher concentrations of elements/ ions such as fluoride, chloride, and high acidity levels which can be harmful as reported in several literatures (Monte and Glugilani, 2014;Ayivor*et al*., 2011; Adriana and Dana, 2013) . It is unfortunate that there is no verifiable way to know

precisely how much of these are being ingested by babies and children through various commercial baby foods and drinks. Exposure is therefore far more widespread than most people are aware. There is need for awareness in this area in order to ensure that these products do not contain high or low amounts of the essential elements that exceed or fall below the recommended values. It is therefore imperative to continuously monitor their levels in varieties of these products so as to ensure that the concentrations of these elements are within the permissible limit recommended.

1.6 Aim and Objectives of Study

The aim of this research work is to carry out proximate analysis and evaluate the mineral contentof selected classes of commercial baby foodsand reconstituted fruit juices.

1.7 Objectives of Study

The following are the objectives of this research work

a. To carry out proximate analysis on the major and frequently consumed classes of commercial baby foods.
b. To determine the concentration of the essential mineral elements calcium and potassium, magnesium, iron, phosphorus, zinc, fluoride, chlorides and nitrates in different brands of selected commercial baby foods and reconstituted fruit juices.

CHAPTER TWO

LITERATURE REVIEW

Jackson *et al.* (2002) observed that significant changes have occurred with respect to children's feeding habits in the last decades, with increasing consumption of industrially processed baby foods and beverages.Several researches have been carried out on various mineral ions/elements usually found in commercial baby foods and reconstituted fruit juices. This is done in order to create awareness on their benefits and side effects which will further enable us to make healthy food choices (Alkhalifa, 2010).

Ayivor*et al.* (2011) investigated trace elements levels of some commercial baby cereals/formulas sold in several markets in Ghana. Instrumental Neutron Activation Analysis (INAA) was used to determine the concentration of Al, Br, F, Ca, K, Mg and Na. The concentrations of the elements in the samples were within the permissible limits set by standard bodies except for aluminum whose concentration was high with value of 11.0ppm.Calcium, chlorine, magnesium and sodium were present in minor concentrations in most of the samples analyzed. The concentration of Ca ranged from 0.27± 0.003% to 1.37 ± 0.07 %, whereas Cl had concentrations ranging from 0.06± 0.003 % to 0.36 ± 0.02 % . Na and K ranged from 0.10 ± 0.01% to 1.03 ± 0.03 %. The results of their investigation showed that the imported commercial baby cereals in the Ghanaian market contained some important nutrients which were within specified limits in international guidelines.

Among various baby foods, milk formulae, along with certain bottled water and beverages, have been identified as significant sources of ingested fluoride, (Buzallaf*et al.*, 2004). During manufacturing, infant dry cereals are processed in slurry and placed in a revolving

drying drum. The water from the slurry evaporates, and the fluoride from the water remains in the cereal. Thus, the fluoride concentration of the water used during processing can substantially affect the final fluoride concentration. Babies who eat large quantities of dry baby food cereals reconstituted with fluoridated water could ingest substantial quantities of fluoride from this source (Heilman*et al.*, 1997).

Previous studies of foods intended for infants and young children available in Poland revealed that all examined bottled waters had low concentrations of fluoride (0.3 mg/L) and can be safely consumed by infants but consumption of some infant tea beverages, as well as reconstitution of infant formulae with water containing more than 0.5 mg/L may increase the risk of dental fluorosis (Stannard*et al.,* 1991).

2.1 Effects of High and Prolong Intake of Fluoride

Fluoride inhibits enzymes that breed acid producing oral bacteria whose acid eats away tooth enamel (Jay and Linda, 1996). However, it is been speculated that the negative impact of fluoride on other useful enzymes far outweighs the beneficial effect of caries prevention. Four epidemiological studies have noted a correlation between increased fluoride intake and low Intelligence quotient (I.Q), as well as fluoride suppressive effect on thyroid (Liu and Qian, 2008). This occurs most especially when iodine is deficient and thus fluoride is associated with low levels of iodine (NRC, 2006). The only remedy is prevention, by keeping fluoride intake within safe limits.

Excessive fluoride intake leads to loss of calcium from the tooth matrix, aggravating cavity formation throughout life and causing dental fluorosis (Bradford *et al*., 1994). Severe, chronic and cumulative overexposure can cause the incurable crippling of skeletal

fluorosis, (Baselt, 2008). Dental fluorosis, which is characterized by discoloured, blackened, mottled or chalky-white teeth, is a clear indication of overexposure to fluoride during childhood when the teeth were developing. These effects are not apparent if the teeth were already fully grown prior to the fluoride overexposure; therefore, the fact that an adult may show no signs of dental fluorosis does not necessarily mean that his or her fluoride intake is within the safety limit. High levels of fluoride intake can have an adverse effect on kidneys, immune, gastrointestinal, genitourinary and respiratory systems, (Baselt, 2008).

Chronic intake of excessive fluoride can lead to the severe and permanent bone and joint deformations of skeletal fluorosis (Tokaliogl*u et al*., 2004). Early symptoms include sporadic pain and stiffness of joints: headache, stomach ache and muscle weakness can also be a warning signs. The next stage is osteosclerosis (hardening and calcifying of the bones), and finally the spine, major joints, muscles and nervous system are damaged. Dental or skeletal, fluorosis is irreversible and no treatment exists.

Analysis by Heilman*et al.* (1997) revealed a wide range of fluoride concentrations in infant foods (0.01 to 8.38 mg/kg). Baby foods containing chicken (dried and powdered) had the highest fluoride concentrations (1.05 to 8.38mg/kg),Similarly, a previous study indicated that the fluoride concentration in baby foods containing chicken, turkey, and fish (deboned, dried in powder form)ranged from 0.12 to 1.06 mg/kg, 0.15 to 0.74 mg/kg, and 0.16 to 0.44 mg/kg, respectively (Opyelo and Opydo, 2011).

The findings of an investigation carried out by Pendrys, (2000) suggest that nearly 10 percent of the enamel fluorosis cases in optimally fluoridated areas could be explained by

having used infant formula in the form of a powdered concentrate during the first year.The critical period for development of fluorosis in permanent maxillary central incisors is from 4 months to 4 years of age. Thus, excessive fluoride intake must occur during early childhood, to affect the most aesthetically important teeth (Fomon*et al.*, 2000).

2.1.1 Chlorides and Nitrates

Chloride is an essential mineral for humans that occur primarily in body fluids. Chloride is a prominent negatively charged ion of the blood, where it represents 70% of the body's total negative ion content. As the principal negatively charged ion in the body, chloride serves as one of the main electrolytes of the body; in addition to sodium and potassium, chloride assist in the conduction of electrical impulses when dissolved in bodily water (Kaleita, 1986). Chloride combines with hydrogen in the stomach to form hydrochloric acid, a powerful digestive enzyme that is responsible for the breakdown of proteins, absorption of other metallic minerals, and activation of intrinsic factor, which in turn absorbs iron and vitamin B12. Chloride also combines with sodium and potassium to aid in the transport of electrical impulses throughout the body, maintain balance of bodily fluids as well as pH. Most of our chloride intake is from salt. Excessive intakes of dietary chloride only occur with the ingestion of large amounts of salt, potassium chloride and it is normally excreted in the urine, sweat, and bowels (Gelb and Anderson, 1981). Deficiency of chloride is rare as chloride is part of table salt which is present in most foods. However, when it does occur, it results in a life threatening condition known as alkalosis.

Nitrates are inorganic compounds made up of nitrogen and oxygen, NO_3^-. These compounds combine with other elements like sodium and potassium to make sodium nitrate or potassium nitrate. Nitrate occurs naturally in the soil, either by itself, or as a

compound such as sodium nitrate. They are usually present in fruits and vegetables and their amount depends on the soil type or fertilizer used for the plants(Scheurwater*et al.,* 2002).Nitrates are usually used as preservatives and color fixatives in some commercial products. When nitrates are consumed, they are converted into nitrites in our digestive system, which are then converted to ammonia and disposed of by the body(Walker,1990).

2.1.2 Concentration of Fluoride in Reconstituted Fruit Juices

The increasing consumption of juices, soft drinks and teas among children has increased significantly fluoride ingestion at the age range of risk for development of dental fluorosis and this have made fluoride concentration in these products an important issue and reason for study. Studies have shown that 42% of the 43 brands of the selected reconstituted fruit juice samples had more than 1ppm of fluoride (Thippeswamy*et al*., 2010). Few studies have investigated fluoride exposures from juices and juice-flavored drinks. In a study by Pang *et al*., (2000) F^-contents of analyze juices and juice drinks, concentrations ranged from 0.02 to 2.80 parts per million, in part because of variations in fluoride concentrations of water used in production. Generally the fluoride content of most reconstituted carbonated soft drinks was close to 1.0ppm.

Similarly, a research was conducted by Carolina *et al*. (2007), on the fluoride concentrations in industrialized beverages consumed by children in the city of Bauru. Fluoride concentration in selected commercial beverages from the market was determined with the use of a hexamethyldisiloxane (HMD)-facilitated diffusion, using a fluoride ion selective electrode (Orion9409). Fluoride concentrations ranged between 0.04 and 1.76 mg/ml. A wide variation in fluoride concentrations among the different brands was observed, which was an indication that some of the products analyzed could contribute

significantly to the total fluoride intake and, thus, be important risk factors for development of dental fluorosis.

Thippeswamy*et al*. (2010) and Jiminez(2004) investigated 12 carbonated soft drinks, three samples of each brand with different batch numbers and date of bottling. The samples of carbonated soft drinks were marketed in plastic bottles while three samples of fruit juice concentrate were bought from different shops and juices were obtained with the addition of water. All samples were stored in a dark place and in their original closed containers at room temperature until the fluoride analysis was performed. All the samples were analyzed for fluoride using an Orion fluoride ion-specific electrode (Model 96-09 BN) in conjunction with an ion analyzer using an acetate buffer system (TISAB). One batch number (out of three) for each of the samples; carbonated soft drinks and juices was randomly selected and the samples were reanalyzed to assess the reliability of the method.

The mean fluoride concentration of all the soft drinks was found to be 0.29 mg ±0.06 mg/L, with a range from 0.19 to 0.42 mg/L. The highest mean concentration was found in ThumsUp, which contained 0.4 mg ±0.02 mg/L, followed by Citra, which contained 0.37 mg ±0.01 mg/L of fluoride. There were no significant differences in concentration of fluoride between different fruit juices. The highest fluoride concentration was shown in apple and banana juice, containing 0.27 mg ±0.22 mg/L and 0.27 mg ±0.20 mg/L, respectively. The lowest concentration was found in lemon juice, which contained 0.13 mg ±0.08 mg/L of fluoride.Heilman, (1999) observed that several brands of drinks such as frequently consumed reconstituted beverages which are all reconstituted had fluoride levels at 0.02-1.28ppm, 0.02-1.10, 0.70-1.28 and 0.02-1.22ppm respectively.

2.2 Mineral Concentrations of Reconstituted Fruit Juices

Calcium, though an important dietary component, can be an issue for patients with renal insufficiency. Potassium is also essential for good health and is present in significant concentrations in some juices (Tormen*et al*., 2011).

Adriana and Dana (2013) evaluated some commercial fruit juices available in Romanian market for heavy metal and essential mineral concentrations by inductively coupled plasma mass spectrometry and found their mineral concentration to be 21.54-338.35 mg/L for Ca, 13.07-140.42 mg/L for Mg,52.52-642.34 mg/L for K and3.38 mg/L for Fe respectively.

Similarly, in a comparative study by Mahmood *et al*., (2014) on the elemental composition of several pomogranate fruit juice bought from Tunisia and Turkish market; potassium concentration was determined using theJenway Flame Emission Spectrophotometer for evaluation of sodium and potassium. The results showed its potassium concentration to be (50-95mg/100g) indicating that pomogranate juice is good source of mineral element in human diet which are essential for human health. In addition the researcher stated emphasized on the ease and advantage of method used due to its good perspective of being applied without further chemical treatments.

Dosumu*et al*., (2009) conducted a research on some Nigerian reconstituted fruit juices and local beverages for their mineral elements content, using the atomic absorption spectrophotometer. Amongst few of the reconstituted juices, potassium was found to be the most abundant with its content ranging from 5.100-5.850 mg/L while calcium ranged from 0.730 - 0.925 mg/L, that of magnesium, iron and zinc were 0.005-0.0010 mg/L,0.010-0.025 mg/L and 0.005-0.010 mg/L respectively. These results showed that the drinks contain safe amounts of these mineral ions for human consumptions and are sufficiently stable and safe.

2.3 The Need for Consumption of Commercial Baby Foods (Benefits for Complementary Feeding)

The growth of the infant in the first or second years is very rapid and breast feeding alone will not meet the child nutritional requirement. After about four months of age the child needs supplementary feeding (Ijarotimi and Famurewa, 2006). As a result many brands of preparatory weaning foods has been developed and marketed in most developing countries including Nigeria (Okafor*et al*., 2008). In these countries, the child is usually weaned into a porridge prepared from cereal flour such as maize which is characterized by bulky, high viscosity and low energy density per unit volume of the food, thus necessitating frequent feedings to meet the daily energy requirements of the child. Apart from energy, the food is usually inadequate in other nutrients, leading to widespread protein energy malnutrition and its complications, during the weaning period (WHO, 2000; Ijarotimi and Famurewa, 2006; Ugwu, 2009). Cereals foods are probably the greatest available and in expensive source of energy for humans, this is probably the prime reason why people from all class prefer cereals foods as the major source of energy.

In cereals, about 95% of minerals are the sulphates and phosphates of magnesium, iron, potassium and calcium(Song *et al*., 2006). A good amount of phosphorous in cereals is present, called phytin; also commercial baby foods are similar in nutrient content compared to the homemade foods. Proteinsare present in every tissue of the cereal grain. The protein content varies in each type of cereal. For instance, rice contains less protein in comparison to other cereals. In a survey done by the National health and nutrition examination survey(NHANES,2006)on commercially prepared cereal foods for children consumption revealed that consumption cereal with milk provides a good source of 10

nutrients in children's diets adding essential vitamins such as A, B6, B12 and D to their diets daily. However, cereals are undoubtedly full of nutrition; but unfortunately, the some refining process degrades their quality. The degree of milling, polishing and refining to some extent decides the nutrient content of cereals (Pedersen *et al.*,1994).

According to Peter (2015) children who consumed regular amount of commercial cereal foods, hadhigher intakes of carbohydrate, enhanced micro nutrient intake, higher intakes of total sugars, lower, intakes of fat, lower cholesterol intakes, higher protein intake(from addition of milk or soy bean powder) therefore had greater likelihood of meeting the micronutrient recommended intakes and improved nutritional status. Other benefits include:

a .Appropriate texture: foods are formulated to contain recommended textures based on age or stage of development.

b. Variety of tastes and ingredients:foods are available in many flavors and with a large variety of fruits, vegetables and other foods.

c. Food combinations in recommended proportions:foods are carefully combined and formulated to be acceptable to infants, young children and provide the right proportion of ingredients.

d. Less pesticide contamination: baby foods are made from produce that is lower in pesticide residues and other chemicals than are fruits and vegetables purchased at markets for adult use.

e. Stability of ingredients: commercial baby foods are guaranteed to contain what is listed on the label and will remain unspoiled for the stated time.

f. Hygiene: manufacturers follow strict quality control standards and monitor the cleanliness of preparation, the storage conditions of the suppliers and ingredients, and the clean-up procedures after manufacturing.

2.4 Recommended Daily Intake of minerals for Babies and Children

The adequate supply of nutrients through the provision of safe foodstuffs with a balanced Composition is more important for babies and young children than for adults during this period of rapid rate of growth and development as observed be Scientific Committee on Food (SCF,2003). In addition to immediate consequences of infant feeding on growth, body composition, health and well-being, a number of recent studies have also provided indications that the quantity and quality of nutrient supply during infancy and childhood has important long-term consequences on organ development and function, health and disease risks as well as cognitive ability in later life(Lucas,1998).

In view of this, the Institute of Medicine (IOM) and National Institute of Health (N I H)have given recommendations on the daily required amounts of mineral elements considered adequate to meet the normal nutritional requirements, promote normal growth and development of generally healthy infants and young children.

2.4.1 Fluoride

Infant and young children may be exposed to an additional fluoride intake, e.g. from fluoride containing water. The benefit of a high fluoride intake during early infancy isquestionable and carries the risk of dental fluorosis in children as stated by the Scientific committee on food report(SCF,2003). According to the National Institutes of Health

children between the ages of 1 and 3 require 0.25 mg of fluoride a day. Those between 4 and 8 years require 0.25 mg, while children between ages of 9 to 13 years require 1.00 mg daily.

2.4.2 Calcium

The daily required intake of calcium according to the institute of medicine, (IOM, 2004//2007) is 26 mg/day for children between 6 months to 1 year, 700mg daily for 1-3year old children, 1000mg/daily for 4-8 years and 1200mg/day for –1years respectively

2.4.3 Potassium

According to Institute Of Medicine (IOM, 2004/2007), the adequate daily required intake of potassium is 700mg/l daily for children of six months one year of age, 3000 mg/day for 1-3 years, 3800mg for 4-8years and 500mg/day for 9-16 year old children**.**

2.4.4 Magnesium

According to the Institute of Medicine (2004/2007), children between the ages of 1 and 3 need 80 mg of magnesium a day. Those between 4 and 8 years need 130 mg, while children ages 9 to 13 need 240 mg. Teenage boys need 410 mg, while teenage girls should get 360 mg daily

2.4.5 Iron

The recommended daily intake of iron according to Institute of Medicine IOM, (2001) for babies and young children are in ranges of 11mg/day for 7-12month old babies, 7mg for ages1-3yrs, 10mg/day for ages4-8yrs, 8mg/day for ages9-13yrs, and 11-15mg/day for ages 1-18 yrs.

2.4.6 Phosphorus

In the past a minimum content but no maximum content for phosphorus had been specified. Phosphorus metabolism is closely linked with calcium metabolism(LSRO,1998). During early life anexcessive intake of phosphorus may be associated with hypocalcaemia, because of the relativesensitivity of the maturing kidney and increased renal losses.Also concerns were expressed by the Panel that hypocalcaemia in the neonatal period might occur as a result of consuming a foods which contained a calcium to phosphorus ratio of 0:1 (LSRO, 1998). According to Institute of Medicine (2004/2007), the recommended dietary intakes of phosphorus are as follows: 0 to 6 months: 100mg/day, 7 to 12 months: 275 mg/day1 to 3 yrs: 460 mg/day, 4 to 8 years: 500 mg/day and 9 to 18 years: 1,250 mg daily.

2.4.7 Chloride

The Food & Nutrition Board (FNB) of the Institute of Medicine, National Academy of Sciences (NAS) in 2001 set the daily Adequate Intake (AI) of Chloride as follows: 0 to 6months(0.18g), 7-12months(0.57g),1-3yrs(1.5g), 4-8yrs(1.9g), 9-13yrs (2.3-3.4 g) and 14-18yrs(2.3-3.6g) daily.

2.4.8 Zinc

Institute of Medicine (2001) recommends that the required amount of zinc needed to be consumed daily is as follow; 0-6 months: 2 mg/day,7-12 months:3 mg/day, 1-3 yrs: 3 mg/day, 4 -8 yrs:4 mg/day, 9-13 yrs:6 m/day and14-18 yrs:7-13 mg/day respectively.

2.5 Fluoride Concentration in Baby Foods

The critical period for development of fluorosis in permanent maxillary central incisors is from 4 months to 4 years of age. Thus, excessive fluoride intake can occur during early childhood, to affect the most aesthetically important teeth (Fomon*et al*., 2000). Among various baby foods, milk formulas, along with certain bottled water and beverages, have been identified as significant sources of ingested fluoride, (Buzallaf*et al*., 2004). During manufacturing, infant dry cereals are processed in slurry and placed in a revolving drying drum. The water from the slurry evaporates, and the fluoride from the water remains in the cereal. Thus, the fluoride concentration of the water used during processing can substantially affect the final fluoride concentration.

Babies who eat large quantities of dry baby food cereals reconstituted with fluoridated water could ingest substantial quantities of fluoride from this source, (Heilman*et al*., 1997). Previous studies of foods intended for infants and young children available in Poland revealed that all examined bottled waters had low concentrations of fluoride (0.3 mg/L) and can be safely consumed by infants but consumption of some infant tea beverages, as well as reconstitution of infant formulas with water containing more than 0.5 mg F/L may increase the risk of dental fluorosis (Stannard*et al*., 1991).

Another research by Hong *et al*., (2006), suggests that mixing powdered or liquid infant formula concentrate with water on a regular basis may increase the chance of a child developing the faint, white markings of very mild or mild enamel fluorosis due to fluoride levels found in both baby food and fluoridated water. Analysis by Heilman*et al*.,(1997) revealed a wide range of fluoride concentrations in infant foods (0.01 to 8.38 mg/kg). Baby

foods containing chicken (dried and powdered) had the highest fluoride concentrations (1.05 to 8.38mg/kg),Similarly, a previous study indicated that the fluoride concentration in baby foods containing chicken, turkey, and fish (deboned, dried in powder form)ranged from 0.12 to 1.06 mg/kg, 0.15 to 0.74 mg/kg, and 0.16 to 0.44 mg/kg, respectively (Opyelo and Opydo, 2011).

The findings of an investigation carried out by Pendrys, (2000) suggest that nearly 10 percent of the enamel fluorosis cases in optimally fluoridated areas could be explained by having used infant formula in the form of a powdered concentrate during the first year. However, a 2009 study published in the Journal of American dental association,(ADA, 2009)states that most babies from birth to age 12 months who consume predominantly powdered and liquid concentrate formula are likely to exceed the upper tolerable limit of fluoride, if the formula is reconstituted with water.

2.6 Mineral Concentration in Commercial Baby Foods

Investigation by Joseph *et al*. (2011) revealed that the levels of calcium, potassium, magnesium, zinc and others compares well with certified values obtained except for some which were below detection limit of the counting system under the experiment conditions. The elements were determined using instrumental neutron activation analysis (INAA).

Ruiz *et al.* (1996) determine the concentration of calcium, sodium, and potassium content of few different infant formulas marketed in Spain using atomic spectrometry. The mineral intake of infants fed exclusively with these formulas was estimated. The contents in (mg/100 kJ) were in the following range; Calcium 14–24 and Potassium 19–35. These

values do not exceed the limits established by the European Union (EU). The mean values and ranges of estimated intakes for each formula type and period of infancy (0–1, 3–4 and 4–5 months) expressed in mg element/kg body weight were tabulated. The mean Ca, K and daily intakes of infants (0–5 months) fed with infant formulas met the recommended values.Another research results by Helena *et al*. (2009) obtained from the determination of potassium, ascorbic acid content and overall quality of purchased fruit based baby foods samples indicated that there was great difference in its composition compared to information on its labeling. The potassium concentration was low in comparison to the declared values on their labels.

The calcium, iron, zinc, potassium and magnesium as well as some non-essential elements (Al, As,Cd, Hg, and Pb) concentrations in different branded baby foods from markets were determined using inductive coupled plasma optical-emission spectrometry (ICP-OES) by Al Khalifaand Dilshad (2010). The cereal based food showed a higherconcentration of calcium, copper, iron, chromium and potassium in comparison with literature (Ikem*et al*., 2002). Some of the milk based baby foods were found within the limit and notexceeding the required upper limit set by EC Regulation446, (2001). Calcium had the highest value determined (710.77± 132.00mg/100g), followed by potassium (589.39±4.96mg/100g), magnesium values were between 42.0-62.87 mg/100 g, iron had (6.58, 8.29 and 13.01 mg/100g) values respectively. Their findings showed that all five types of babyfoods were commercially prepared to fulfill thebabies' need of nutrients as required by WHO/UNICEF(1998). It was also observed that there were presence of some nonessential elements (Al, As, Hg, Zn and Cd) though in small quantities but of concern to the researcher due to health reasons. It was conclude that the reasons for the different

variations in these mineral elements could be attributed to the different manufacturing practices, quality of raw materials and packaging containers used by infant food manufacturers, especially cereal based food products for babies.

Similarly, in a recent study by Moreno *et al.* (2014) a probabilistic model was developed to estimate the intake levels of Fe, Zn, Ca, P, Mg, Mn, Cu, Na, and K derived from consumption of milk based baby foods and processed cereal-based food in Spain. Determinations of Ca, Mg, Fe, Zn, and Mn were carried out byflame atomic absorption spectrophotometry while Na and K weredetermined by flame atomic emission. Cu was determined by atomic absorption spectrophotometry.

Karin *et al*. (2011) evaluated the presence of high concentrations of essential and toxic elements in commercial infant foods sold in Sweden usinginductively coupled plasma mass spectrometry and concluded from results (Ca:1111-1659 mg/kg), (Mg:127-233 mg/kg), (Fe:44.3-26 mg/kg), and (Zn:6.3-10 mg/kg) that these complementary foods contributed a significant amount of essential mineral elements to the diet of the growing child.

Similarly, some mineral element concentrations were determined in some samples of baby foods by Anigo*et al.*(2010) using atomic absorption spectrophotometer. Phosphorus was determined spectrophotometrically by the vanadomolybdate method (AOAC, 1990). The concentration of minerals range were Ca(39.82-47.66mg/100g), K(387.32-437.90mg/100g), Mg(114.06-146.77mg/100g), P(172.28-219.98mg/100g), Fe(19.00-47.66mg/100g) and Zn(7.88-10.79m/100g respectively.

2.7 Proximate Composition of Selected Commercial Baby Foods

2.7.1 Moisture content

The moisture content of the food material is important in other to consider the food suitable before consumption, this is so becausemoisture contentaffects the physical, chemical aspects of food which relates with the freshness and stability for the storage of food for a long period of time. The moisture content determine the actual quality of the food before consumption and to the subsequent processing in the food sector by the food producers (Isengard,2001).

Furthermore, microbial activity of the food materials favor with the moisture availability in the food. Moisture rich foods are easily susceptible to the microbial attack and get damaged. Thus the shelf life of the food material is determined by the moisture content in the food. Low moisture foods usually slow down growth of microorganisms hence the need for analysis and control of food moisture(Mulvaney,1995).

Iombor*et al*.(2009) reported the moisture content range of 3.0,4.40 and 4.06% respectively in selected samples of millet/soybeans based complementary baby foods. Also values of 3.70, 3.75% and 4.90 % were reported for 3 samples of baby foods based on cereals by Mariam (2005). In another study on the nutrient value and proximate analysis in samples of commercial infant foods in Ghana by William*et al*.(2011) moisture range was 3.75 %, 6.15 % and 9.32 %. Similarly Lalude and Fashakin (2006) reported on proximate analysis for both experimental and commercial samples of baby food showed moisture content values of 1.18 and 4.0% respectively.

2.7.2 Ash content

Ash is the inorganic residue remaining after the water and organic matter have been removed by heating in the presence of oxidizing agents, which provides a measure of the total amount of minerals within a food. The ash content of a food material is important for the following reasons; the quality of many foods depends on the concentration and type of minerals they contain, including their taste, appearance, texture and stability.High mineral contents are sometimes used to retard the growth of certain microorganisms. Some minerals are essential to a healthy diet (*e.g.*, calcium, phosphorous, potassium and sodium) whereas others can be toxic *e.g.*, lead, mercury, cadmium and aluminum (Ayivor*et al*., 2011).

Iombor*et al*. (2009) found that the ash content of selected millet/soybeans formulated baby foods were 1.70, 2.30 and 3.0 % respectively; these value are similar to that of Anigo, *et al*.(2010) with values of 1.03, 1.11 and 2.28g/100g in MLRSG,MGBSG and MGRSG baby food samples. Results from works of Lalude and Fashakin (2006) and Mariam,(2005) shows higher values of ash to be 2.06, 2.33.and 2.60 % respectively. William *et al*. (2011) reported both low and high values of ash content in samples of commercial infant foods in Ghana as 0.66, 1.6 and 2.05 %.

2.8.3 Crude protein

Crude protein measures the total nitrogen content of a product and, from that, estimates the amount of protein within that product. Crude protein is a conventional expression of the

total content of nitrogen compounds of the analysed product, calculated by multiplying the corresponding nitrogen content by a conversion factor.

2.7.4 Crude fibre

Crude fibre determination is the measurement of quantity of indigestible cellulose. Also known as weende cellulose, crude fibre is the insoluble residue remaining after an acid hydrolysis followed by an alkaline one. This residue contains true cellulose and insoluble lignin.

The values of crude fibre in soybeans, ground nut and cereal formulated foods samples as reported by Anigo*et al*. (2010) was 0.99,1.02 and 1.7g/100 g respectively while Iombor*et al*. (2009) gave crude fibre values of 3.30 %-5.0 % for millet/soy based baby food samples used.

2.7.5 Crude fat/ lipid

Crude fat is the term used to refer to the crude mixture of fat-soluble material present in a sample. It is also known as the ether extract or the free lipid content and also as the traditional measure of fat in food products.

Results of crude fat values reported by Iombor *et al*. (2009) and Mariam, (2005) were 7.0-9.0 % and 15.6-17.7 % respectively. Similarly, some commercial baby food samples in Ghana had crude fat/lipid values ranging from 6.22 %-9.04 % (William *et al.*,2011). Anigo*et al*.(2010) recorded lower crude fat/lipid values of 1.09,1.09, and 2.46g/100g in soybeans, groundnut and cereal formulated baby foods respectively.

2.7.6 Total carbohydrate

Carbohydrates are the body's most important and readily available source of energy.They are classified into starches (also known as complex carbohydrates), sugars and fiber. Carbohydrates may be present as isolated molecules or they may be physically associated or chemically bound to other molecules.The measurement of total carbohydrates is very important in nutrition.

Iombor*et al*. (2009) reported carbohydrate content of millet/soybeans based baby foods to be 67.5%- 68.75% and that of cereal based baby foods were also reported to be 67.95%-68.0% (Mariam, 2005).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Sampling

Samples were purchased from three different market locations: Zaria,Kaduna and Abuja in Nigeria. Fifteen sealed samples of reconstituted fruit juices and fifteen samples of commercial baby foods were collected. The sealed samples were taken to the laboratory for the determination of fluoride, calcium, potassium, magnesium, phosphorus, iron, zincchloride and nitrate. Also six samples of commercial baby foods classified based on source were separately collected for proximate analysis. All the samples remained sealed until the time for sample preparation.

3.2 Sample Preparation

The baby food samples were diluted with deionized water to form a $100cm^3$ solution in a clean beaker whereas the reconstituted fruit juice samples were not diluted.

Both the baby food samples and reconstituted fruit juice samples were each digested using acid digestion method before carrying out elemental determination, however the samples used for proximate analysis and physical parameters were not subjected to digestion.

3.3 Reagents and Apparatus

All the reagents were of analytical grade. Distilled deionized water was used in the preparation of all solutions. The glass wares used were properly washed with liquid soaps,

rinsed with water, soaked in dilute nitric acid overnight and then rinsed thoroughly with deionized water before use.

3.4 Preparation of Reagent Solution

3.4.1 Standard fluoride solution

a. Stock solution

Anhydrous sodium fluoride NaF (2.21 g) was dissolved in distilled water in a volumetric flask and diluted to 1000cm^3 which produced a solution in which 1.0cm^3 =100 mg of fluoride.

The 2.21g of anhydrous sodium fluoride (NaF)was gotten thus:

Atomic mass of NaF = 41.988173g/mol

Where Na = 22.989g /mol , F =18.998 g /mol

1.0 g/L of NaF = 1000 mg/L which is same as $\frac{\text{Atomic mass of NaF}}{\text{Atomic mass of } F^-} = 2.21g$

The stock fluoride solution (100 cm^3) was diluted to 1000cm^3 with deionized water, which yielded 1.0cm^3 of fluoride (100.00 mg of fluoride). From this concentration series of fluoride standard solution were prepared by dilution.

3.4.2 Standard potassium solution:

a. Stock potassium solution

Potassium chloride (KCl) crystals 1.907g which was dried at 110^oC was weighed dissolved in distilled deionized water and made to a 1000 cm^3 mark in a volumetric flask. This produced a solution in which 1.0 cm^3 =1.0 mg of potassium

The 1.907 g of KCl crystals was gotten as thus:

Atomic mass ofKCl = 74.5513 g/mol

Where K = 39.0983g /mol ,Cl = 35.4527 g /mol

1.0 g/L of KCl = 1000 mg/L which is same as $\frac{\text{Atomic mass of KCl}}{\text{Atomic mass of K}}$ = 1.9067 g

b. Intermediate potassium solution

A 10cm^3 of stock potassium solution was weighed and diluted to 100cm^3 with deionised water so that 1.0cm^3 = 100 mg of K. This solution was used to prepare concentrations ranging from 1.0 to 10.0 mg/L, which was used for preparing the calibration curve.

c . Standard potassium solution

A 10cm^3 of the intermediate potassium solution was pipette and transferred into a 100 cm^3volumetric flask. This was made upto the mark with distilled water and shaken.

For this solution, 1.0cm^3 =10µg of K.

3.4.3. Standard calcium solution:

The standard calcium solution was prepared from dried $CaCO_3$, from which 2.50 g was weighed and dissolved in 2M HCl. It was thereafter, diluted to 1000 cm^3 in a volumetric flaskwith distilled deionized water. Molar mass of $CaCO_3$ = 100.0869 g/mol

Where $CaCO_3$ = 100.0869 g/mol

1.0 g/L of $CaCO_3$ = 1000 mg/L which is same as $\frac{\text{Atomic mass of } CaCO_3}{\text{Atomic mass of Ca}} = 2.495$

3.4.4. Standard magnesium solution

a. Stock solution of 1000 mg/L was prepared as follows

Magnesium metal 1.0 g was dissolved 50cm^3 of 5M HCl and thereafter, diluted to 1000 cm^3 in a volumetric flask with deionized water.

3.4.5. Standard iron solution

a**.** Ferric ammonium sulfate (8.63 g) was weighed and dissolved in 20cm^3 of diluted nitric acid (1: 10) with water in a volumetric flask to make 1000cm^3.

The 8.63 g of ferric ammonium sulphate was gotten as thus:

Molar mass of $FeNH_4(SO_4)_2.12H_2O$ = 482.19g/mol

Molar mass of Fe = 55.845g/ mol

$$\text{The dissolved mass} = \frac{\text{Atomic mass of } FeNH_4(SO_4)_2.12H_2O}{\text{Atomic mass of Fe}} = 8.63g$$

Exactly 10cm^3 of the solution was measured and 20cm^3 of diluted nitric acid (1:10) andwater added was added to make 1000cm^3in which 1.0 cm^3 of this solution contained 0.01 mg of iron.

3.4.6. Standard phosphorus solution

a. Stock solution was prepared using KH_2PO_4 (1.098 g) which was weighed into a volumetric flask and dissolved with distilled deionized water and thereafter, diluted to 250cm^3.

Molar mass of KH_2PO_4 = 136.0776 g/mol

Molar mass of phosphorus = 30.97g/ mol

Dissolved mass = $\frac{\text{Atomic mass of } KH_2PO_4}{\text{Atomic mass of P}}$ =4.39 g

If 4.39 g of P is dissolved in 1000 cm^3

Then X → 250 cm^3

$\frac{4.39 \times 250}{1000}$ = 1.098 g in 250 cm^3

b. From this solution, 10 cm^3 was transferred to a 250 cm^3 volumetric flask (Stock solution B) and made up to volume with distilled deionized water. A standard series of 0.20, 0.40, 0.60, 0.80 and 1.0 mg P/dm^3, was prepared by pipetting 5, 10, 15, 20 and 25 cm^3 portions of stock b respectively to separate labeled 100 cm^3 volumetric flasks.

3.4.7. Standard Zinc solution:

a. Zinc sulfate (4.40 g) was weighed and dissolved in water to make 1000 cm^3in a volumetric flask.

b. The solution was again measured (10.0 cm^3) and made up to 1000cm^3 mark with water in which1.0 cm^3 of this solution contains 0.01 mg of zinc .

The 4.40 g of zinc sulphate was calculated as thus:

Molar mass of $ZnSO_4.7H_2O$ = 287.53 g/mol

Molar mass of zinc = 65.38 g/ mol

Weighed /dissovled mass = $\frac{\text{Atomic mass of } ZnSO_4}{\text{Atomic mass of Zn}}$ = 4.39 g , approx. 4.40 g

3.5Perchloric acid digestion (wet oxidation)

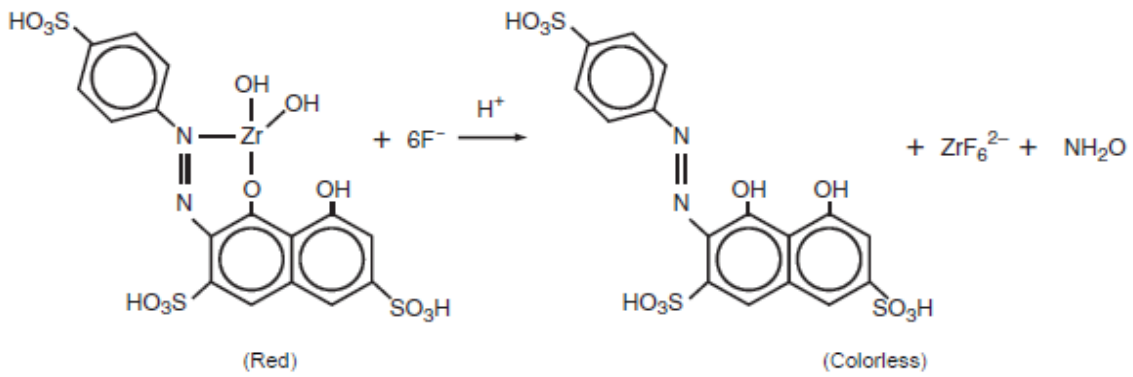
Acid digestion of the baby food samples for mineral element determination (Ca, Mg, P, Fe, Zn, K) was carried out using 1.0 g of the baby food sample being weighed into 125.0 cm^3 Pyrex Erlenmeyer flask and 4.0 $cm^3$of perchloricacid, 25.0 cm^3concentrated HNO_3 , 2.0 $cm^3$of concentrated H_2SO_4were added to it and the mixture placed under a fume hood. The contents were gently mixed and heated at low to medium heat on a hot plate under the perchloricacid fume hood.Heating of the contents continued until dense white fumes appeared and then the heat was increased for 30 seconds. The contents were allowed to cool then50.0 cm^3 of deionised water was added. The contents wereheated again for 30seconds at medium heat and allowed to cool before it was filtered into a 100cm^3pyrexvolumetric flask using a whatman 2 filter paper. The filtered solution was stored for elemental analysis.

3.6 Spectrophotometric Determination of Mineral Elements (F^-,Mg, K, P, Fe, Zn Cl^-)

3.6.1 Determination of Fluoride Concentration(SPADNS method)

The diluted commercial baby food and the reconstituted fruit juice samples, 10.0 cm^3each from the different batches were measuredand carefully transferred into individual containers for each. 5.0 cm^3 each of alizarin and zirconyl acid were added to the solution before the samples were transferred into the cuvettes, capped, replaced and allowed to stand for 1 hour. The absorbance of the solution was then determined using a HI 83200 multi-parameter bench photometer between the wavelength of 520-550nm.

Figure 3.1 Chemical reaction between fluoride and spadns reagent



3.6.2 Determination of Potassium Concentration (Turbidimetric method):

The diluted commercial baby food and the reconstituted fruit juice samples were carefully transferredinto the sample cuvette and mixed withtetrephenylborate reagent. The cuvette cap was replaced, and placed in the photometer where the absorbance measurements were taken for each individual sample accordingly.

Figure 3.2 Chemical reaction between potassium and tetraphenylborate

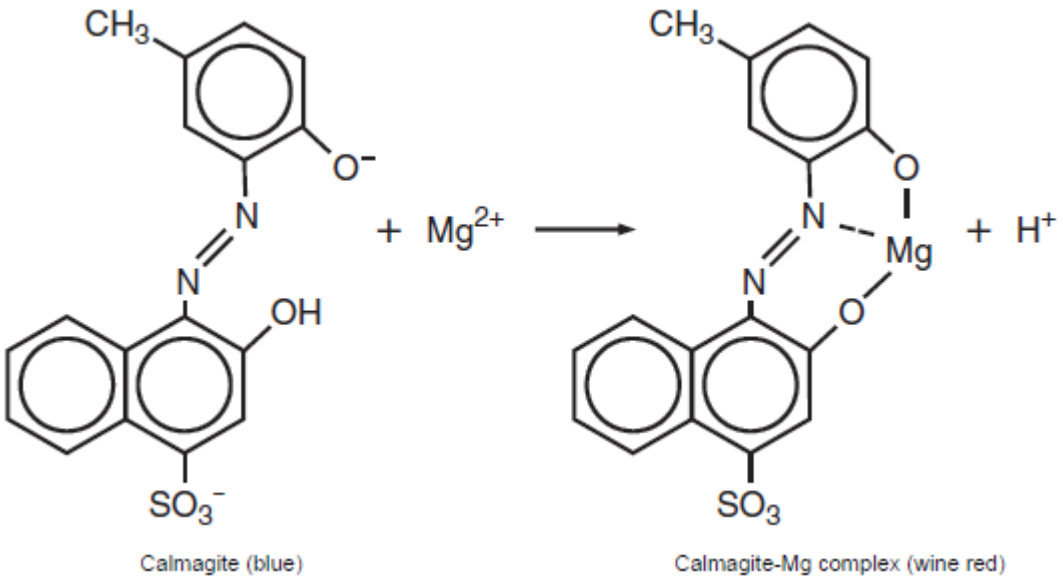
$$Na\ B(C_6H_5)_4 + K^{+} \rightarrow + KB(C_6H_5)_4 \downarrow + Na^{+}$$

3.6.3 Determination of Magnesium Concentration (Calmagite method)

The Mg buffer reagent (EGTA), 1.0 cm^3 was added to a clean cuvette using a 1.0 cm^3 syringe and made up to a 10.0 cm^3 mark with the calmagite indicator reagent using a pipette. The cap of the cuvette was replaced and inverted several times to mix. The cuvette was then placed into the photometer holder, closed and zeroed.Thereafter, the cuvette was removed and 0.5 cm^3 of the sample to be analyzed was added to it, closed and inverted several times to mix. The cuvette was re inserted into the spectrophotometer for

measurement. The photometer measures the light intensity of the solution and measurements of absorbance was carried out at a wavelength of 466 nm. The calibration curve was prepared for both standard and analyte solutions.

Figure 3.3 Chemical reaction for magnesium with calmagite indicator and EGTA



Calmagite (blue) Calmagite-Mg complex (wine red)

3.6.4 Determination of phosphorus concentration (Amino acid method)

The cuvette was filled with 10.0 $cm^3$of sample, the cap replaced and placed into the holder with lid closed.When the instrument was zeroed and ready for measurement, the cuvette was removed.10 drops of ammonium molybdate reagent, plus 2.0 g of amino acid powder were added to the cuvette and cap replaced. The mixture was shaken gently until completely dissolved.The cuvette was reinserted into the instrument for measurement.The photometer measures the light intensity of the solution and measurements of absorbance was carried out at a wavelength of 525 nm. A calibration curve(absorbance versus concentration) was prepared for both standard and analyte solutions.

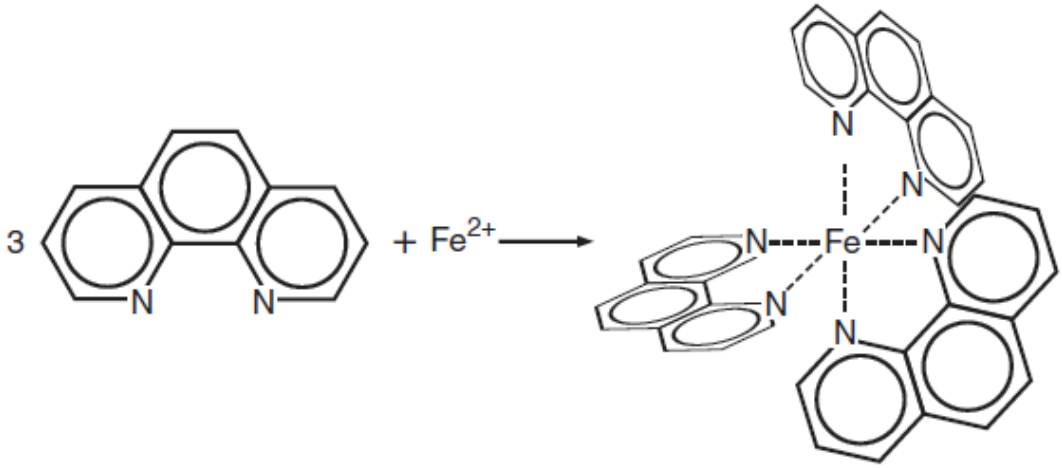
Figure 3.4 Chemical reaction between phosphorus and ammonium molybdate

$PO_4^{3-} + 12(NH_4)_2MoO_4 + 24H^+ \rightarrow 4(NH_4)_3PO_4.3MoO_3$

3.6.5 Determination of Iron Concentration (Phenanthroline method)

The cuvette was filled with 10.0 cm^3 of the sample to be analyzed and the cap replaced.The cuvette was placed into the holder and closed. The meter was zeroed and ready for measurement.Thereafter, the cuvette was removed, opened and the reagent(1,10phenanthroline) was added to the content. The cap was then replaced and shaken until dissolution was complete. The cuvette was reinserted into the spectrophotometer for measurement.The photometer measures the light intensity of the solution and measurement of absorbance was carried out at a wavelength of 525 nm. A calibration curve was prepared for both the standard and analyte solutions.

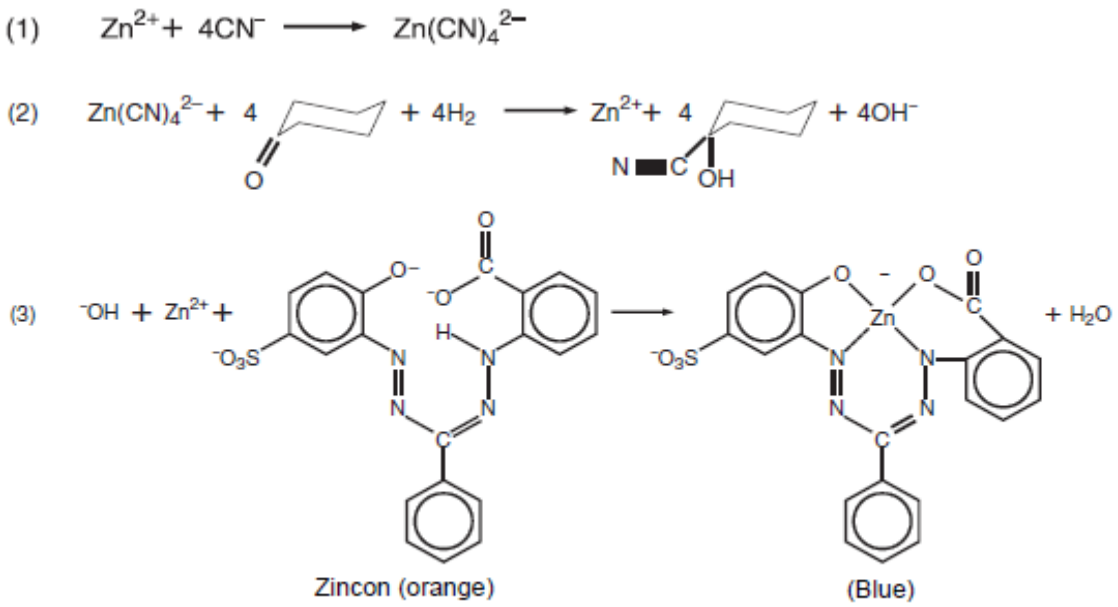
Figure 3.5 Chemical reaction between iron and 1,10-phenanhroline



3.6.6 Determination of Zinc Concentration (Zincon method)

Agraduated mixing cylinder was filled up to the 20cm^3 mark with the baby food and fruit juice samples. Zincon reagent was added to the content and then closed,this was then inverted several times tomix until completely dissolved.Another cuvette was filled with 10 cm^3 of the reacted sample up tothe mark and the cap was closed. The cuvette was then inserted into the instrument, and the lid closed. The meter was zeroed and ready for measurement.The cuvette was again removed and 0.5 cm^3 of the second reagent (cyclohexanone) was added to the cuvette, closed and shaken for fifteen seconds to mix. The mixed sample was inserted into the instrument for measurement.The photometer measured the light intensity of the solution and measurement of absorbance was carried out at a wavelength of 575 nm. A calibration curve was prepared for both standard and analyte solutions.

Figure 3.6 Chemical reaction between Zinc and zincon/ cyclohexanone



3.6.7 Determination of calcium concentration by titrimetric method:

A 25.0 $cm^3$of each of the diluted commercial baby food and reconstituted fruit juice samples from the different batches were measured and made up to the mark of a 50.0 cm^3 volumetric flask. Thenbuffer solution, of volume2.0 cm^3 and 2 drops of eriochrome black T was added and then titrated with EDTA till a bluish colour, indicating an end point emerged. The concentration of calcium was determined as follows:

$$\frac{A \times B \times 400.8}{\text{Volume of sample used}}$$

Where A= Volume of titrant used (EDTA)

B = mg of $CaCO_3$which is equivalent to 1.0 cm^3

Volume of sample used = 50.0 cm^3

$$\text{EDTA} = 2.5252.\ A \times 2.5252 \times \frac{A \times B \times 400.8}{50} = \text{mg/L}$$

Figure 3.7 Chemical reaction between calcium and EDTA

Reaction taking place during titration is

$Ca^{2+} + EDTA^{4-} \rightleftharpoons Ca\text{-}EDTA^{2-}$

EDTA reacts with all metal ions in 1:1 ratio:

That means number of moles of calcium is exactly that of number of moles of EDTA used.

3.6.8 Determination of nitrates in baby food and fruit juice samples

A. Baby food samples (Using KCl extraction method)

Baby food samples (15 g each) was weighed into the centrifuge tube and 30.0 cm^3 of 1 mol/dm^3KClwas added to it and placed in a shaker to mix for one hour. The sample was centrifuged to get a clear solution which was transferred to another plastic container. The KCl extract (10.0 cm^3) and 2g of magnesium oxide were weighed and placed into the distillation flask and distilled over with 2% boric acid, during the distillation the addition of 2 to 3 drops of the mixed indicator was done. Then 30 to 50 cm^3 of the distillatewas collected and titrated with 0.01M H_2SO_4(for NH_4). A 1.0 g of devarda's alloy was added to the same sample as above in the distillation flask and distilled off with 2% boric acid and 2 to 3 drops of mixed indicator. It was then titrated with 0.01m/$dm^3$$H_2SO_4$ toobtain the concentration of nitrate present in the baby food samples.

a. Fruit Juice Samples (Kjeldahl distillation unit):

Each of the fruit juice samples of volume 10.0 $cm^3$was pipetted into a distillation flask and1.0 g of magnesium oxide was added.The flask was then connected to a boiling unit, and few drops of mixed indicator added.The content was distilled into a 20.0 $cm^3$of 2%boric acid solution under the condensers. The distillate obtained was titrated with 0.025 mol/$dm^3$of H_2SO_4, and a green to purple colour indicated end point to obtain ammonium nitrogen.In the same flask, 30cm^3 of distilled water and 1.0 g of davarda's alloy was added and distilled into a new conical flask with mixed indicator and 20.0 cm^3 2%boric acid. Thereafter, 50.0 $cm^3$of the distillate was collected and titrated with 0.025mol/dm^3sulphuric acid, a green to purple colour indicated to obtain end point to get nitrate(NO^-_3).

Calculation $\% NO_3 = \frac{0.014 \times 0.025 \times 100}{10.0\ cm^3 \text{ of sample}}$

3.6.9 Determination of chlorides in baby food and fruit juice samples

The baby food and fruit juice samples of volume 20.0 cm^3 were measured and pipetted into a 100 cm^3 conical flask, and about three drops of potassium chromate solution added and stirred. A drop wise addition of silver nitrate solution from the burette was done while stirring until a first permanent reddish brown colour was obtained,this indicated the presence of chloride in sample. A blank titration was run with distilled water.

3.6.10 Determination of pH

Two drops each of the sample were placed on the pH indicator paper. The colour changes for each sample was observed and compared to the standard pH scale.

3.7 Proximate determination

3.7.1 Determination of Moisture content (AOAC 1980)

A clean crucible was dried to a constant weight in an air tight oven at 110°C, this was allowed to cool in a desiccator for an hour and weighed (W_1).Then 2.0g of finely ground baby food sample was weighed into the previously labeled crucible and reweighed (W_2). The crucible containing the sample was then placed in the oven at 110°C for 3 hour. The sample was removed, allowed to cool in a desiccator and weighed (W_3). The difference in weight after and before drying the sample in the oven gives the moisture content of the sample and it is expressed as the total percentage of the moisture content. This procedure was carried out for each of the baby food sample.

The percentage moisture content was calculated thus:

$$\% \text{ Moisture content} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

3.7.2 Determination of Ash content

Crucibles werecleaned and dried in the oven at 110°C, thereafter, allowed to cool in a desiccator for one hour and weighed (W_1). Then 2.0 grams of each of the ground baby food samples were placed in each crucible and weighed (W_2). They were each transferred into the Muffle Furnace at 550^o C for 4 hour until each turned into ash. Thereafter, the crucible and the content were removed,allowed to cool in the desiccator and weighed (W_3). The difference in weights before and after ashing gives the total ash content and is expressed in terms of the total percentage of ash in the respective samples as thus:

$$\text{The \% Ash content} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

3.7.3 Determination of Crude Protein

The sample (2.0 g) was measured into a Kjeldahl flask. One tablet of catalyst(Copper) and 25.0 cm^3 of concentrated H_2SO_4 was added; the flask was then transferred to the Kjeldahl digestion apparatus. The mixture was digested (heated) until a clear green colour was obtained. It was allowed to cool and any black particles showing at the mouth and neck of the flask was washed down with distilled water. The digest was transferred into a 250.0 cm^3flask.A solution of 40% NaOH was measured (10.0cm^3), slowly added to a conical flask which contained a mixture of 10.0 cm^3 2% boric acid and 3 drops of mixed indicator was used to trap the ammonia being liberated. The conical flask and the Kjeldahlflask were

then placed on Kjeldahl distillation apparatus with the tubes inserted into the conical flask, heat was applied to distill out the NH_3. The distillate was collected into the boric acid solution. The distillate was then titrated into the receiving flask using 0.1 M HCl

The nitrogen and protein content was calculated as thus:

$$\% N_2 = \frac{14 \times M \times V_t \times V_{100}}{\text{Weight of sample (g)} \times Va}$$

% Crude Protein = % N_2(Nitrogen) × 6.35

Where:

M = Actual Molarity of Acid

V = Titre Value (Volume) of HCl used

V_t= Total volume of diluted digest

V_a = Aliquot volume distilled

40% NaOH was prepared by dissolving 400 g of NaOH into a clean beaker , then 400 cm^3 of distilled/deionized water was added to it and gently stirred to dissolve. The solution was transferred into a 1000 cm^3volumetric flask and made up to mark with distilled/ deionized water. It was gently stirred and allowed to cool. Molecular weight of NaOH = 40

3.7.4 Determination of Crude fiber content

The baby food sample (2.0 g) was weighed into a 100cm^3 beaker, 1.20 cm^3sulphuricacid per 100 cm^3 solution was added and the mixture boiled for 30 minutes. The hot solution was quickly filtered and the insoluble matter (residue) was washed several times with hot water until it was acid free. It was quantitatively transferred into a beaker containing 1.20g ofNaOH , boiled for 30 minutes and filtered. The residue was washed with hot water until it was base free, dried in an oven at 100°C, cooled in a desiccator and weighed (C_1). The

weighed sample (C_1) was then incinerated in a muffle furnace at 550°C for 2 hours, allowed to cool in a desiccator and reweighed (C_2).

Calculation:

The loss in weight on incineration = C_1-C_2

$$\% \text{ Crude fibre} = \frac{C_1 - C_2}{\text{Weight of original sample}} \times 100$$

3.7.5 Determination of Lipids (Fat) by Soxhlet method

A clean 250 cm^3 round bottom flask was dried in an oven a 100^o C. It was then transferred into a desiccator, allowed to cool and weighed (W_1) . 2.0g each of the samples were weighed into labeled extractor thimbles and fixed into the soxhlet unit. The round bottom flask containing 100 cm^3 petroleum ether (40 to 60^o C) for extraction and a condenser were connected to the Soxhlet extractor and cold water circulation was connected/ put on. The heating mantle was switched on and the heating rate adjusted until the solvent was refluxing at a steady rate. The samples were refluxed for 8 hours in the soxhlet apparatus. The solvent was recovered and the fat dried in an oven set at 70°C for 1 hour. The round bottom flask and fat was then Weighed (W_2). The fat content was calculated thus:

$$\% \text{ Crude Lipid/ fat content} = \frac{W2 - W1}{\text{Weight of Sample}} \times 100$$

3.7.6 Determination of Carbohydrate (Pearson 1976)

The carbohydrate content was obtained by subtracting the sum total of % Moisture, %Ash, % Protein and % Fat from 100.

That is (100 - % of moisture + % Ash + % Protein + % Fat)

CHAPTER FOUR

RESULTS

Figure 4.1 shows the proximate composition (%) of commercial baby food based on source. The moisture content across these food groups ranged from 1.39% in protein based baby food, PBBF to 3.19% in maize based baby food samples, MBBF. Ash content ranged from 1.04% in modified starch based baby food MSBBF to 3.15% in MBBF. The crude protein content ranged from 5.25% in mixed cereal based baby food; MCBB to 8.75% in MBBF and CFBBF (cereal fruit based baby food). Crude fibre range was 0.97% in MSBBF to 4.73% in PBBF samples. Crude lipid/fat content ranged from 3.40% in MBBF to 5.90% in MCBBF. All six classes of food samples had adequate amount of carbohydrate ranging from 81.51% MBBF to 86.65% in wheat based baby food WBBF.

Figure 4.2 and 4.3 show the mean concentration of fluoride in reconstituted fruit juices and commercial baby foods respectively. Fluoride concentrations in reconstituted fruit juices ranged from 0.0003 in samples CEJ, SMJ, FYYJ AND NYJ to 0.0030mg/L in sample RBCJ. Fluoride was not detected in samples DOJ, HLJ, VYJ and CYNMJ. The concentration of fluoride in commercial baby food samples ranged from 0.0004 in samples BBC and BPNWS to 0.0033mg/kg in sample FGC. Fluoride was not detected in samples PBC, SP and NICWS.

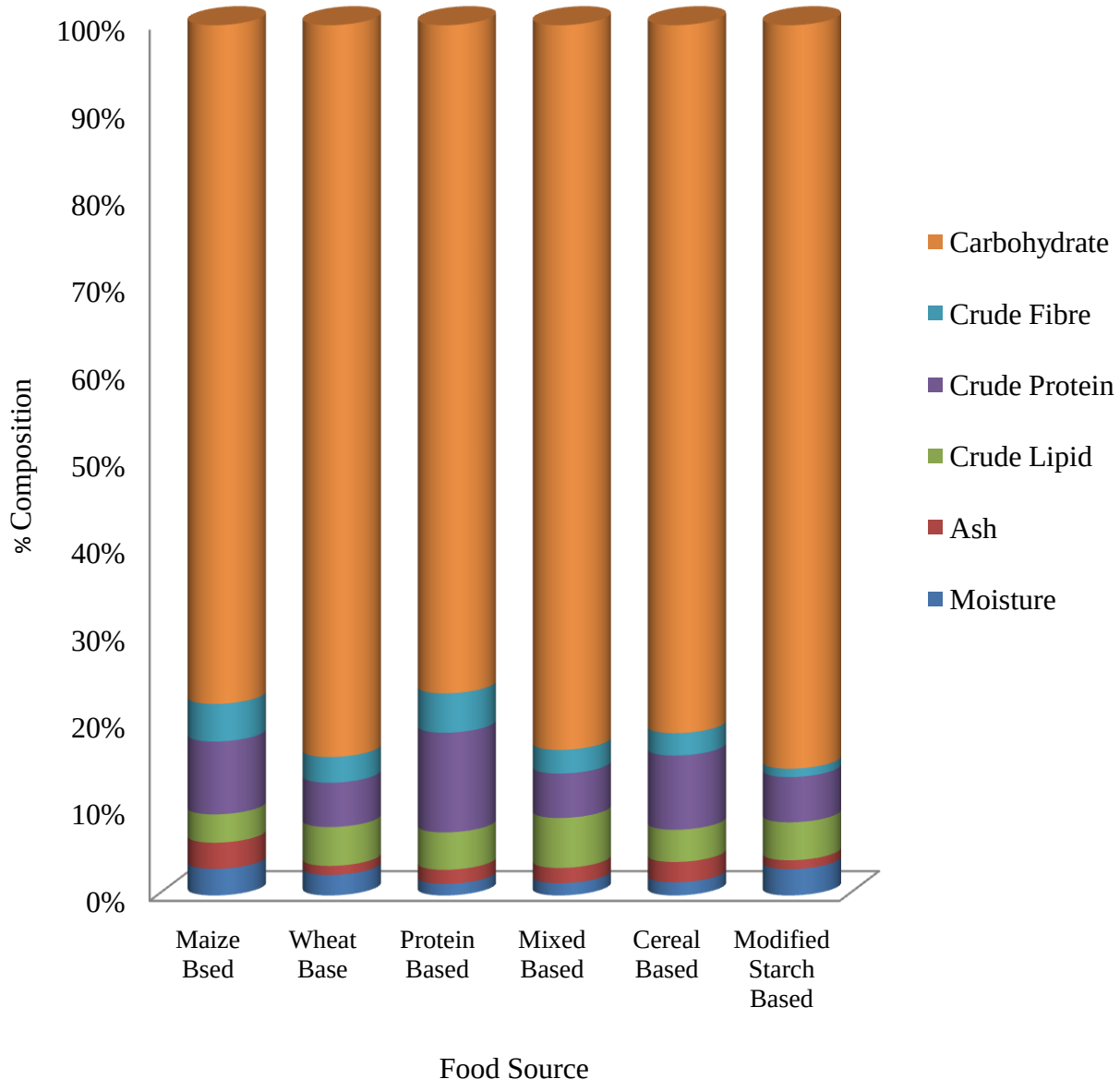


Figure 4.1: Proximate composition (%) of commercial baby food based on source

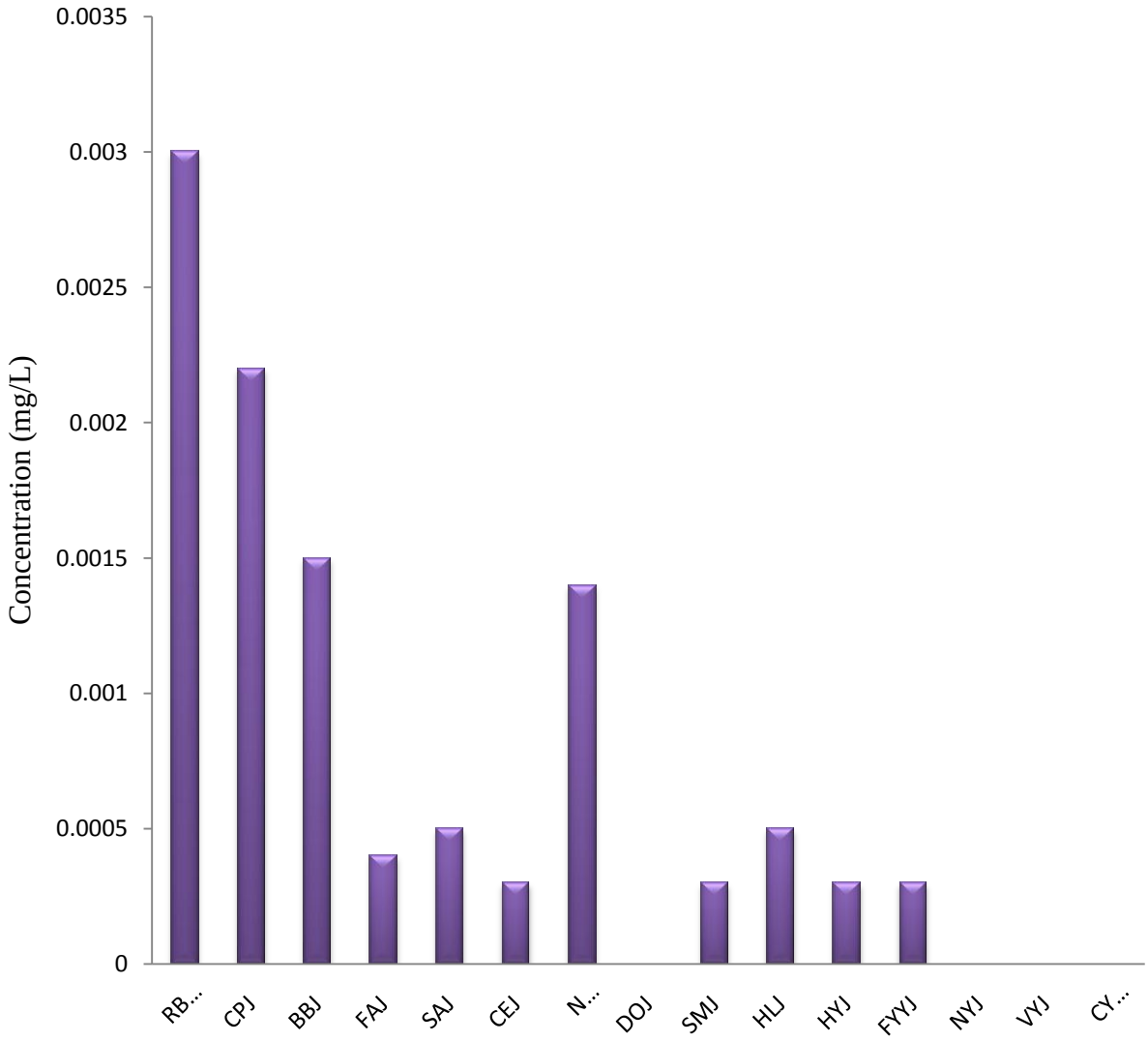


Figure 4.2: Concentration of F^- (mg/L) in reconstituted fruit juice

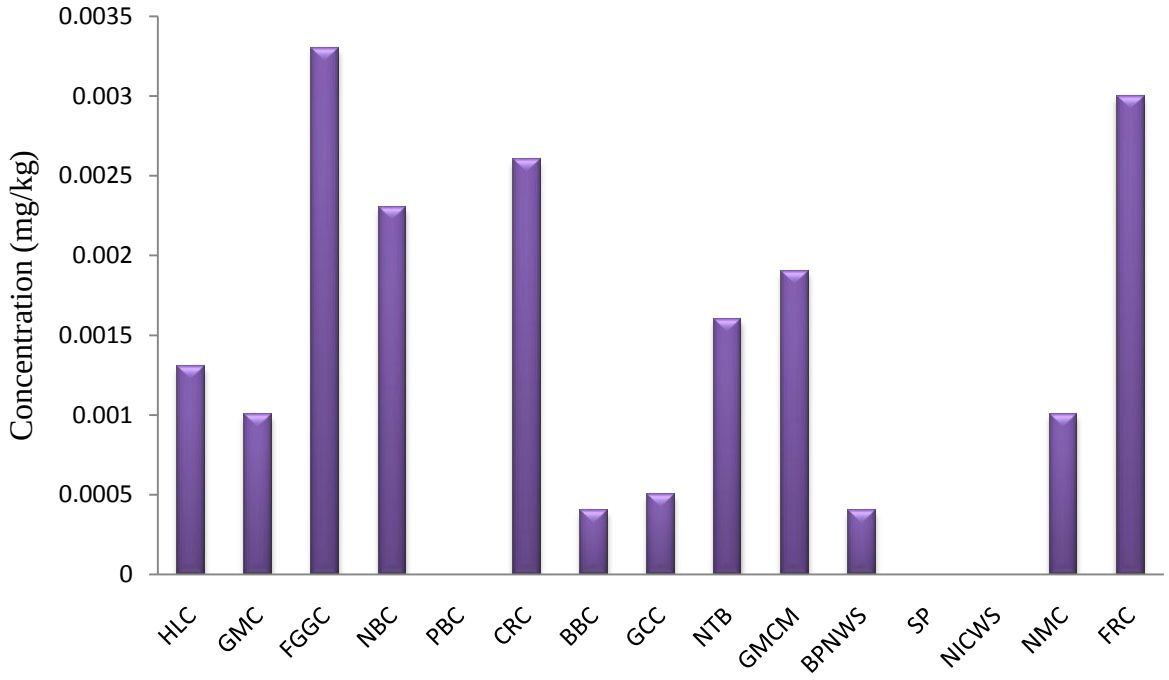


Figure 4.3: Concentration of F^- (mg/L) in commercial Baby Foods

Figure 4.4 and 4.5 show the concentration of K (mg/L) in reconstituted fruit juice and concentration of K (mg/kg) in commercial baby foods respectively. It was observed that potassium was present in all samples analyzed. The potassium levels in reconstituted fruit juices ranged from 10.33 in sample NTCJ to 450.04 mg/L in sample CYNMJ. The potassium levels in commercial baby food sample were much higher compared that of the fruit juices.

The potassium concentration ranged from 579.25 in sample BBC to 4250.00 mg/kg in sample FRC. Also comparing the levels of potassium across the six groups of commercial baby food samples based on source (Appendix B) indicated that those produced from mixed cereal had the highest concentration of potassium(3052.09mg/kg).

Figure 4.6 and 4.7 depicts the mean concentration of Ca (mg/L) in reconstituted fruit juice and concentration of Ca (mg/kg) in commercial baby foods. The concentrations of the calcium in the juices are generally lower than the concentration of calcium in baby foods.The concentration of calcium in fruit juices ranged from 124.42 in sample HYJ to 442.50mg/L in sample CYNMJ. The concentration of calcium in commercial baby foods ranged from545.92 in sample CRC to 5368.85mg/kg in sample FRC.

Calcium was also detected in all the samples. This is expected because of the very important role it plays in the growth of bone (Barba and Russo, 2006). Also the highest concentration of calcium was found in baby foods made from mixed cereals.

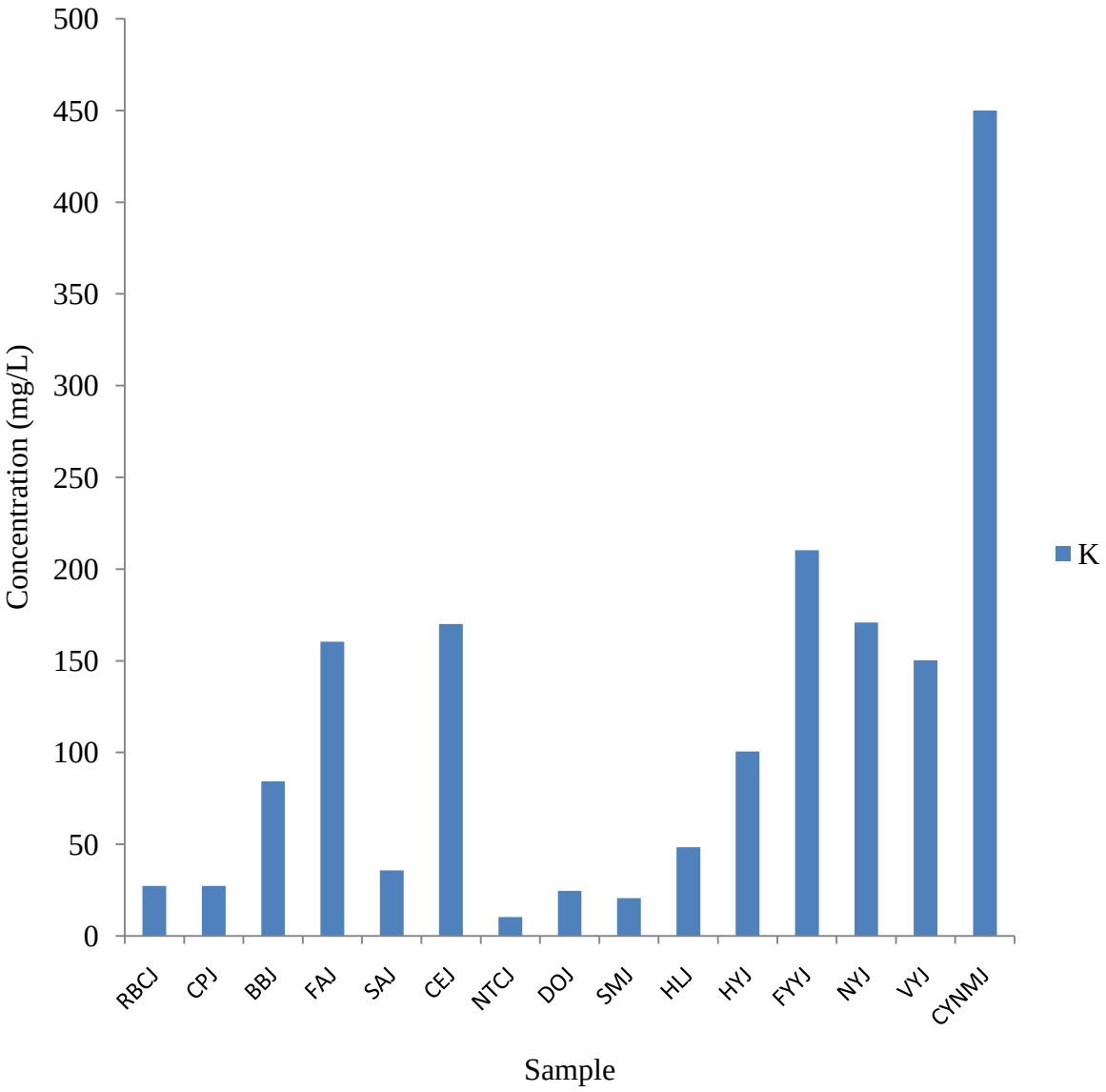


Figure 4.4: Concentration of K (mg/L) in reconstituted fruit juice

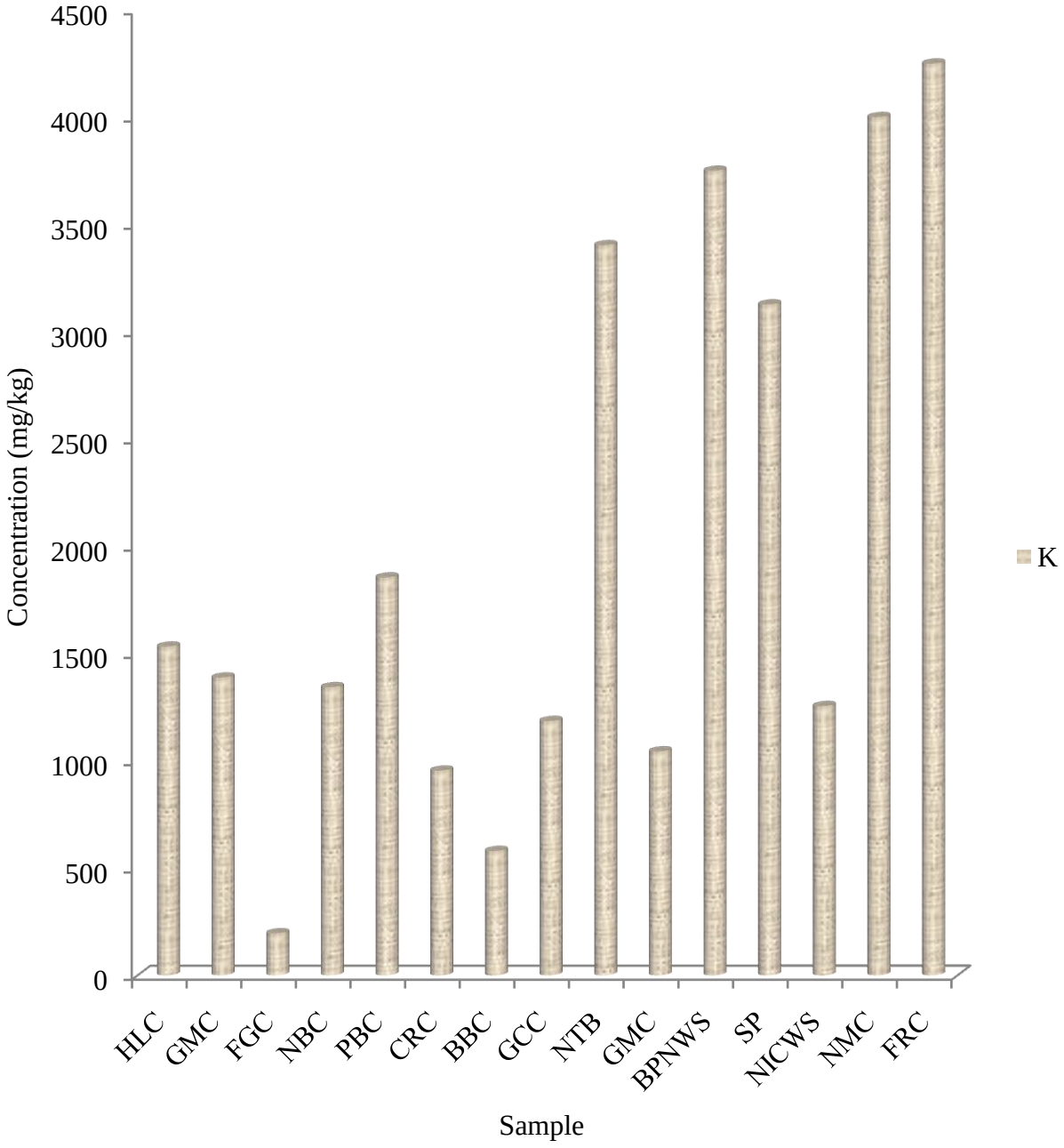


Figure 4.5: Concentration of K (mg/kg) in commercial baby food

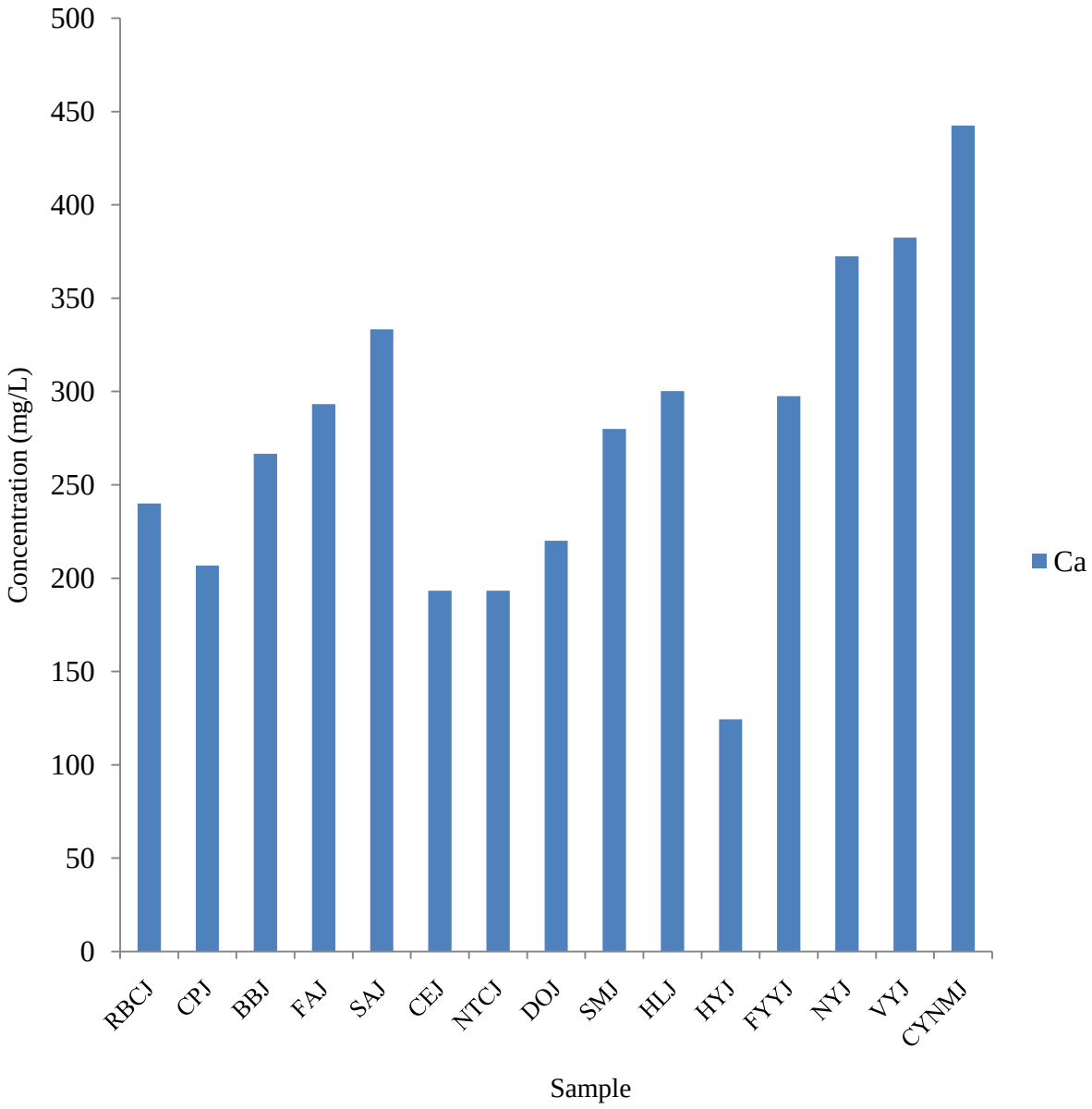


Figure 4.6: Concentration of Ca (mg/L) in reconstituted fruit juice

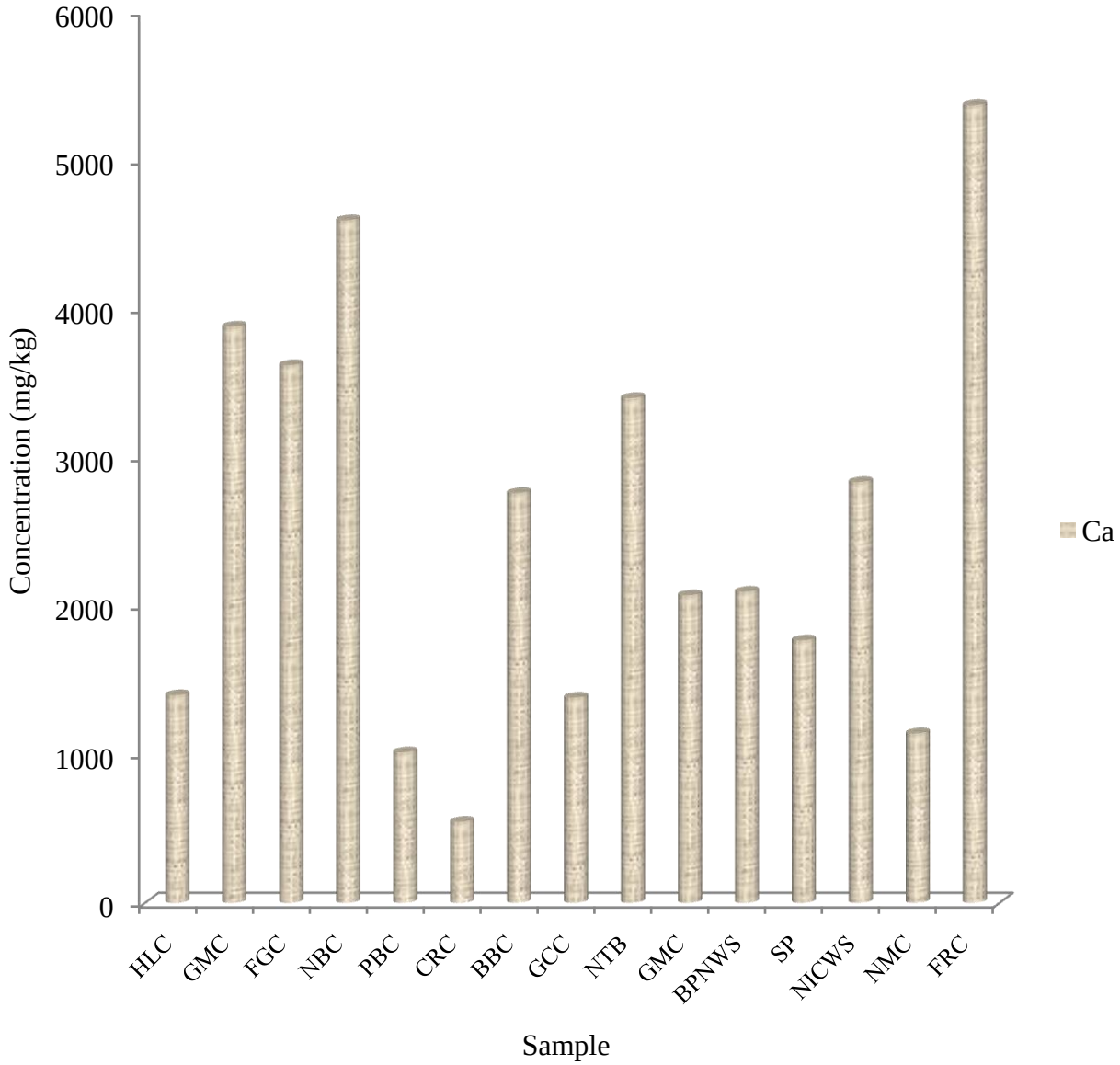


Figure 4.7: Concentration of Ca (mg/kg) in commercial baby food

Figure 4.8 and 4.9 shows the mean concentration of Mg (mg/L) in reconstituted fruit juices and Mg (mg/kg) in commercial baby foods. The reconstituted fruit juice samples had very low concentrations of magnesium ranging from 78.70 in sample RBCJ to 141.56mg/L in sample HYJ. Higher concentration of magnesium in baby food samples as compared to that in fruit juice samples ranged from 566.08 in sample HLC to 1150.73mg/kg in sample BPNWS. Protein based baby food samples also had the highest concentration of magnesium across the six classes of commercial baby foods.

Figure 4.10 and 4.11 shows the mean concentration of P (mg/L) in reconstituted fruit juice and the concentration of P (mg/kg) in commercial baby foods. The concentration of phosphorus in fruit juice samples are much lower than the concentration in baby foods samples. The concentrations in fruit juice samples ranged from 272.73 in samples CPJ and BBJ to 795.46 mg/L in sample CYNMJ. The concentrations of phosphorus in commercial baby food samples were high with range from 2301.60 in sample BBC to 9943.46mg/kg in sample HLC. Also the highest concentration of phosphorus across the six classes of baby food evaluated (Appendix B) was found in baby food produced from protein.

Figure 4.12 and 4.13 shows the mean concentration of Fe (mg/L) in reconstituted fruit juice and Fe (mg/kg) in commercial baby foods. The iron content in reconstituted fruit juice ranged from 3.09 to 34.50 mg/L in samples DOJ and FYJ, CYNMJ respectively. However, iron was not detected in samples CPJ, SAJ and VYJ. The range of iron concentration in baby foods was 31.25 to 549.11mg/kg in samples BBC and PBC respectively.

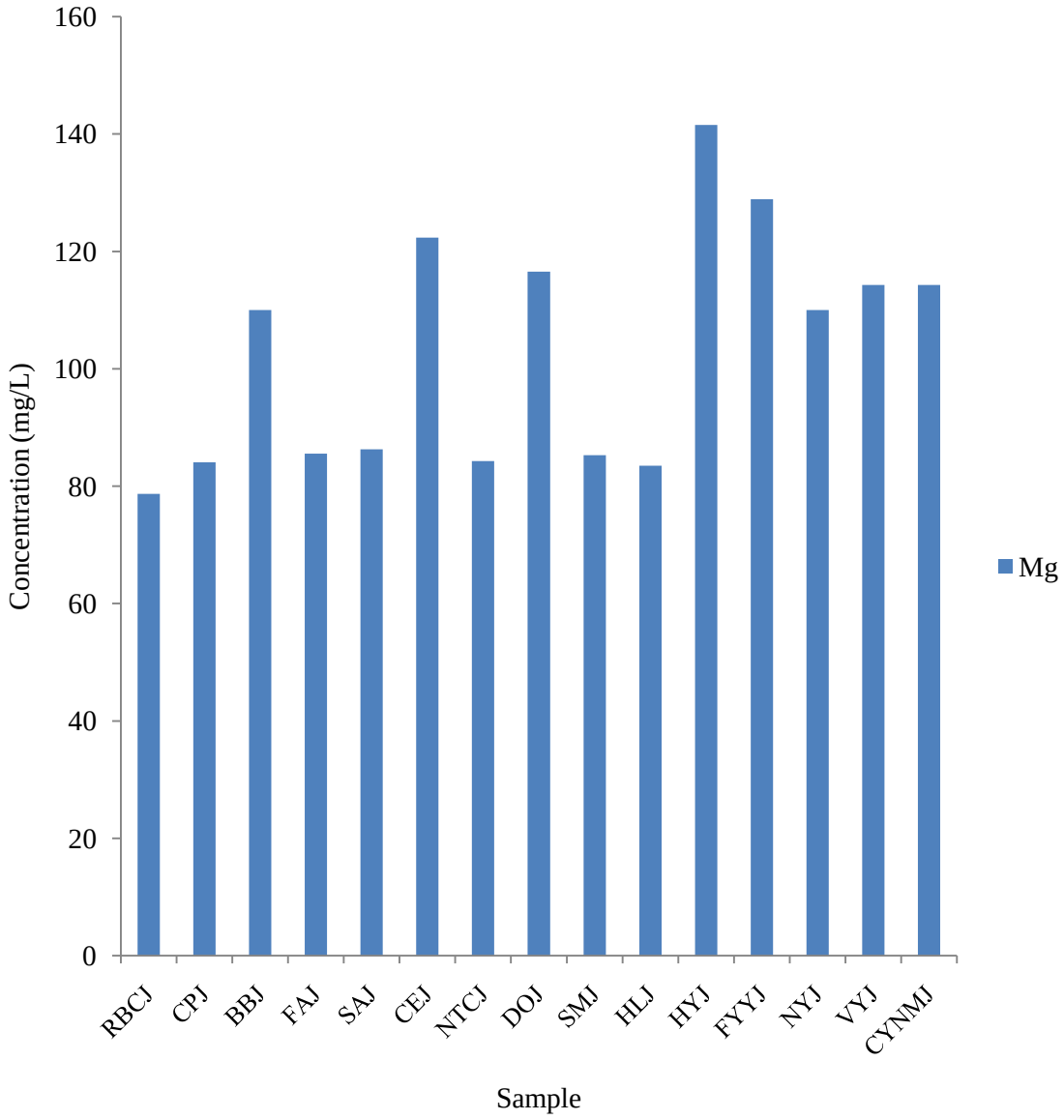


Figure 4.8: Concentration of Mg (mg/L) in reconstituted fruit juice

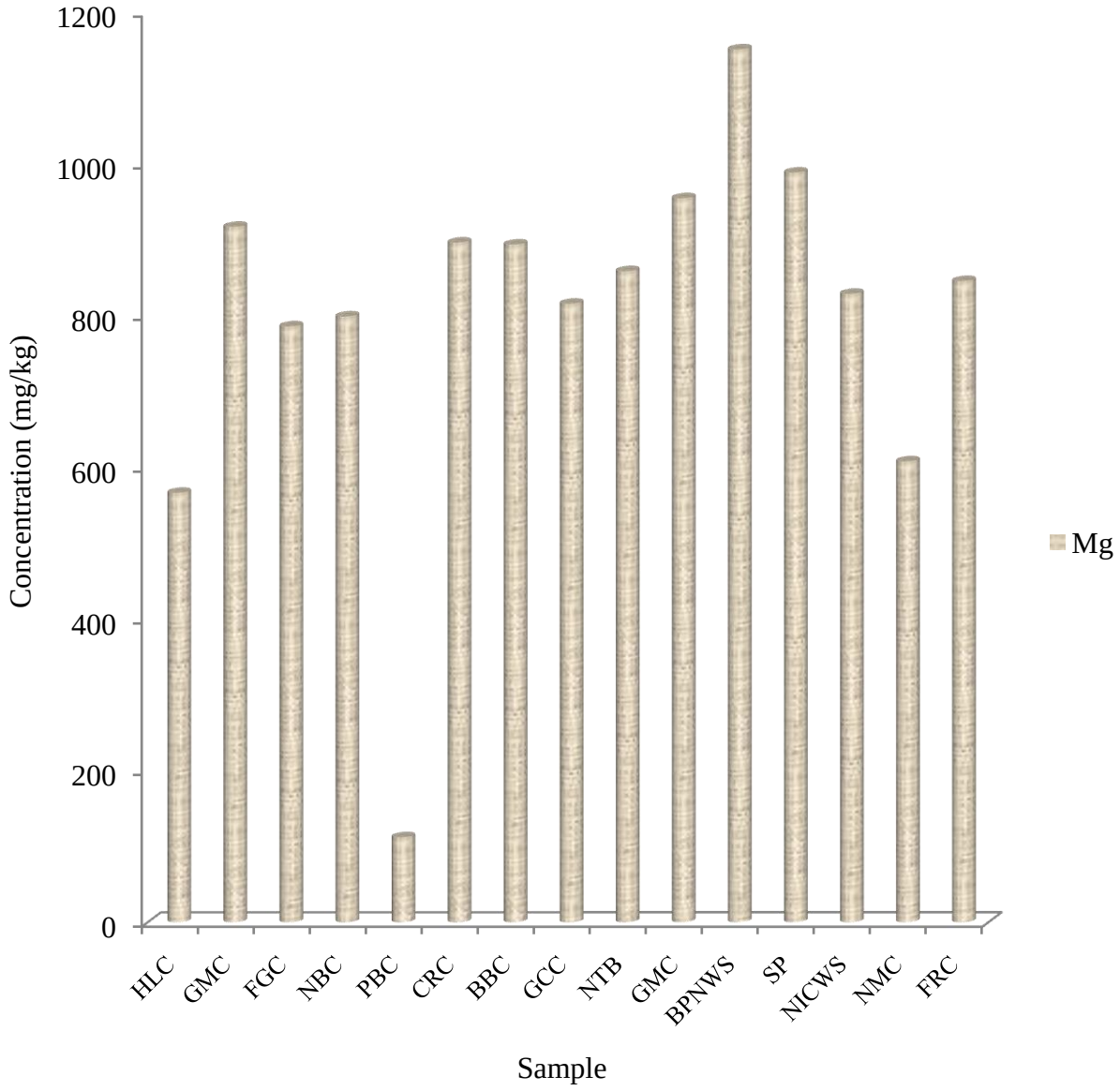


Figure 4.9: Concentration of Mg (mg/kg) in commercial baby food

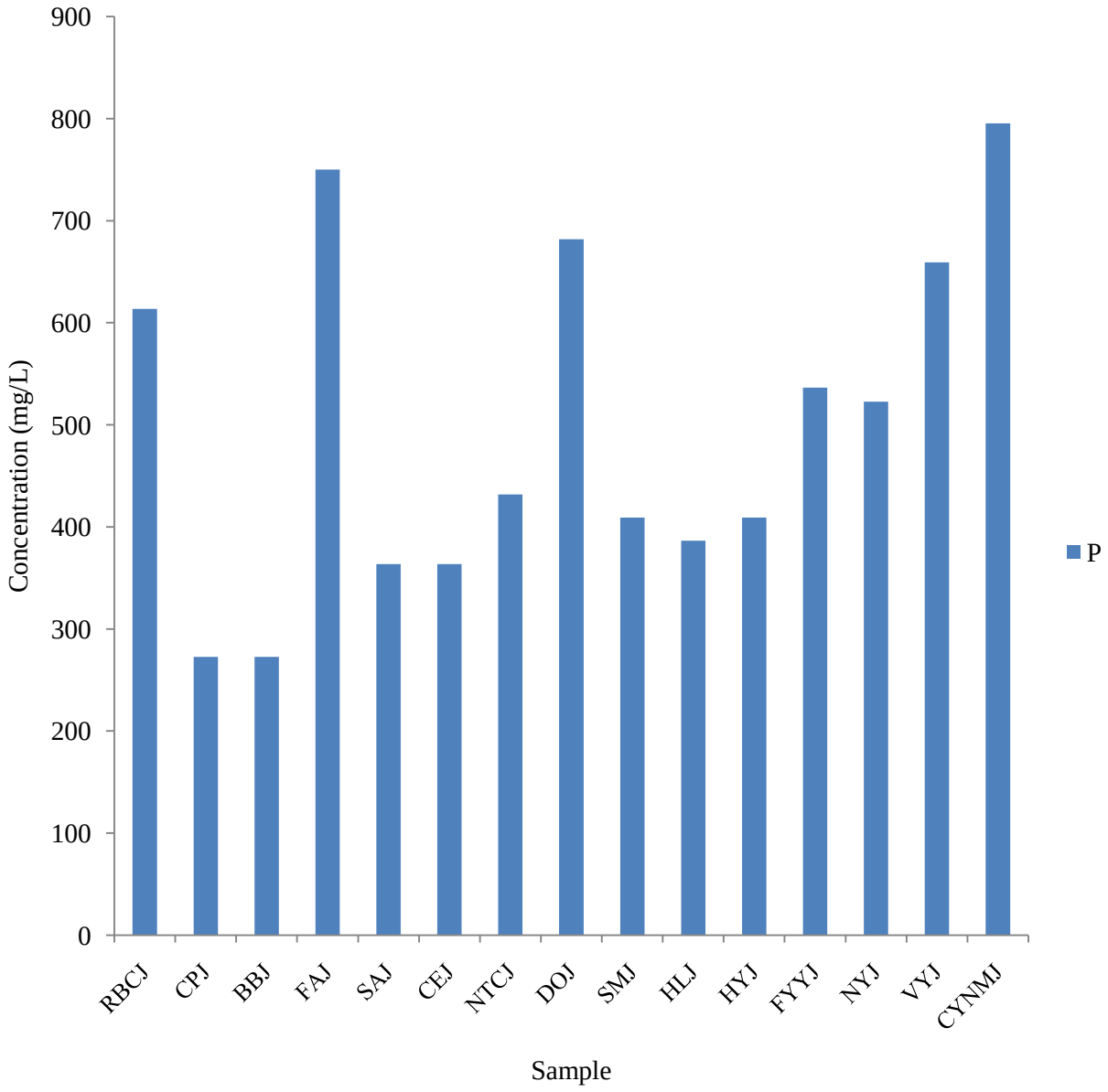


Figure 4.10: Concentration of P (mg/L) in reconstituted fruit juice

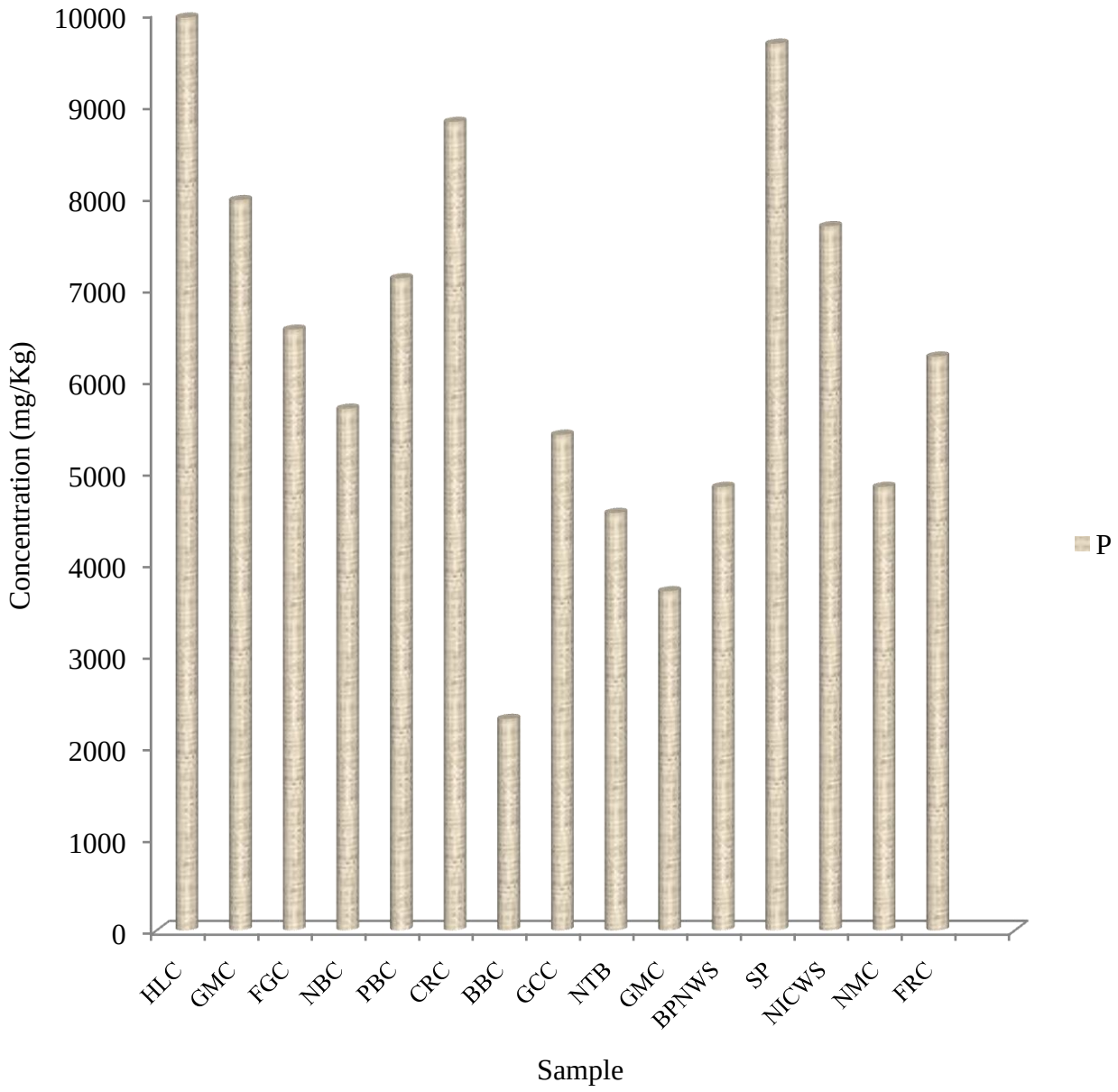


Figure 4.11: Concentration of P (mg/kg) in commercial baby food

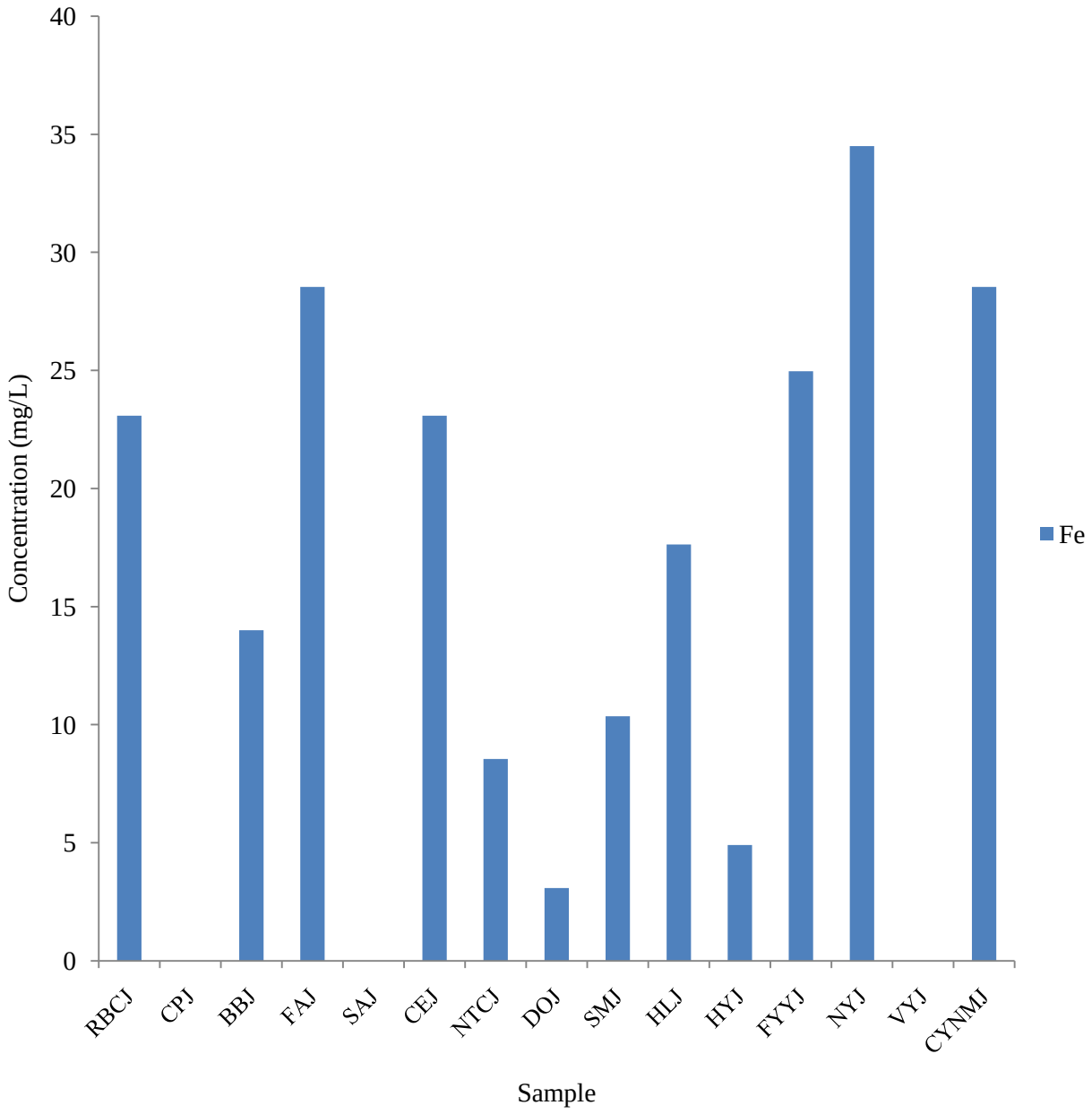


Figure 4.12: Concentration of Fe (mg/L) in reconstituted fruit juice

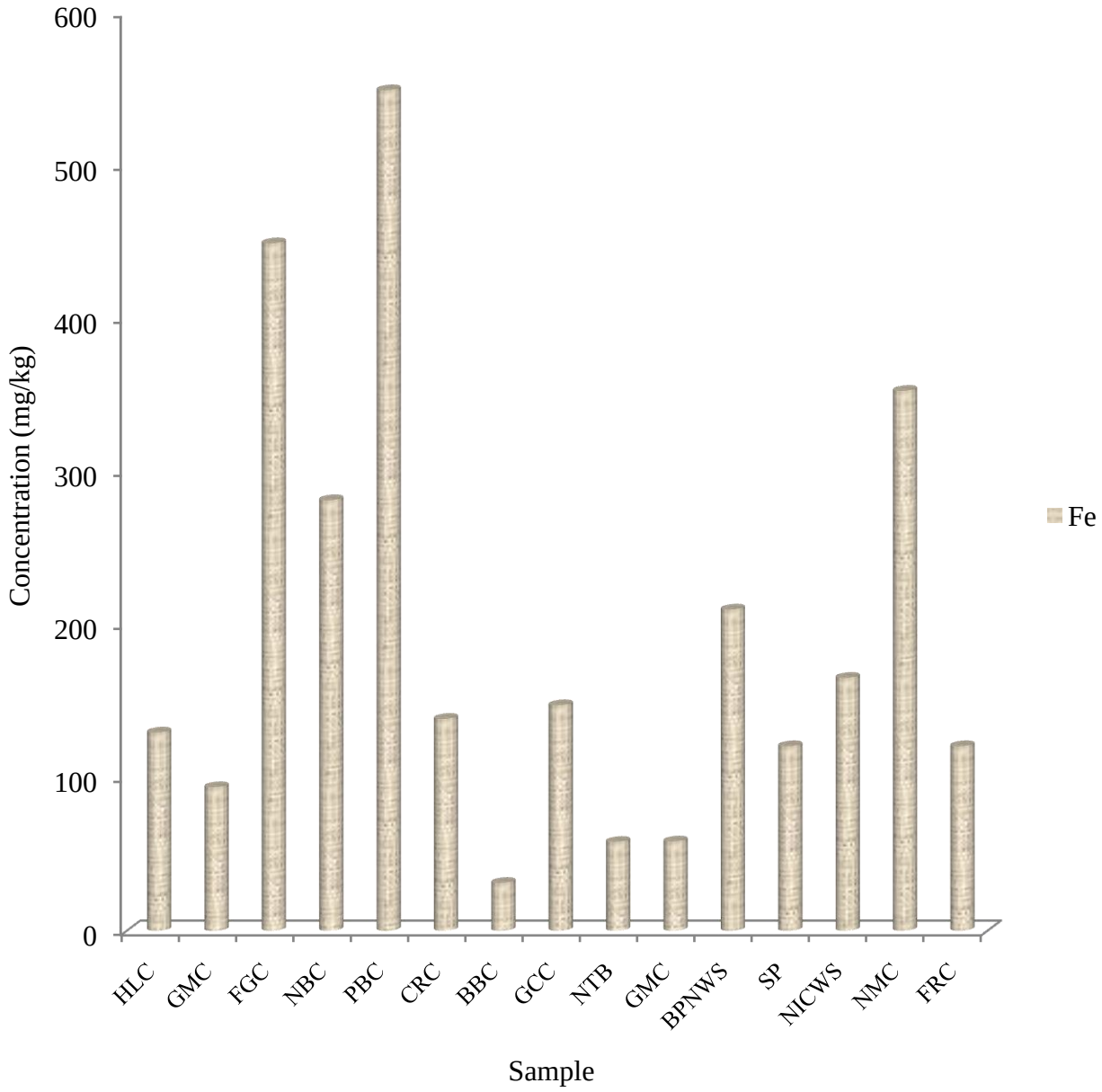


Figure 4.13: Concentration of Fe (mg/kg) in commercial baby food

The mean concentration of Zn (mg/L) in reconstituted fruit juice and concentration of Zn (mg/kg) in commercial baby food samples are presented in Figure 4.14 and 4.15 respectively. Only one among all the fruit juice samples analyzed had zinc in a detectable quantity at a very low concentration of 0.86 mg/L. The concentration of zinc in commercial baby food samples were also low ranging from 2.87 in sample FRC to 171.49 mg/kg in sample PBC. However zinc was not detected in sample HLC. The highest concentration of zinc across the six classes of commercial baby food sample was detected in maize based baby food sample.

The chloride concentrations of the samples are shown in Figure 4.16 and 4.17 while the nitrate levels are shown in Figure 4.18 and 4.19. The variation in pH of the samples are shown in Figure 4.20 and 4.21

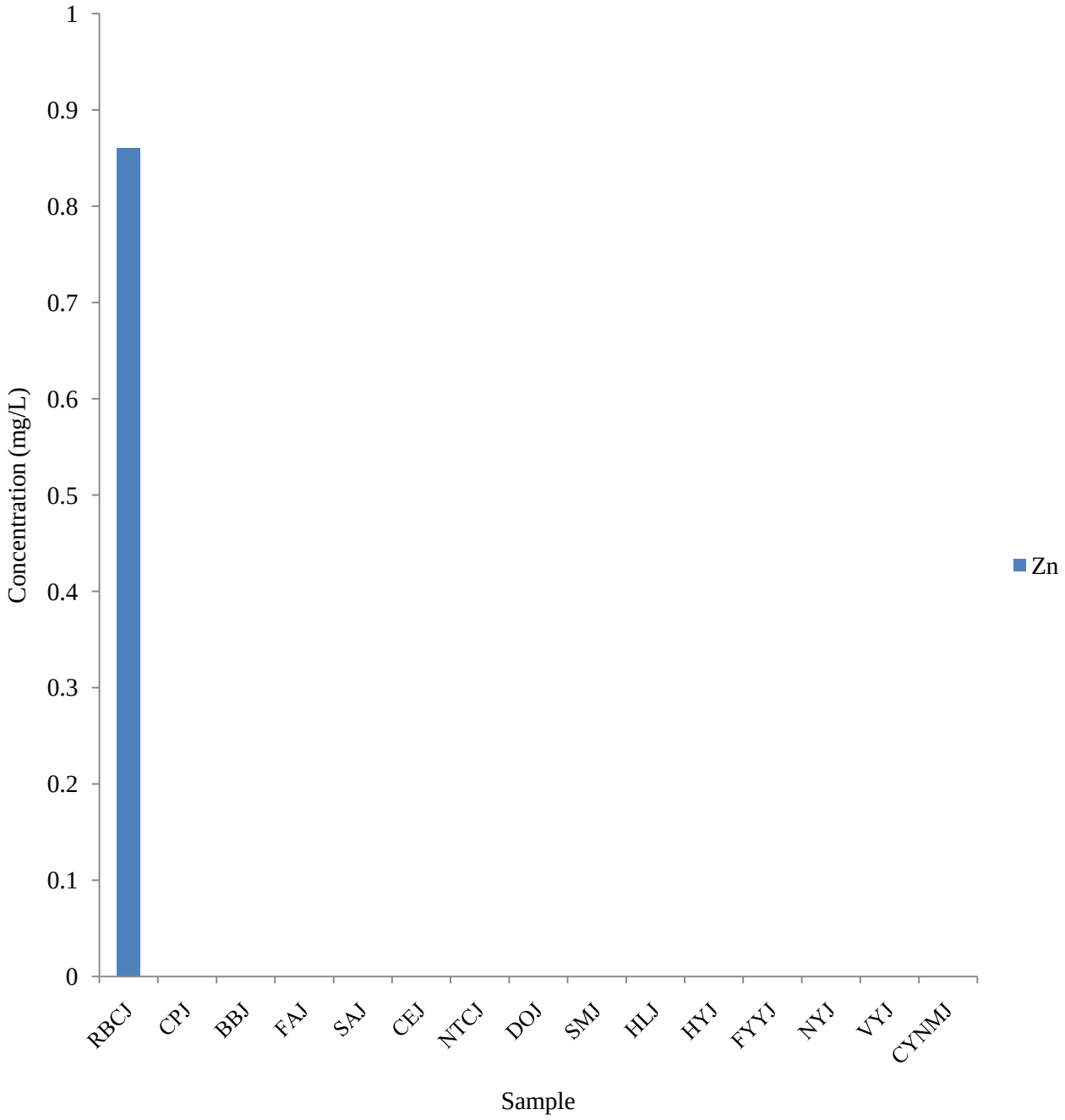


Figure 4.14: Concentration of Zn (mg/L) in reconstituted fruit juice

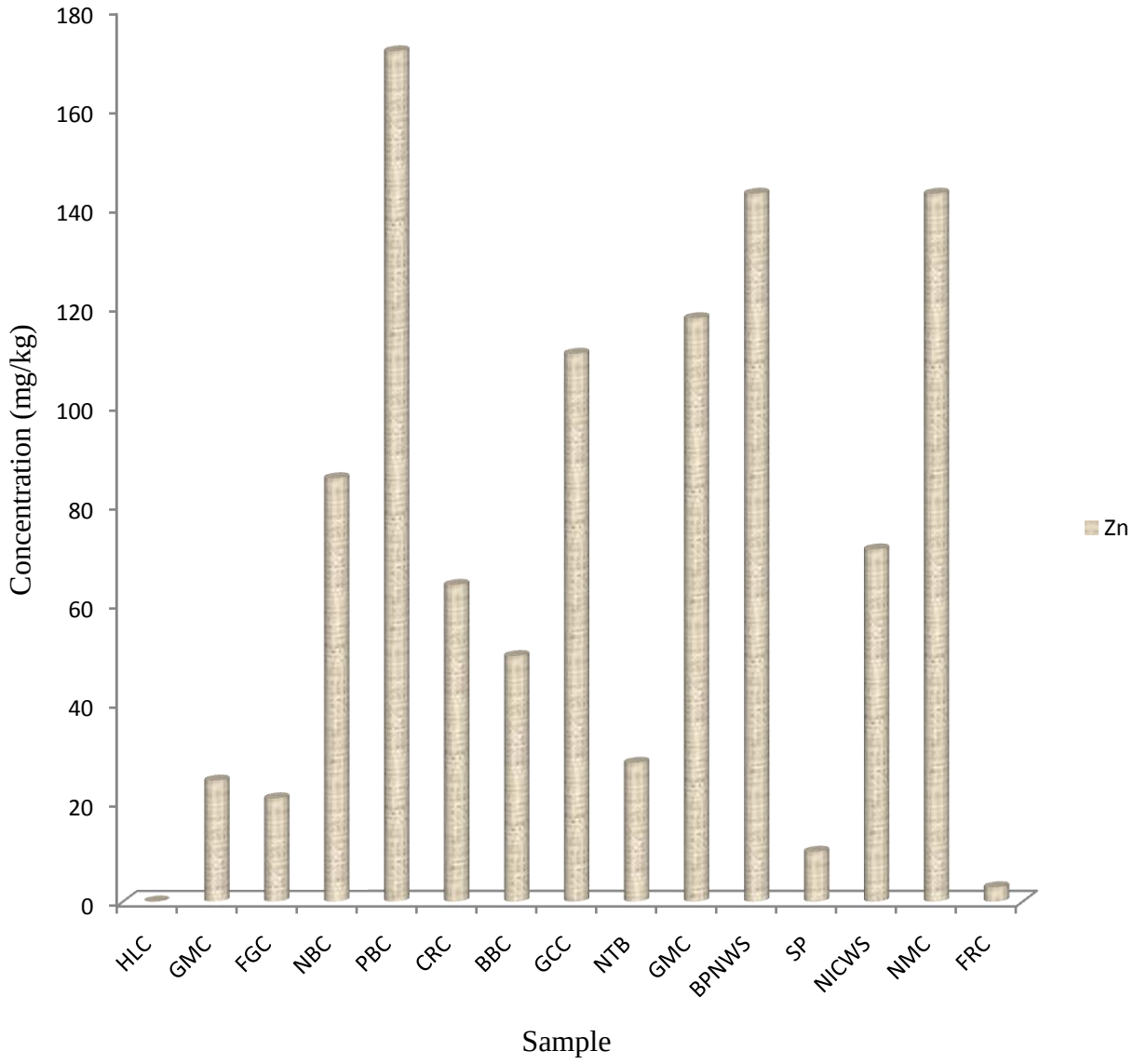


Figure 4.15: Concentration of Zn (mg/kg) in commercial baby food

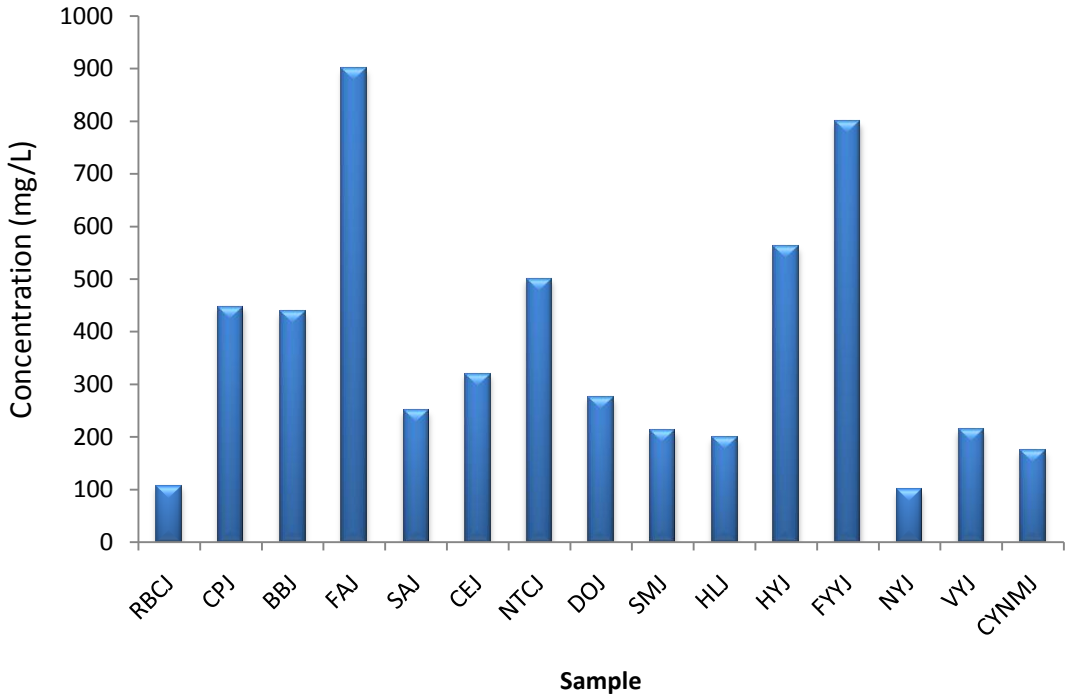


Figure 4.16: Concentration of Cl^- (mg/L) in reconstituted fruit juice

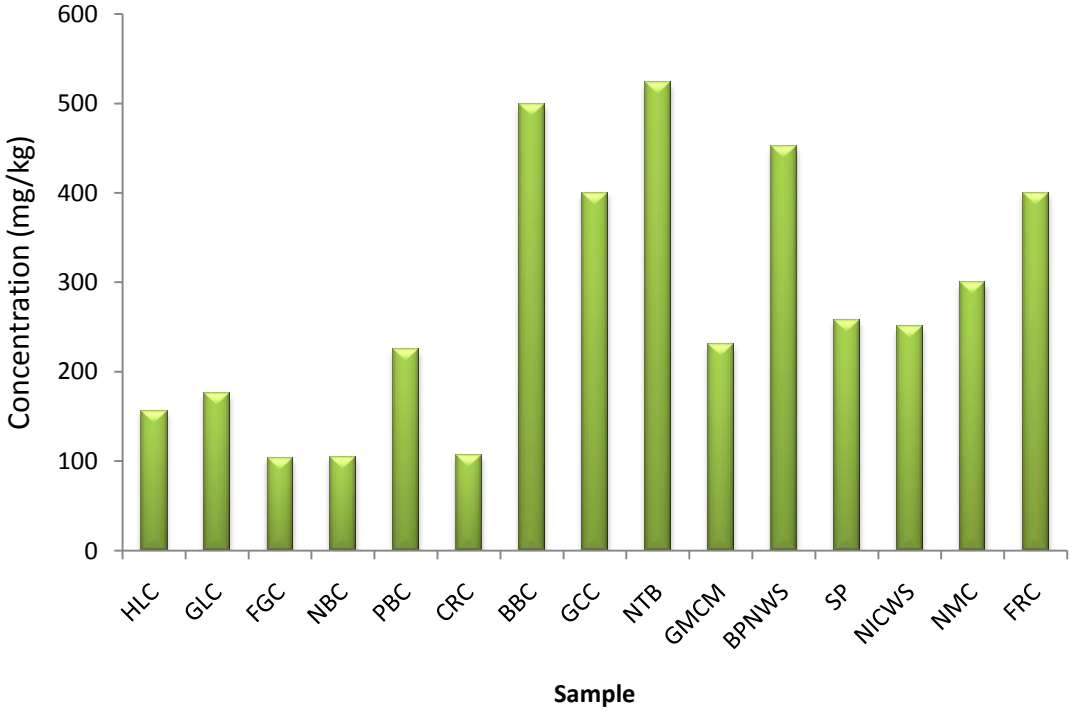


Figure 4.17: Concentration of Cl^- (mg/kg) in commercial baby foods

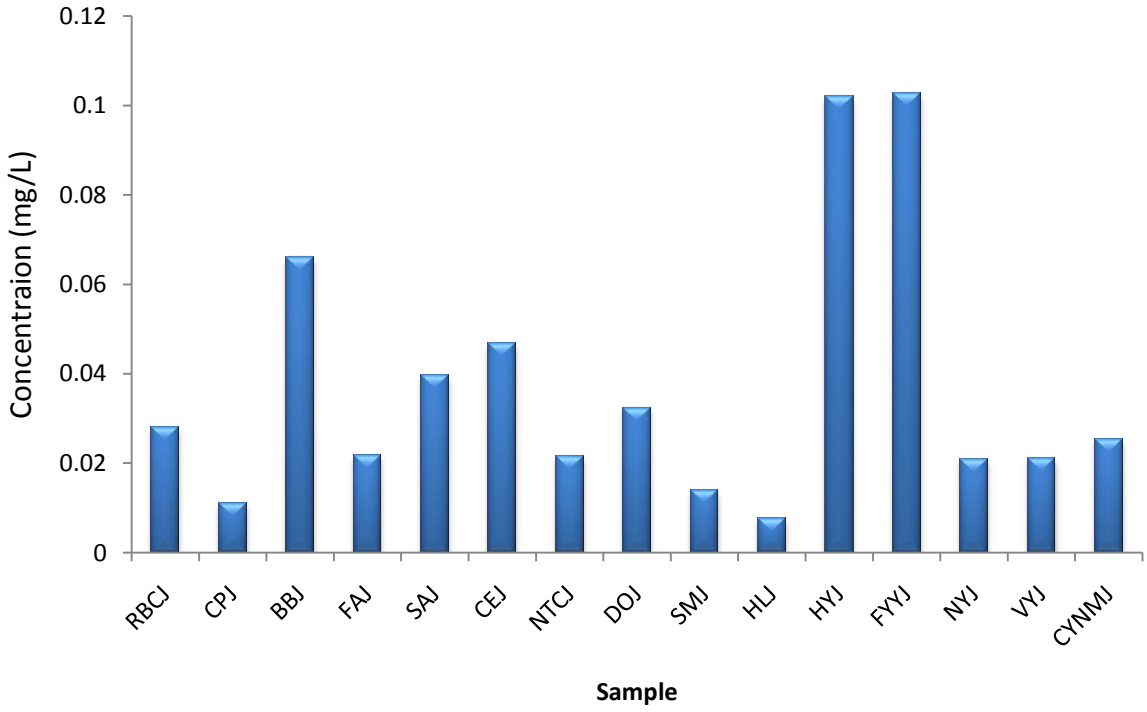


Figure 4.18: Concentration of NO_3^-(mg/L) in reconstituted fruit juices

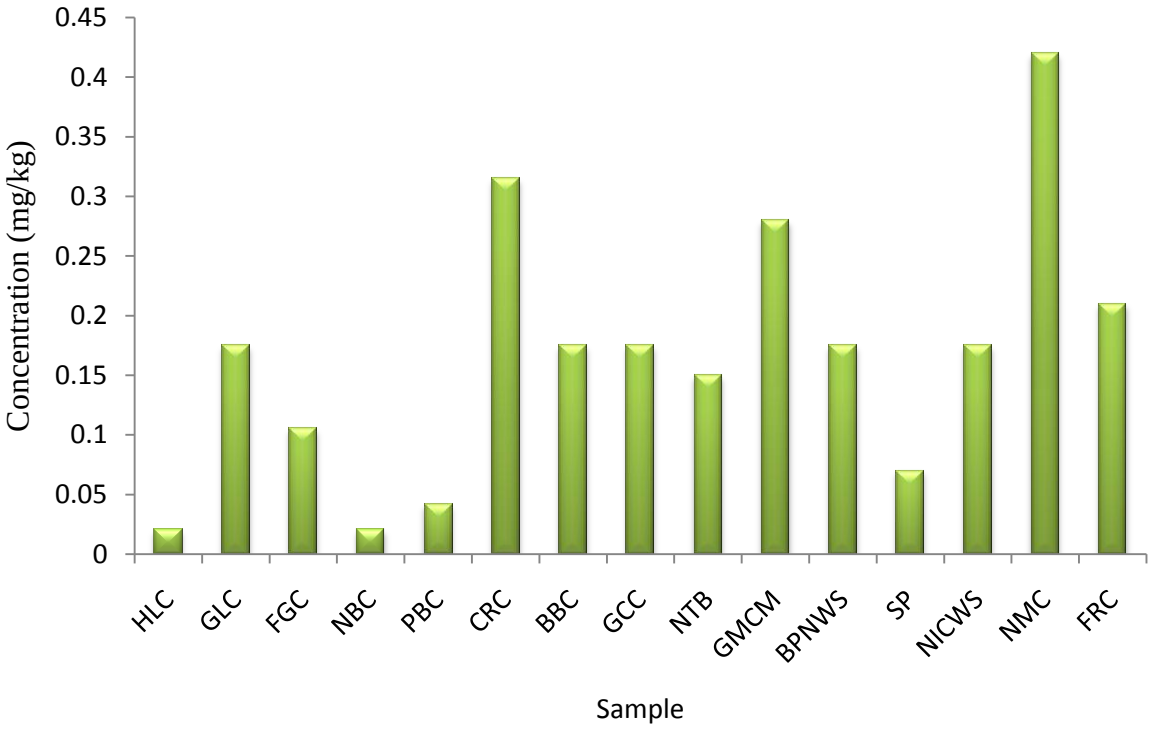


Figure 4.19: Concentration of NO_3^- (mg/kg) in commercial baby foods

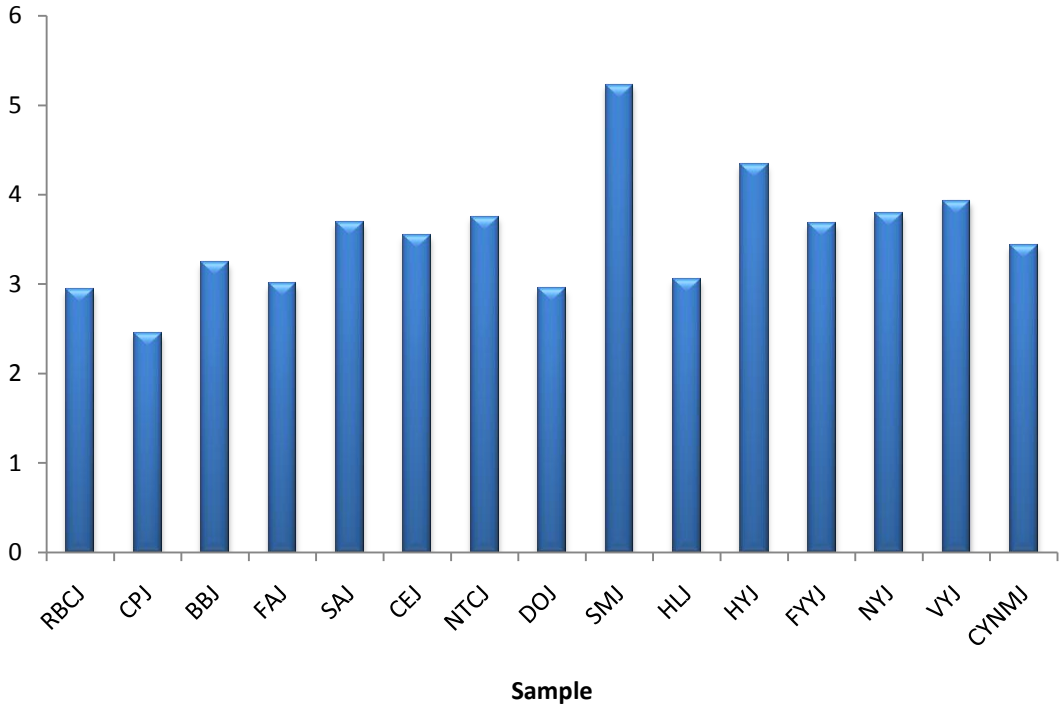


Figure 4.20: pH values in reconstituted fruit juice samples

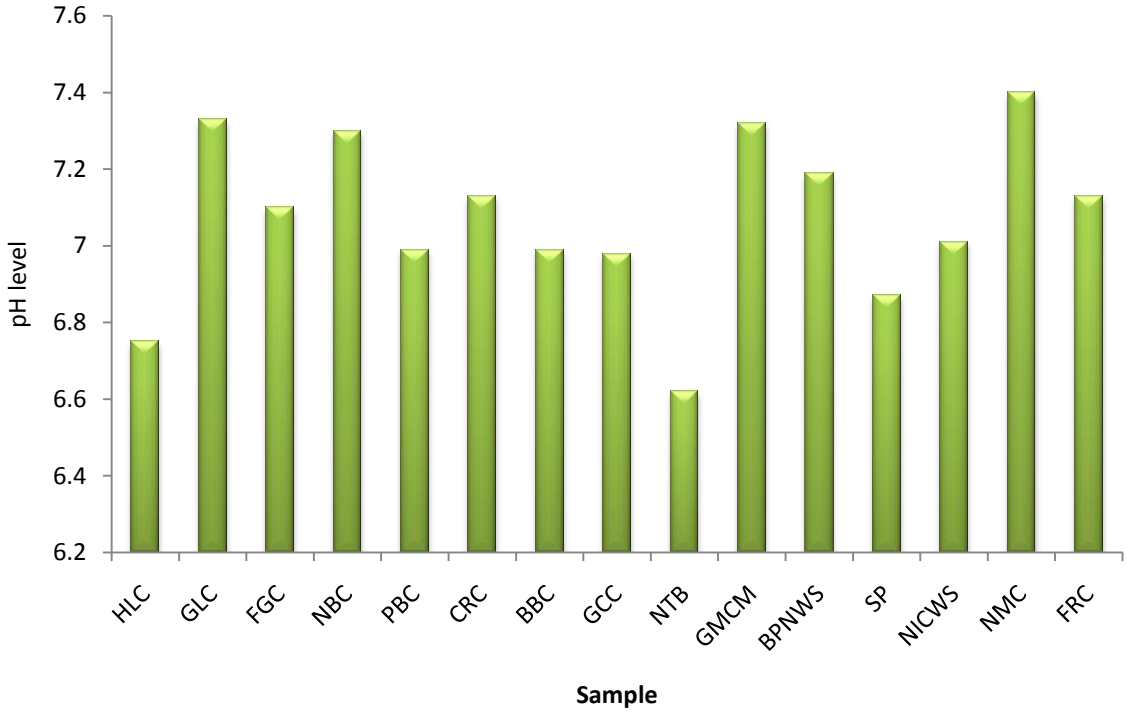


Figure 4.21: pH of commercial baby foods

CHAPTER FIVE

DISCUSSION

5.1 Proximate Composition of Commercial Baby Foods

5.1.1 Moisture content

Figure 4.1 shows the proximate composition of the six food groups of commercial baby foods. Sample MBBF has the highest value for moisture content (3.19%). This value is lower than those reported in literature for baby food samples 3.7- 4.9% (Mariam, 2005) ,3.75- 9.32% (Iombor*et al*.,2009) and 3.0- 4.60% (William 2011) respectively. The lowest moisture content of 1.39% was found in sample PBBF. This is not completely outside the range of values 1.18-4.0% reported by Lalude and Fashakin (2006). The moisture content values from this work are all below the standard value of 5-10% recommended by the Standard Organization of Nigeria (SON, 1988) (Appendix I). However it is of advantage since it has been noted that low moisture content remains an asset to shelf life and preservation of food nutrients whereas a higher moisture content could lead to spoilage through increase in microbial action(Temple *et al.*,1996).

5.1.2 Ash content

The ash content ranged from 1.04%, to 3.15% with its lowest value found in product sample MSBF and highest in sample MBBF (Figure 4.1.). Samples MSBF, WBBF, PBBF,MCBF,CFBBF were all within the maximum standard value of 2.0% (SON, 1988) except for samples CFBBF(2.40%) and MBBF(3.15%) which were higher than the standard range. In similar studies, values of ash content ranged in millet/soybeans based baby foods from 1.70-2.30% (Iombor*et al*.,2009) and cereal based baby foods ranged from

2.06 to 2.60% (Mariam, 2005). These were slightly higher than the values obtained in this studies but not far from the maximum recommended standard value (SON, 1988) (Appendix I).

5.1.3 Crude protein content

The crude protein content of samples MSBBF, MCBBF and WBBF was 5.25% (Figure 4.1) MBBF and C/FBBF were8.75% and that of sample PBBF was 7.0%. These values obtained differs from values of 15.9- 16.9% from other studies (Iombor*et al.*, 2009), 13.5-15.0% (Mariam,2005) and 14.4-18.2% (William *et al*.,2011). The crude protein values of this work is notably low when compared to other works and also falls below the minimum range of 14-17% recommended by SON(1988) (Appendix I). Protein is important for babies in their growth, so increase in the protein content of this food is needed to optimise nutritional values derived from their intake. It is very important that a child gets enough protein in their daily diet. They are the building blocks of body tissue and can also serve as a fuel source (Food and Nutrition Board, 2005). Protein can be found in all cells of the body and is the major structural component of all cells in the body, especially muscle. They are complex combinations of smaller chemical compounds called amino acids which are used as precursors to nucleic acid, co-enzymes, hormones, immune response, cellular repair, and other molecules essential for life. Additionally, protein is needed to form blood cells.

Protein is needed by everyone to maintain and repair the body, and it is especially important for babies and young children because protein supports growth and development. Breast milk or formula supplies all the protein a baby needs until 4 to 6

months; protein-rich solid foods should. Protein is important for babies because walking requires protein to power muscles, and brain cells need this nutrient to learn speech and language skills. Healthy 1- to 3-year-olds need 0.55 grams of protein per pound daily, which means the average child should get 16 grams of protein each day(WHO, 2000). The low protein content observed for these products calls for improvement on these foods by increasing the amount of protein or use of protein supplements or pairing them with other suitable protein source.

5.1.4 Crudefibre content

The crude fibre content (Appendix A)are 0.97%(MSBBF), 2.64% (CFBBF), 2.80%(MCBBF), 3.04%(WBBF),4.52%(MBBF) and 4.73% (PBBF). These values are close to range of values reported for soy/millet based baby foods 3.30- 5.0% (Iombor*et al*.,2009). However they do not compare with other reported values for cereal based baby foods 9.29- 10.8% (Mariam, 2005) which is higher and exceeds the standard maximum value of 5% based on SON(1988) recommendations.

5.1.5 Crude lipid/fat content

The values for crude lipid content in the selected baby foods are 3.40% MCBBF, 3.80% WBBF, 4.40% MSBBF, 4.50% PBBF, 4.60% WBBF, and 5.90 % for MCBBF samples. These values, however, do not compare to higher values of 7.0-9.0% (Iombor*et al*.,2009) and 15.6% -17.7% (Mariam,2005). The recommended standard value for crude lipid fat content for commercial baby foods is a maximum of 10.0%(SON,1988) and values from this work do not exceed the recommended standard value. However an appropriate inclusion of essential fatty acids in infants and children's diet is vital, because it does not

only increase energy density and ensure proper neural development, but also serves as a transport vehicle for fat soluble vitamins(FAO/WHO,1998).

5.1.6 Carbohydrate content

The carbohydrate content of selected commercial baby food samples evaluated in this work were all above the recommended standard values of 60% minimum. The values are 81.51%, 83.50%, 85.41%, 85.60%, 86.26%, 86.65% for samples MBBF, C/FBBF, PBBF, MCBBF, MSBBF and WBBF respectively(Appendix A). However, these values are higherthan that of crude protein and also when compared to values from reported literature 67.5-68.75% (Iombor*et al*., 2009); 67.95-68.40% (Mariam,2005). The recommended standard value for carbohydrate content is a minimum of 60% (SON, 1988) and values from this work suggest that all the samples of selected commercial baby foods evaluated contains a sufficient amount of carbohydrate. Carbohydrates are important in infant and children's diet as it provides energy. The Food and Agricultural Organization and the World Health Organization (1998) recommended that foods fed to infants and children should be energy dense ones. This, according to the recommendation is necessary because adequate energy fuels child's metabolism, support growth, keeps their brain and nervous system working and maintains overall health whereas low energy foods tend to limit total energy intake and the utilization of other nutrients and functions as mentioned above (WHO, 1998).

5.2 Mineral Concentration in Reconstituted Fruit Juices and Commercial Baby Foods

5.2.1 Fluoride concentration in reconstituted fruit juices

Foods, beverages, fruit juices, drinking water and dental products are considered as the main sources of fluoride intake for children above one year of age (Buzallaf*et al*., 2002; 2004). Fluoride concentrations in commercial fruit juices usually result from the concentration of this ion in the water used during industrial processing. The highest concentration of fluoride was obtained in the product labeled RBCJ (0.0030 mg/L) and lowest concentration in the products CEJ, SMJ, FYYJ and NYJ (0.0003 mg/L) (Figure 4.2). However,samples DOJ, VYJ, CYNMJ and HLJ had no fluoride detected. This indicates that the water used for the production of these fruit juices contain very minimal amount of fluoride.

These concentrations are below required daily intake stated by the institute of medicine in 2004 which is within 0.25mg for six month to three years old children, 0.50mg for three years to six years and 1.00mg(Appendix J) for six to sixteen years children who are within the age group of primary consumers of these products. However, there is need for continuous monitoring of fluoride concentrations in various products. The results in this study does not compare favorably with previous reports (Larsen and Nyvad, 1998); Thippeswamy*et al*., 2010 and Jiminez 2004 as their reported values for fluoride concentration in similar products were all higher. Theobtained concentration of fluoride from this work was however, similar to that of Pang *et al*. (2000) and Tokaliogl*uet al.,* (2004).

Cases of dental fluorosis occurred mainly in the mildest forms in the last decades (Bradford *et al.,* 1994). However, there is the need for controlling fluoride intake, especially in children below six years of age. This control must be based on the correct monitoring of fluoride in commercial drinks consumed by children. Instructions should be available to general populace concerning the main sources of fluoride intake, in order to make possible the rational use of this non-invasive caries control approach. Furthermore, sanitary surveillance actions must be more effectively reinforced, by means of a systematic analysis, in order to regulate and establish as mandatory the presentation of fluoride concentration on the labels of reconstituted fruit juices, foods and baby foods.

5.2.2 Fluoride concentration in selected baby foods

Most foods have fluoride concentrations lower than 0.0005 mg/kg except for seafood and chicken products, which may present higher fluoride levels due to the inclusion of bone, skin and shells during processing (Lima and Cury, 2001). The fluoride concentrations in the selected baby foods are shown in Figure 4.3. The figure shows that fluoride concentrations ranged from 0.0004 mg/kg to 0.0033 mg/kg. The concentration of fluoride was highest in sample FGC and lowest in sample BBC and BPNWS. These are also below the minimum permissible limit set by Institute of Medicine in 2004/2007 (Appendix J). Fluoride was not detected in sample PBC, SP and NICWS. These values compare closely with 0.001 to 0.003 mg/L values reported from previous determinations carried out by Hong *et al* (2006). Never the less, higher dose of fluoride is considered harmful to children (Tokalioglu, 2004).

5.2.3 Potassium concentration in selected reconstituted fruit juices

The mean concentration of potassium resulting from three replicate determinations of selected juices shows that the value of potassium concentration determined was 450.04 mg/L in CYNMJ . This was the highest level of potassium observed in all the fruit juice samples analyzed. The lowest concentration of 10.33 mg/L was obtained in sample NTCJ (Figure 4.4). It was also noted that potassium was found in all the samples. The value of potassium concentration recorded is far higher than results from earlier reports 2.97, 0-3mg/L Larsen and Nyvad (1998) and 5.100 to 5.850 mg/L reported by Dosumu*et al*(2009).

According to Institute of Medicine (IOM, 2004/2007), the adequate daily required intake of potassium is 700 mg/L daily for children of six months to one year of age, 3000 mg/day for 1-3 years, 3800mg for 4-8years and 500mg/day for 9-16 year old children (Appendix J). The levels of potassium in the samples are quite low when compared with required daily intake for children. These drinks cannot be relied on as a sole source of potassium for human but can serve as a contributing agent for potassium requirements in the body of human.

5.2.4 Potassium concentration in selected baby foods

The highest value of 4250.00 mg/kg was obtained in thebaby food labeled FRC followed by 4000.54 mg/kg (NMC) and lowest value of 579.25 mg/kg in sample BBC (Figure 4.5). These values do not compare favourably with values obtained in previous works (19-35 mg/Kg) by Ruiz *et al.* (1996). Joseph *et al*. (2011) reported higher potassium concentration in baby cereal. Also comparison of potassium concentrations were carried out across the six classes of baby food types available and results showed that samples from mixed cereal

commercial baby foods had the highest amount of potassium whereas baby foods produced from wheat grains had the lowest concentration of potassium.

However, the presence of potassium in these studied samples is vital. Potassium is crucial for good health and development of children. It works with sodium to control the body's water balance, which helps maintain healthy blood pressure (Slonim and Pollack, 2006). In fact, it has been established that a diet low in potassium and high in sodium appears to be a contributing factor in high blood pressure(Webster*et al.*,2010). Potassium also helps with muscle function and heart rhythm and, in later years, may reduce the risk of kidney stones and osteoporosis. Previous research has shown that besides milk, meat and other vegetables which are hardly consumed by babies and young children, cereal based foods have become a better source of potassium for them considering the fact that these cereal based baby foods are a popular, cheap and regular alternative for kid's consumption (Joseph *et al.*,2011). There is no upper intake level for potassium. An infant's body keeps a steady amount of potassium in the bloodstream while excreting excess amounts through the urine.

However, babies born with kidney or adrenal problems may have trouble filtering out potassium levels, resulting in high concentrations of potassium in the bloodstream, a condition known as hyperkalemia (Slonim and Pollack, 2006). Whereas, children with potassium levels below normal, suffer from a condition called hypokalemia; this usually occurs among babies who have persistent vomiting, diarrhea or those who are ill and given diuretic medications causing them to excrete too much potassium out of the body through the urine (Joseph *et al*., 2011). All the baby food samples analyzed contained an adequate amount of the required potassium needed for the body.

5.2.5 Calcium concentrations in selected reconstituted fruit juices

The calcium concentrations of the samples of reconstituted juices are shown in Figure 4.6. It indicates varied distributions of calcium among the samples. The highest mean value of 442.50 mg/L was obtained for sample CYNMJ and the lowest mean values of 124.42mg/L for sample HYJ. The daily required intake of calcium according to the institute of medicine (IOM, 2004/2007) is 26 mg/day for children between 6 months to 1 year, 700mg daily for 1-3year old children, 1000mg/daily for 4-8 years and 1200mg/day for –1years respectively (Appendix J). These values of calcium concentration determined does not compare favorably with the range of values (0.560-0.925 mg/L) obtained from previous study by Dosumu*et al*. (2009). It is observed that the samples contain calcium levels suitable for all category of children's age group.

5.2.6 Calcium concentration in selected baby foods

The levels of calcium in baby foods are depicted in Figure 4.7. It is seen that the highest values of calcium was found in sample FRC which has a value of 5368.85 mg/kg and the lowest value of 545.92mg/kg was obtained in sample CRC. These values compare with calcium values (4789.0-6200.0 mg/kg) reported by Moreno *et al.* (2014). On the other hand, this result is higher when compared to 1114-1659 mg/kg reported by Karin *et al.* (2011). Comparison of calcium concentrations across the six classes of baby food types available and results showed that samples of commercial baby foods produced from mixed cereals had the highest amount of calcium whereas baby foods produced from modified starch had the lowest concentration of calcium ion.

The importance of calcium to babies and growing children cannot be over emphasized as it is crucial for their health and development. Calcium is vital for building strong bones and teeth, promoting nerve and muscle function, helping blood clot, and activating the enzymes that convert food into energy. About 99 percent of the body's calcium is stored in the teeth and bones; and because children are growing new bones all the time, they need a steady supply of calcium to support healthy growth (Barba and Russo, 2006). During childhood and adolescence, the body uses the mineral calcium to build strong bones, a process that is all but complete by the end of the teenage years. Bone calcium begins to decrease in young adulthood and progressive loss of bone occurs as we age, particularly in women (FNB and IOM, 2004).

Teenagers, especially girls, whose diets don't provide the nutrients to build bones to their maximum potential, are at greater risk of developing the bone disease osteoporosis, which increases the risk of fractures from weakened bones (IOM, 2004). Younger kids and babies who don't get enough calcium and vitamin D (which aids in calcium absorption) are at increased risk for rickets. Rickets is a bone-softening disease that causes severe bowing of the legs, poor growth, and sometimes muscle pain and weakness(IOM, 2001).

Calcium also plays an important part in making sure that muscles and nerves work properly, and in the release of hormones and enzymes. So if blood calcium levels are low, the body takes calcium from the bones to help these functions and when kids get enough calcium and physical activity during childhood and the teenage years, they can start out their adult lives with the strongest bones possible (Cook and Friday, 2003).

5.2.7 Magnesium concentration in reconstituted fruit juices

The highest mean concentration of magnesium determined in reconstituted fruit juices was 141.56mg/L in product sample HYJ and the lowest 78.70mg/L in RBCJ (Figure 4.8). These concentrations are comparable to values reported by Adriana and Dana (2013) which were within the range of 13.07-140.42mg/L; though their lower values were much lower than the lowest mean value from this work. Furthermore, the concentration of magnesium in fruit juice samples studied in this work does not compare to other values (0.005-0.010mg/L) in commercial fruit juice FOJ and COJ reported by Dosumu*et al.*(2009).

5.2.8 Mg concentration in commercial baby foods

The mean concentration of magnesium in commercial baby foods as shown in Figure 4.9 has its highest value in product sample BPNWS (1150.73mg/kg) followed by sample SP(988.31mg/kg)and sample HLC had the lowest mean concentration (566.08mg/kg). These values compare well with values reported by Anigo*et al*. (2010) in cereal/soybeans based baby food. However, values from this work are higher in comparison to values from other reports; 127.0-233.0mg/kg and 492-568mg/kg (Karin,2011; Moreno *et al*.,2014) for commercial baby food sample and Spanish based baby foods respectively. Comparison of mineral concentration across the six classes of commercial baby foods indicated that protein based baby food had the highest concentration of magnesium followed by cereal fruit based whereas mixed cereal based food had the lowest concentration of magnesium. Generally, the concentrations of magnesium in fruit juices are lower compared to the amount present in commercial baby foods. This trend could be attributed to the fact that emphasis on the inclusion of a particular minimum and maximum amount of magnesium

in commercial baby foods by some committees and research organizations due to the health value attached to magnesium intake for babies and young children (SCF, 2003).

The metabolism of magnesium is tightly regulated. It is an integral constituent of bone mineral and as the second most abundant intracellular cation, plays a fundamental role in many aspects of intermediary metabolism, as a cofactor for many different enzymes and as a modulator of physiological processes (Rude and Shils, 2006). Magnesium is essential for the proper functioning of the body. It decides the correct course of pregnancy and in babies magnesium deficiency may lead to the sudden infant death Syndrome (Graczyka,2011). According to the National Institutes of Health (2008), children between the ages of 1 and 3 need 80 mg of magnesium a day. Those between 4 and 8 years need 130 mg, while children ages 9 to 13 need 240 mg. Teenage boys need 410 mg, while teenage girls should get 360 mg daily(Appendix K). Considering the overall concentration of magnesium found in the baby food samples evaluated, it has been observed that children within all the category of age group will get the considerable dosage of magnesium needed by the body from these foods. However, exceeding the recommended Mg doses as a result of supplementation with large amounts of fruit juices and teas can be toxic and could result in nausea, vomiting and a condition known as hypotension (Lewis*et al*.,1989).

5.2.9 Phosphorus concentration in reconstituted fruit juice

The highest mean concentration of Phosphorus in reconstituted fruit juice samples (Figure 4.10) was found in product sample CYNMJ (795.46mg/L)followed by FAJ (750.03mg/L).Samples CPJ and BBJ had the lowest concentration of phosphorus (272.73mg/L).

5.2.10 Phosphorus concentration in commercial baby foods

The mean concentrations of phosphorus in baby food samples were high in samples HLC(9943.46mg/kg), SP(9659.27mg/kg)and CRC(8806.91mg/L) respectively (Figure 4.11). The lowest mean concentration was found in sample BBC(2301.60mg/kg). These values do not compare to values for cereal/soy beans based baby foods (172.28-219.98mg/100g) earlier reported by Anigo *et al*. (2010). Comparison of phosphorus concentrations across the six classes of baby food types available and results showed that samples from modified starch based commercial baby foods had the highest amount of phosphorus, followed by protein based baby food whereas baby foods produced from wheat grains had the lowest concentration of phosphorus.

However the presence and amount of phosphorus in foods, beverages or juices consumed by children is important. Phosphorus is an important constituent of human bones, meaning that it would be impossible to function normally without an adequate amount of this mineral in the body. Phosphorus is regularly noted as the second most profuse mineral in the human body, and is the second most important element when it comes to maintaining bone health and integrity, after calcium(Fomon and Nelson,1993). It is essential for performing essential activities for different body parts like the brain, kidney, heart and

blood. Therefore during growth the retention of phosphorus is determined by the rate of bone growth and the rate of lean tissue accumulation for children.

Bioavailability of phosphorus is highest from human milk (85-90%) in infants, followed by cow's milk (72%) and soy based foods (59%)(Moya*et al.*, 1992). However, cow's milk and soy-based infant cereal foods generally contain substantially more phosphorus than human milk. As a result, phosphorus absorption for infants fed by cow's milk and soy formulas appears to be almost twice that of infants fed human milk (Moya*et al.*, 1992).According to the National Institutes of Health, (2008) and Institute of Medicine (2004/2007) children between the ages of 0-6months require 100mg/day, from7-12months needs 275mg/day, 1- 3yrs need 460 mg of phosphorus a day(Appendix K). Those between 4 and 8 years need 500 mg, while children between the ages of 9 and 13 and above need 1250mg daily. The results for concentration of phosphorus in both fruit juice and commercial baby food samples analyzed indicate that phosphorus deficiency will not be an issue for concern in babies and children who frequently consume these products.

5.2.11 Iron concentration in reconstituted fruit juices

The highest mean concentration of iron determined was found in samples FAJ 34.50 mg/L and CYNMJ 28.54mg/L while the lowest mean concentration in sample DOJ 3.09mg/L (Figure 4.12). Iron was not detected in samples CPJ, SAJ and VYJ. Much lower values within the range of 0.010- 0.025 mg/L in fruit juice samples (FOJ, COJ) was reported by Dosumu *et al.*(2010) which are not comparable to the values of Iron concentration from this work. On a similar note Adrian and Dana,(2013) reported low values of 0.17- 1.86 mg/L in selected fruit juice samples.

5.2.12 Iron concentration in commercial baby foods

A high mean value of 549.11mg/kg and 449.11mg/kg of iron was found in baby food samples PBC and FGC respectively. Samples BBC, NTB and GMC had lower values of 31.25mg/kg,58.04 and 58.32 respectively (Figure 4.13). The values of iron concentration from this work compares well with values 19.0-47.66mg/100g reported by Karin, (2011) but differs from others with 4.3-26.0mg/kg reported for rice and fruit based baby foods (Karin,2011). Based on result of mineral concentration across the six classes of commercial baby foods evaluated, baby foods produced from mixed cereals had the highest concentration of Iron followed by that produced from maize. The lowest concentration of Iron was found in cereal/fruit based baby foods.

It is highly unlikely that life in any form can exist without iron because of its diverse functions. It is essential for the production of haemoglobin, which helps deliver oxygen from the lungs to body tissues, transport electrons in cells, and synthesis of iron-containing enzymes that are required to utilize oxygen (O_2) for the production of cellular energy (Cook, 1982). The body's iron stores, iron absorption and iron loss determine iron balance. At least two-third of body iron is functional iron, mostly haemoglobin within circulating red blood cells, with some myoglobin in muscle cells and parts of iron-containing enzymes. Most of the remaining body iron is storage iron (existing as ferritin and haemosiderin), which serves as a deposit to be mobilized whenneeded (ACC/SCN, 2000). If body iron reserves are present at birth, the infant will need virtually no dietary iron for at least three months after birth. Intake from six months and above can be obtained mainly

through diet, such as iron-fortified complementary foods to meet the cut-off point for blood hemoglobin concentration.

Iron deficiency and its anaemia (IDA) is the most common micronutrient malnutrition problem in the world as it affects more than 3.5 billion people globally, of which about 2 billion are children and women and in Nigeria, more than 50% of children and women suffer from IDA, (UNICEF, 1998; UNICEF/UNU/WHO/MI, 1999). Iron deficiency weaken children's learning abilities through compromised mental development, lowers resistance to infections, growth retardation, and increased morbidity in the developing world. (WHO,1997). In view of preventing these conditions associated with IDA, The required daily intake of iron as recommended by the Institute of Medicine(IOM), (2001) and National Institute of Health(NIH),(2008) for babies and children are 11mg for (7-12months), 7mg(1-3yrs), 10mg(4-8yrs), 8mg(9-13yrs)and 15mg for14yrs and above (Appendix K).

5.2. 13 Zincconcentration in reconstituted fruit juices

Zinc was not detected in all fruit juice samples except for one (RBCJ- 0.86 mg/L). Adriana and Dana,(2013) reported a value of 3.38mg/L while Dosumu *et al*.(2010) reported Zinc concentrations values of 0.005- 0.010mg/L in selected fruit juice, DOJ and COJ samples respectively.

5.2.14 Zinc concentration in commercial baby foods

The highest mean concentration of zinc determined in the selected baby foods was 171.49mg/kg found in product sample PBC followed by 142.76mg/kg, 117.655mg/kg for sample BPNWS and GMC respectively. The lowest mean concentration was 2.87 mg/kg, followed by 10.04mg/kg and 20.80mg/kg for sample FRC, SP and FGC

respectively(Figure 4.15). Zinc was not detected in Sample HLC. The low concentration of zinc determined in this work compares to (6.3- 10mg/kg)values reported for rice/fruit cereal based baby foods, (Karin,2011);Also Anigo*et al.*(2010) reported higher values within the range of 7.88- 10.79mg/100g for cereal/soybeans based baby foods (Figure 4.15). The concentration of zinc across the six classes of commercial baby foods where generally low though baby foods based on maize had the highest value whereas, wheat based baby foods had the lowest value for zinc concentration. However zinc was not present in modified starch based baby food samples.

Zinc is one of the essential mineral elements found in almost every cell,where it stimulates the activity of over 100 enzymes needed for various biochemicalreactions (NIH, 2002). Important enzymes stimulated by zinc, support metabolic processes such as the immune system, wound healing, organoleptic abilities of taste and smell, brain development, synthesis of DNA and RNA, normal growth and development during pregnancy, cell division, sexual maturation, storage and release of insulin among others (Bahijri, 2001; IOM, FNB, 2001). Zinc is considered as one of the most essential mineral elements in foetal, infant andearly childhood development. For instance, the essentiality of zinc in normal braindevelopment suggests a clinical function for the element during the prenatal period. During the early feeding period of infants, the high level of zinc in colostrums (2mg/L) covers the requirement of the period. This level however declines to 1.2mg/L at one year therefore lack of supplementation or introduction of zinc-fortified complementary foods at this stage results in deficiency (IOM, FNB, 2001). However, The generally low values for zinc concentrations in evaluated samples could be attributed to the fact that the daily required amount of zinc(IOM, 2001) by the body is a little lower compared to

amount of other essential minerals needed by the body on a daily basis; therefore the need to include or fortify these products with high concentration of zinc does no arise.

Total dietary zinc intake may be adequate, but bioavailability particularly from plant-based foods may be reduced due to high phytate contents (SCN, 1995). Populations that largely depend on plant-based foods would require supplementation and fortification of foods meant for infant and children. To ensure that babies and children get the adequate and appropriate amount of zinc through their mostly consumed food, the required daily intake of zinc as recommended by the Institute of Medicine (IOM, 2001) and National Institute of Health(NIH),(2008) for babies and children are 2mg for (0- 6months), 3mg(7-12months), 3mg(1-3yrs), 4mg(4-8yrs), 6mg(9-13yrs)and 7-13mg for14years and above per day (Appendix K).However the result for concentration of Zn determined in this work indicates that regular consumption of these products will result to an adequate supply of zinc needed by the body.

5.3 Physicochemical parameters in reconstituted fruit juice and commercial baby foods

5.3.1 pH values of reconstituted fruit juice and baby food samples

All the fruit juice samples tested had their pH values below 7(neutral). This indicates that they were all acidic. The pH(Figure 4.21) were within the range of 2.45 in sample CPJ(most acidic) to 5.23 in sample SMJ. However this is expected because generally commercial reconstituted fruit juices are made from fruit concentrates which are generally acidic because of the presence of citric acid, phosphoric acid and sometimes ascorbic acid (Sullivan and Milosevic,2008). The pH values of different type of juices vary due to the

variation in amount of these acidic contents. The consumption of good quality fruit juice in moderate amounts can help children meet their daily recommendations for fruit consumption, provide the required nutrients and vitamin intake needed for the growth of body as well as mind. But giving excessive quantities of these reconstituted juices to children especially those below 6 years can lead to tooth decay, poor nutrition, diarrhea, gas, abdominal pain, and bloating due to their acidic nature (Beezy,2009).

Acid/dental erosion, also known as dental erosion is a type of tooth wear that initially develops in the enamel. It is the irreversible loss of tooth structure due to chemical dissolution by acids not of bacterial origin and if left unchecked may proceed to the underlying dentin,(Dugmore and Rock, 2004) . It is the most common chronic disease of children ages 5 to 17years, (NCCDPHP, 2007). Although, it is only recently that it has been recognized as a dental health problem, There is generally widespread ignorance of the damaging effects of acid erosion; this is particularly the case with erosion due to fruit juices, because they tend to be seen as healthy.

The pH of all the commercial baby foods are all higher than that of the fruit juices which indicates that all the samples of baby foods analyzed were not acidic. However based on their pH values in Appendix F which ranged from 6.62 for sample(NTB) to 7.40 for sample(NMC), it is an indication that those with values slightly below or above 7 are just slightly acidic or basic. With these pH values the issue of acidity related problems after consumption of these commercial baby foods does not arise as they are meant not to be acidic or basic. In general foods and fruit juices with a pH value below 5.0 are said to trigger those acid related conditions earlier mentioned.

5.3.2 Chlorides in reconstituted fruit juices and commercial baby foods

Chloride concentration in fruit juice samples ranged from 100.3700mg/L in sample NYJ to 899.5050mg/L in sample FAJ.The chloride concentration in commercial baby foods (Appendix F) ranged from 104.0300mg/kg in sample FGC to 523.0002mg/kg in sample NTB.To ensure that both children and adults get the optimal dose of chloride needed by the body, ward off deficiency as well as toxicity, The Food & Nutrition Board (FNB) of the Institute of Medicine, National Academy of Sciences (NAS) in 2001 set the daily Adequate Intake (AI) of Chloride as follows: 0 to 6months(0.18g), 7-12months(0.57g),1-3yrs(1.5g), 4-8yrs(1.9g), 9-13yrs (2.3-3.4 g) and 14-18yrs(2.3-3.6g) daily.

5.3.3 Nitrates in reconstituted fruit juices and commercial baby foods

The concentration of nitrates in reconstituted fruit juices are very low ranging from 0.0077mg/L in sample HLJ to 0.1027mg/L in sample HYYJ (Appendix E). The concentration of nitrates in commercial baby food sample falls within the range of 0.0210 mg/kg in samples HLC and NBC to 0.4200 mg/kg in sample NMC (Appendix F). This however is a little higher compared to the concentration in reconstituted fruit juice samples. The slight difference in concentration of nitrate in baby foods could be attributed to the fact that nitrates are found naturally in plants which are the main source for the production of these products (Xu*et al., 2012).*

Nitrates are usually distributed in foods at very low concentrations therefore are generally not harmful unless they are consumed in massive quantities. However, the dietary consumption of nitrates by infants and children through these products makes a substantial contribution to their dietary exposure. This is due to their smaller body weight and the fact

that they consume more of these foods compared to adults. Guideline values have been established by the World Health Organization in 2008 to protect young infants from methaemoglobin formation (a rare condition of nitrate toxicity). Drinking water guidelines are 50mg/L, however the guideline advises that water with a nitrate concentration of up to 100 mg/L can be used by adults and children over 3 months of age without risk of significant health effects (NHMRC,2004).

5.4 Correlation analysis

5.4.1 Correlation matrices of analyte concentrations in selected reconstituted fruit juices

Table 4.7 presents the correlation matrices of analyte concentration in the reconstituted fruit juices. The pH in reconstituted fruit juices samples analyzed is weakly correlated with all the parameters determined (Cl^-, F^-, NO_3, K, Ca, Mg, P, Fe and Zn). This indicates that there is no significant relationship between pH and concentration of the elements in reconstituted fruit juice samples. On the same note chloride is also weakly correlated with all parameters determined. However, fluoride is weakly correlated with all parameters except zinc. Fluoride is positively correlated with zinc (0.770^{**}) at 0.001(99%) confidence level, which indicates that the concentration of either fluoride or zinc in the fruit juice samples moves in the same direction as the concentration of zinc increases the concentration of fluoride also increases or as the concentration of fluoride decreases, the concentration of zinc also decreases. This further implies that Fluoride and Zinc could come from the same source. There is a positive correlation between nitrate and magnesium (0.744^{**}) at 0.001(99%) confidence level indicating that there is a significant relationship between the concentration of nitrates and magnesium. As the concentration of nitrates in the fruit juice samples increases, the concentration of magnesium also increases and as the

concentration of nitrates decreases, so does the concentration of magnesium. This also implies that nitrates and magnesium could be from the same source.

Potassium is positively correlated with Ca (0.605^{*}), Mg (0.474^{*}), P (0.548^{*}), Fe (0.580^{*}) all at 0.05 (95%) confidence levels. This indicates that there is a significant relationship between the concentration of Potassium with the concentrations of Ca, Mg, P and Fe in fruit juice samples. The increase or decrease in concentration of Potassium moves in the same direction with the concentration of these other elements and vice versa.

5.4.2 Correlation matrices of analyte concentrations in selected commercial baby foods

Table 4.8 shows the correlation matrices of analyte concentrations in selected baby foods. The pH values in selected baby foods are weakly correlated with the concentration of Cl^{-}, F^{-}, NO_3^{-}, K, Ca, Mg, P, Fe and Zn with the exception of nitrates. This implies that pH is positively correlated with the concentration of nitrates (0.502^{*}) at 0.05 (95%) confidence level; indicating a significant relationship between the level of pH and concentration of nitrates in baby foods. As pH increases the concentration of nitrates increases or as pH decreases, the concentration of nitrates decreases too. There is a negative correlation between chloride and phosphorus concentration. This implies that chloride has a significant negative relationship with phosphorus (-0.615^{*}) at 0.05(95%) confidence level. This also indicates that both ions could be from different sources (Appendix H).

It is shown (Table 4.8, Appendix H) that there is a weak correlation between F^{-}, NO_3, K, Ca, and other elements with the exception of Mg and Fe. There is a negative correlation between magnesium and Iron concentration (-0.675^{**}) at 0.001(99%) confidence level.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATION

6.1. Summary

In this research work, determination of fluoride, calcium, potassium, magnesium, iron, phosphorus and zinc concentrations were carried out in selected samples of commercial baby foods and reconstituted fruit juices in order to establish their quality using standard techniques. Also proximate analysis were carried out on selected 6 classes of commercial baby food samples.

The highest concentration of fluoride determined in reconstituted fruit juice and baby food samples were (0.0030 mg/L) and (0.0033 mg/kg) respectively. The highest concentration of potassium in reconstituted fruit juices and commercial baby foods were (450.04 mg/L) in sample CYNMJ and (4250.00 mg/kg) in sample FRC. The highest concentration of calcium determined in fruit juice and baby food samples were (442.50 mg/L) in sample CYNMJ and (5368.85 mg/kg) in sample FRC. The highest concentration of magnesium determined in fruit juice and baby food samples were (141.56 mg/L) in sample HYJ and (1150.73 mg/kg) in sample BPNWS respectively.

The mineral element with the highest concentration across all samples analyzed was phosphorus in commercial baby food samples with a concentration value of 9943.46 mg/kg, 9659.27 mg/kg and 8806.91 mg/kg in samples HLC, SP and CRC respectively.

Phosphorus in fruit juice was lower 795.46 mg/L (CYNMJ) than in baby food samples. Reconstituted fruit juice samples FAJ, CYNMJ had the highest concentration of Iron of 34.50 and 28.54mg/L respectively whereas the concentration of iron in baby foods were higher than that of fruit juice in samples PBC and FGC. Zinc was not detected in all reconstituted fruit juice samples except for sample RBCJ (0.86mg/L). The highest concentration of zinc in baby food samples were171.49 and 142.76mg/kg in samples BPC and BPNWS respectively.

The results of proximate analysis across the six classes of commercial baby foods showed that they generally had low moisture, ash, crude protein, crude fibre and crude fat/lipid content. The carbohydrate content of all the samples were high which suggest that they all good sources of carbohydrates but poor sources of protein for babies and children. Moisture content ranged from 1.39 to 3.19% in samples PBBF and MBBF which is a good asset for the shelf life of these products. Ash content ranged from1.04 (MSBF) to 3.15% (MBBF). Crude protein ranged from 5.25% (MCBBF) to 8.75% (MBBF, CFBBF). Crude fibre was 0.97% (MSBBF) to 4.73% (PBBF) and crude fat/lipid ranged from 3.40% (MBBF) to 5.90% (MCBBF). Carbohydrate content ranged from 81.51% to 86.65% in samples MBBF and WBBF respectively. The physicochemical parameters assayed results indicated that all fruit juices samples had higher concentration of acids. This high concentration is expected due to the presence of citric and ascorbic acids which are usually used as flavor enhancers and preservatives in these commercial fruit juices. Baby food samples were not acidic and also not basic since they were all close to being neutral which was also expected. The concentration of chlorides and nitrates were low in all sample analyzed.

Positive significant correlations were obtained between F^- and Zn (0.770^{**}), NO_3 and Mg (0.744^{**}) at 0.001 (99%) confidence level; between K and Ca(0.605^{*}), Mg(0.474^{*}), P(0.548^{*}), Fe(0.580^{*}) at 0.05(95%) confidence levels in the selected reconstituted fruit juice samples. No negative correlations were obtained. However, in selected commercial baby food samples, positive significant correlations were obtained between pH and NO_3 (0.502^{*}) at 0.05 (95%) confidence level whereas negative correlations were obtained between Cl^- and P (-0.615^{*}) at 0.05(95%) confidence level, and between the concentration of Mg and Fe (-0.675^{**}) at 0.001(99%) confidence level respectively.

6.2 Conclusion

Minerals are important components of foods, drinking water, fruit juices, baby foods and are of both direct and indirect health significance. They help in body growth and development. Sufficient evidence is now available to confirm that a certain minimum amount of minerals is desirable, since their deficiency and or excesses have many negative health effects (NIH 2008; IOM 2001/2004/2007)**.** The results showed that among all samples analyzed, baby foods samples had higher concentration of mineral elements compared to the reconstituted fruit juices.

In conclusion, the results from the evaluations carried out on selected baby foods and reconstituted fruit juices samples analyzed indicates that the essential minerals are present in adequate concentrations in all the commercial baby food samples whereas, the amounts in the reconstituted fruit juice samples were lower than what is required daily. However fluoride, and zinc were not detected in some samples. Based on the pH values of the fruit juices analyzed, they are to be given to children in moderation since consuming large

amounts of acid concentrated fruit juices daily can have a negative effect on dental development in children. However, the commercial baby food samplesall have low moisture content which is an asset as this prolongs the shelf life and also inhibits microbial activity on these products thereby preventing spoilage. They are also a good source of energy and other mineral elements but cannot be relied on as the sole source of complete nutrient intake needed daily by its consumers since they were all low in protein and fiber. These baby foods have to be paired with other protein of choice to get the full nutrient value expected. Furthermore, it should be noted that commercial baby foods produced from mixed cereals have higher concentrations of calcium, potassium and iron. Those produced from protein are rich sources of magnesium and phosphorus whereas maize based baby foods were high in zinc.

It is noted that the concentrations of these elements and nutrients are within safe limits recommended by WHO (2000) ; N I H (2008) and IOM (2001/2004/2007) standards.

It can therefore be concluded that these products do not pose a health problem to its consumers. However supplementation of these baby food products, fruit juices withnatural foods and fruits would be required to increase the quantity of nutrients and minerals needed by growing babies and children; as the concentration of mineral elements in these fruit juices, proximate composition of commercial baby food products do not meet the complete daily required amount needed.

6.3 Recommendations

Reconstituted fruits juices and commercial baby foods are an important source of mineral elements in the diet of infants and young children therefore continuous monitoring of these products should be carried out to assess their nutritional quality.

There is need for improvement on the protein content of these foods or introduction of other sources of protein like soy milk powder which should be mixed with them during feeding.

Also the following are recommended for further studies.

-It is recommended that studies be carried out to determine the vitamin content of these commercial baby foods and fruit juices so as to have comprehensive information about their nutritive values.

-It has also been reported in literature that these foods contained traces of heavy metals and contaminants such as pesticides acquired during processing. It is therefore recommended that studies to ascertain the level of heavy metals and pesticides in these food products be carried out.

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APPENDICES

Appendix A: (Table 4.1) Mean Proximate Analysis of Some Selected Baby Food Based on Source

Food Source	Moisture (%)	Ash (%)	Crude lipid (%)	Crude Protein (%)	Crude fibre (%)	Carbohydrate (%)
Maize based	3.19±0.46	3.15±1.20	3.40±1.03	8.75±1.02	4.52±0.28	81.51±2.06
Wheat based	2.42±0.19	1.08±0.54	4.60±2.06	5.25±2.01	3.04±0.54	86.65±2.04
Protein Based	1.39±0.47	1.70±0.65	4.50±0.43	12.00±3.03	4.73±0.41	80.41±3.06
Mixed cereal	1.45±0.82	1.80±0.19	5.90±1.03	5.25±0.76	2.80±1.05	85.60±2.19
Cereal based	1.55±0.12	2.40±0.54	3.80±0.38	8.75±0.21	2.64±1.03	83.50±0.5
Modified starch based	3.05±0.65	1.04±0.72	4.40±2.10	5.25±0.82	0.97±0.64	86.26±2.43

Appendix B:(Table 4.2) Mean concentrations of mineral (mg/kg) across some selected commercial baby food groups based on source

S/no	Sample source	K(mg/kg)	Ca(mg/kg)	Mg(mg/kg)	P(mg/kg)	Fe(mg/kg)	Zn(mg/kg)
1	Maize based baby food	2098.93	2093.57	767.41	6439.47	257.44	97.32
2	Wheat based	687.25	3188.53	839.52	4422.38	240.18	35.15
3	Mixed cereal Based	3052.09	3191.17	478.66	6676.15	334.83	87.18
4	Cereal/fruit based	1847.34	1774.87	856.64	6250.14	114.58	67.43
5	Protein based	2379.81	2642.54	971.09	7528.51	147.32	62.05
6	Modified starch based	1532.05	1397.54	566.08	9943.35	129.46	0.00

Appendix C: (Table 4.3)Mean Concentrations and Standard Deviations of Mineral Elements in Reconstituted Fruit Juices

Product Code	K (mg/L)	Ca (mg/L)	Mg (mg/L)	P (mg/L)	Fe (mg/L)	Zn (mg/L)
RBCJ	27.33±8.34^{hi}	240.02±8.72^{f}	78.70±0.42^{e}	613.64±3.20^{c}	23.09±0.05^{c}	0.86±0.23^{a}
CPJ	27.33±2.55^{hi}	206.70±6.11^{h}	84.06±0.09^{d}	272.73±4.10^{g}	ND	ND
BBJ	84.20±41.53^{f}	266.70±4.62^{e}	109.99±0.20^{c}	272.73±1.94^{g}	14.00±0.08^{de}	ND
FAJ	160.33±10.05^{c}	293.30±1.16^{d}	85.52±0.44^{d}	750.03±1.05^{a}	28.54±0.03^{b}	ND
SAJ	35.67±16.84^{h}	333.33±5.03^{c}	86.27±0.16^{d}	363.64±0.47^{f}	ND	ND
CEJ	170.00±6.14^{c}	193.30±2.31^{i}	122.35±0.27^{ab}	363.64±1.38^{f}	23.09±0.05^{c}	ND
NTCJ	10.33±6.51^{k}	193.30±2.70^{i}	84.25±0.23^{d}	431.82±2.97^{e}	8.55±0.05^{e}	ND
DOJ	24.67±4.62^{i}	220.00±4.00^{g}	116.54±0.41^{b}	681.83±7.43^{b}	3.09±0.06^{f}	ND
SMJ	20.67±1.16^{i}	280.00±7.00^{e}	85.27±0.06^{d}	409.10±3.07^{e}	10.36±0.07^{e}	ND
HLJ	48.33±5.50^{g}	300.20±5.00^{d}	83.50±0.03^{d}	386.37±2.54^{f}	17.63±0.08^{d}	ND
HYJ	100.53±3.08^{e}	124.42±0.76^{j}	141.56±0.15^{a}	409.10±4.17^{e}	4.90±0.05^{f}	ND
FYYJ	210.19±1.86^{b}	297.50±0.22^{d}	128.91±0.28^{ab}	536.38±5.07^{d}	24.97±0.07^{c}	ND
NYJ	170.94±4.98^{c}	372.50±0.24^{b}	109.99±0.59^{c}	522.73±5.87^{d}	34.50±0.12^{a}	ND
VYJ	150.26±3.09^{d}	382.50±0.22^{b}	114.27±0.40^{b}	659.10±2.39^{b}	ND	ND
CYNMJ	450.04±2.65^{a}	442.50±0.19^{a}	114.27±0.72^{b}	795.46±5.08^{a}	28.54±0.01^{b}	ND

Values in same column with different letters as superscript are significantly different at $p<0.05$. Values are mean Values of n=3, ND means "

Not Detected"

Appendix D: (Table 4.4) Mean Concentrations and Standard Deviations of Mineral Elements in Commercial Baby Food

Product Code	K (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	P (mg/kg)	Fe (mg/kg)	Zn (mg/kg)
HLC	1532.05±32.79^{d}	1397.54±0.15^{g}	566.08±0.43^{f}	9943.35±32.65^{a}	129.46±0.85^{e}	ND
GMC	1387.53±3.20^{d}	3877.54±0.39^{c}	916.84±3.47^{b}	7954.63±24.08^{b}	93.75±4.61^{f}	24.39±1.04^{e}
FGC	795.29±13.98^{f}	3618.85±0.04^{c}	785.60±2.13^{d}	6543.16±16.98^{e}	449.11±4.08^{b}	20.80±0.64^{e}
NBC	1342.52±2.03`^{d}	4594.26±0.17^{b}	798.60±28.50^{d}	5681.88±6.07^{f}	281.25.5.19^{d}	85.37±2.04^{c}
PBC	1854.18±0.21^{d}	1013.49±2.90^{h}	111.95±0.05^{g}	7102.24±7.09^{d}	549.11±5.30^{a}	171.49±1.86^{a}
CRC	953.74±0.67^{e}	545.92±3.48^{i}	896.05±1.56^{c}	8806.91±32.75^{b}	138.39±2.54^{e}	63.85±2.09^{d}
BBC	579.25±3.28^{f}	2758.20±0.13^{d}	893.45±0.40^{c}	2301.60±32.38^{i}	31.25±5.32^{g}	49.50±0.61^{d}
GCC	1185.05±5.20^{e}	1381.15±0.12^{g}	815.49±0.19^{c}	5397.84±0.65^{f}	147.32±2.63^{e}	110.47±1.29^{b}
NTB	3403.23±4.35^{b}	3397.54±2.45^{c}	858.37±17.06^{c}	4545.66±12.75^{g}	58.04±4.65^{g}	27.97±3.06^{e}
GMCM	1042.35±14.93^{e}	2070.00±13.85^{e}	954.52±2.64^{b}	3693.22±14.69^{h}	58.32±5.06^{g}	117.65±6.18^{b}
BPNWS	3750.00±6.43^{b}	2094.26±2.36^{e}	1150.73±0.24^{a}	4829.60±10.98^{g}	209.82±6.10^{d}	142.76±3.98^{a}
SP	3127.06±0.56^{c}	1766.39±14.75^{f}	988.31±0.64^{b}	9659.27±9.16^{a}	120.54±1.54^{e}	10.04±1.05^{f}
NICWS	1254.65±0.54^{d}	2831.97±1.58^{d}	828.48±0.21^{c}	7670.53±41.54^{b}	165.18±5.43^{e}	71.02±5.10^{c}
NMC	4000.54±1.76^{a}	1140.54±12.20^{gh}	607.59±23.85^{e}	4829.63±15.96^{g}	352.69±4.07^{c}	142.76±0.73^{a}
FRC	4250.00±3.98^{a}	5368.85±0.39^{a}	845.37±14.77^{c}	6250.06±54.08^{e}	120.54±0.59^{e}	2.87±0.88^{g}

Values in same column with different letters as superscript are significantly different at $p<0.05$. Values are mean Values of n=3, ND means “Not Detected”

Appendix E:(Table 4.5) Mean Concentrations of Physicochemical Chemical Parameters in Reconstituted Fruit Juice.

Sample Code	pH	Cl^-(mg/L)	F^-(mg/L)	NO_3^-(mg/L)
RBCJ	2.9400±0.5300	106.5409±0.1062	0.0030±0.0003	0.0280±0.0003
CPJ	2.4500±0.0490	447.5460±0.3989	0.0022±0.0004	0.0111±0.0004
BBJ	3.2400±0.2010	437.1120±4.8766	0.0015±0.0001	0.0660±0.0030
FAJ	3.0000±0.3488	899.5050±0.6542	0.0004±0.0002	0.0217±0.0021
SAJ	3.6900±0.1109	249.5020±8.8640	0.0005±0.0002	0.0396±0.0046
CEJ	3.5400±0.4780	319.5007±3.7284	0.0003±0.0000	0.0468±0.0043
NTCJ	3.7500±0.4063	500.0030±7.1836	0.0014±0.0002	0.0215±0.0007
DOJ	2.9500±0.7409	274.5003±9.4726	ND	0.0324±0.0005
SMJ	5.2300±0.4722	212.0073±2.8437	0.0003±0.0000	0.0140±0.0054
HLJ	3.0500±0.0288	199.5221±1.0645	ND	0.0077±0.0008
HYJ	4.3400±0.2782	562.0087±0.6272	0.0005±0.0001	0.1020±0.0028
FYYJ	3.6800±0.0476	799.5456±6.0787	0.0003±0.0002	0.1027±0.0084
NYJ	3.7900±0.3876	100.3700±0.3865	0.0003±0.0000	0.0210±0.0059
VYJ	3.9300±0.4752	213.0087±3.8628	ND	0.0211±0.0010
CYNMJ	3.4300±0.6786	174.5000±0.5738	ND	0.0254±0.0034

Values are mean Values of n=3, ND means “Not Detected”

Appendix F: (Table 4.6) Mean Concentrations of Physicochemical Chemical Parameters in Commercial Baby Food.

Sample Code	pH	Cl^-(mg/kg)	F^-(mg/kg)	NO_3^-(mg/kg)
HLC	6.7500±0.8300	156.0200±3.0004	0.0013±0.0005	0.0210±0.0048
GMC	7.3300±1.3200	175.1060±2.1800	0.0010±0.0005	0.1750±0.0035
FGC	7.1000±0.5400	104.0300±1.0002	0.0033±0.0001	0.1050±0.0053
NBC	7.3000±0.7500	105.0544±0.9533	0.0023±0.0002	0.0210±0.0060
PBC	6.9900±0.0000	225.0020±0.3902	ND	0.0420±0.0011
CRC	7.1300±0.0200	107.0005±3.0884	0.0026±0.0004	0.3150±0.0004
BBC	6.9900±0.0400	500.0006±5.0773	0.0004±0.0002	0.1750±0.0050
GCC	6.9800±0.0700	400.0000±5.0272	0.0005±0.0001	0.1750±0.0070
NTB	6.6200±0.2100	523.0002±0.5788	0.0016±0.0007	0.1500±0.0370
GMC	7.3200±0.4300	231.1222±0.2008	0.0019±0.0003	0.2800±0.0002
BPNWS	7.1900±0.0500	452.0744±1.0211	0.0004±0.0002	0.1750±0.0005
SP	6.8700±0.8100	257.9111±0.4711	ND	0.0700±0.0008
NICWS	7.0100±0.0400	250.0472±4.0330	ND	0.1750±0.0005
NMC	7.4000±0.6200	300.0472±0.6887	0.0010±0.0003	0.4200±0.0020
FRC	7.1300±0.0100	400.2201±4.0222	0.0030±0.0002	0.2100±0.0050

Values are mean Values of n=3, ND means “Not Detected”

Appendix G: (Table 4.7) Correlation Matrices of Analytes in Reconstituted Fruit Juice

	pH	Cl^-	F^-	NO_3^-	K	Ca	Mg	P	Fe	Zn
pH	1									
Cl^-	-0.108	1								
F^-	-0.401	-0.401	1							
NO_3^-	0.214	0.214	-0.073	1						
K	0.017	0.017	-0.425	0.163	1					
Ca	0.049	-0.336	-0.398	-0.336	0.605*	1				
Mg	0.249	0.181	-0.458	0.744**	0.474*	-0.086	1			
P	-0.101	0.017	-0.299	-0.160	0.548*	0.488	0.116	1		
Fe	-0.093	0.064	-0.092	0.015	0.580*	0.358	0.069	0.380	1	
Zn	-0.244	-0.298	0.770**	-0.086	-0.205	-0.120	-0.335	0.190	0.195	1

** means significant at 0.001 level (2-tailed) and * means significant at 0.05 level (2-tailed)

Appendix H: (Table 4.8) Correlation Matrices of Analytes in Commercial Baby Food

	pH	Cl^-	F^-	NO_3^-	K	Ca	Mg	P	Fe	Zn
pH	1									
Cl^-	-0.242	1								
F^-	0.337	-0.349	1							
NO_3^-	0.502*	0.185	0.136	1						
K	0.115	0.473	-0.055	0.225	1					
Ca	0.292	0.093	0.459	-0.240		1				
Mg	0.156	0.265	0.136	0.249	0.086	0.288	1			
P	-0.233	-0.615*	-0.019	-0.345	-0.045	-0.205	-0.196	1		
Fe	0.163	-0.393	0.043	-0.184	0.022	-0.154	-0.675**	0.108	1	
Zn	0.298	0.087	-0.375	0.287	0.046	-0.476	-0.308	-0.403	0.477	1

** means significant at 0.001 level (2-tailed) and * means significant at 0.05 level (2-tailed)

Appendix I:(Table 4.9) Recommended standard for proximate composition of commercial foods for infants and children by Standard Organization of Nigeria (SON)

Nutrient/100g	**SON(1988)**
Moisture (g)	5- 10 (max)
Protein(g)	14 -17 (min)
Fat(g)	10 (max)
Ash(g)	5 (max)
Crude fibre(g)	5 (max)
Carbohydrate(%)	60(min)
Energy(kcal/100g)	350 - 400

Appendix J: (Table 4.10)Required daily intake of fluoride, potassium and calcium as recommended by the Institute of Medicine (IOM, 2004/2007).

Age Group	Fluoride (mg/day)	Calcium (mg/day)	Potassium (mg/day)
0— 6months	0	200	400
7--- 12months	0	260	700
1--- 3yrs	0.25	700	3000
4--- 8yrs	0.25	1000	3800
9--- 13yrs	1.00	1300	4500
14 above	1.00	1300	4700

Appendix K: (Table 4.11) Required daily intake of Magnesium, Iron, Phosphorus and Zinc as recommended by the Institute of Medicine (IOM, 2001/2004/2007) and National Institutes of Health(NIH,2008).

Age group	Magnesium (mg/day)	Iron (mg/day)	Phosphorus (mg/day)	Zinc (mg/day)
0-6 months	30(AI)	-	100mg	2mg
7-12months	75(AI)	11mg	275mg	3mg
1-3 yrs	80mg	7mg	460mg	3mg
4-8yrs	130mg	10mg	500mg	4mg
9-13 yrs	240mg	8mg	1250mg	6mg
14 above	360- 410mg	15mg	1250mg	7-13mg