ASSESSING THE NEED FOR BABY FOOD PRODUCTION IN THE LEBANESE MARKET AND THE MANUFACTURING & TESTING OF A NEW PRODUCT

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Abstract

Providing infants and young children with food that is highly nutritious is essential for their growth and development. It is also crucial to maintain high quality, safe meals that contain a great variety of ready-to-eat options which are both convenient for the parents and the baby. The purpose of this study is to learn the current demand in the Lebanese market on ready-to-eat baby food by interviewing a sample of 150 mothers or mothers-to-be living in Lebanon on baby food patterns. In addition, seven locally made and organic baby food prototypes will be manufactured using different recipes while following all the food safety laws and regulations; followed by microbiological and laboratory testing of the end product. Prototypes will be either be blanched, non-blanched, sterilized, pasteurized at different times, blended or homogenized based on the recipe being followed. Several samples of each recipe were made in order to test for all the necessary requirements twice for accuracy. The results indicated that the samples were within the allowed limits of the microbiological parameters tested (total aerobic plate count, total coliforms, *Staphylococcus aureus*, anaeropic sulphite reducing bacteria and *Salmonella spp.)*. Also, once tested, the water activity of the samples ranged between 86 – 92.1%, indicating a high water activity; while the pH recorded pre-canning did not all satisfy the cut-off below 4.6. Lebanon does not have a local brand of baby food and relies on the imported international brands that have become too expensive in light of the economic crisis. Developing a ready-to-eat Lebanese baby food brand both helps use the local crops and ingredients, while providing a reliable stock of prepared meals for infants.

Background

It is essential to well provide infants or young children optimal nutrition throughout their meals starting at birth for their ideal growth and development process. During this development, life-long food preferences, eating habits and healthy intake traits are formed (Amezdroz et al., 2015). Providing the young child with improper nutrition will lead to undernourishment, stunting, wasting and micronutrient as well as nutrient deficiencies (Haileamlak et al., 2019). For the first four to six months of life, a baby should be on an exclusive diet composed of breast milk, or a suitable infant formula (Haileamlak et al., 2019; WHO, 2020). Afterwards, the weaning period begins, which is the gradual introduction of food ingredients and/ or drinks into the baby's diet (CDC, 2020). The texture of the food given to the infant at first is smooth, progressing safely after a few months to lumpy food and then finger food (Vail et al., 2015).

History of Baby Food

Baby food is meant to be used throughout the infant weaning period as well as during the gradual progression from the softest kind of food, all the way to the conventional food that toddlers can consume (Paroche et al., 2017).

Before the year 1920, babies were fed the same soft food that was given to the elderly or to anyone who had mastication problems and could not chew their food well. Understandably, health issues arose since babies had different needs as well as different vitamin and mineral goals to reach daily (Bentley, 2014). The idea of specialized food for babies came to life after a man's baby was sick, and he decided to make vegetable soup for his infant. The soup was such a success that word quickly spread around and he began commercial production of it. Other companies picked up the new trend, which lead to a new field of nutrition and safety being born (Bentley, 2015).

Recommended Daily Intake of the Nutrients of Concern

The CDC (2020) uses the term "infant" to define a person during their first year of life, while the term "toddler" is used for a person aged between 1 to 3 years of age. During infancy, each child is growing at a rapid speed, hence their nutrition consumption is crucial to ensure the ample, correct growth as well as ensuring proper organ development. Macro and micronutrient requirements fluctuate from month to month based on the infants' age, weight and development phase (Patel et al., 2020).

Figure 1: Recommended Daily Allowance (RDA) of macronutrients for infants and toddlers during the first 3 years of life. Some functions of each are also listed (Brown et al., 2011; Mahan et al., 2016; Riley et al., 2018; Patel et al., 2020).

Macronutrient	**Birth – 6 Months**	**6 – 12 Months**	**1 – 3 Years**	**Function**
Carbohydrates (% of total energy/day)	30 – 60	30 – 60	45 – 60	Enhances calcium absorption, prevent infection, provides energy
Fat (% of total energy/day)	30 – 40	30 – 40	30 – 40	Neurologic development, supply energy to the liver, brain and muscles
Protein (% of total energy/day)	5 – 20	5 – 20	10 – 30	Tissue replacement, deposition of lean body mass, growth

Figure 2: Recommended Daily Allowance (RDA) of some nutrients of concern for infants and toddlers during the first 3 years of life. Some functions of each are also listed (Brown et al., 2011; Mahan et al., 2016; Riley et al., 2018; Patel et al., 2020).

Micronutrient	**Birth – 6 Months**	**6 – 12 Months**	**1 – 3 Years**	**Function**
Vitamin A (mcg/d)	400	500	300	Strengthen bone growth, vision, reproduction, cell division, immunity, surface linings of the respiratory tract
Vitamin C (mg/d)	40	50	15	Required for the bio-synthesis of collagen (which is important for connective tissues and wound healing), L-Carnitine and certain neurotransmitters
Vitamin D (IU/d)	400	400	600	Needed for the absorption of calcium and its functioning in the body
Vitamin E (mg/d)	4	5	6	Anti-oxidant that protects cells from the damaging effect of free radicals
Vitamin K (mcg/d)	2.0	2.5	30	Involved in blood clotting and bone metabolism
Vitamin B12 (mcg/d)	0.4	0.5	0.9	Keeps body's nerve and blood

				cells healthy, helps make DNA
Calcium (mg/d)	200	260	700	Required for vascular contraction, muscle function, nerve transmission, hormonal secretion
Iron (mg/d)	0.27	11	7	Basic component of hemoglobin (RBC) and myoglobin (muscles) – part of many proteins & enzymes
Magnesium (mg/d)	30	75	80	Important for all organs, contributes to teeth & bone composition
Phosphorus (mg/d)	100	275	460	Builds strong teeth and helps filter out waste in your kidneys
Zinc (mg/d)	2	3	3	Supports immunity, needed for wound healing, maintains the sense of taste and smell, needed for DNA synthesis, supports normal growth
Potassium (g/d)	0.4	0.7	3.0	Important for heart health
Sodium (g/d)	0.12	0.37	1.0	Helps maintain the proper balance of water and minerals, conduct nerve impulses, contract/ relax muscles

Nutrition Composition & the Nutrition Facts Label

When the introduction of solid food begins, food is chosen carefully in order to fulfill the growing nutritional needs. This period is important for the child to become acquainted with different new flavors and textures while consuming food that is both nutritious and safe, after the infant has been following an exclusive milk-based diet for the first 4 to 6 months of life. Commercially produced complementary food is sold in many forms, one of which is “ready-made” infant food that is purchased most of the time in packaging that doesn’t require any further cooking steps before consumption (Maslin et al., 2017). The texture of the complementary food differs according to the age of the infant and their motor skills. They progress as such:

Figure 3: Progression of textures in the complementary food fed to babies between the ages of 6 – 9 months (USDA, 2019)

When discussing the types of commercial food found on the market, the WHO (2019), has presented several categories, such as biscuits/ wafer, ready-to-eat cereal/ porridge, dry cereal/ porridge, fruit/ vegetable puree, ready-to-drink juice/ smoothie/ tea/others, powdered drinks, chicken/meat/ fish based meal, milkshake powder, pureed dessert, soup and yogurt.

As for the composition of the introduced food, apart from being safe, the meals provided must contain a variety of different ingredients from all the food groups while limiting salt and sugar intake to a point where they are only naturally found in the food, not manually added (Koo et al., 2018).

By means of Codex Alimentarius standards, the usage methods of ingredients from each of the food groups are detailed to ensure the safety of the end-product. They include cereals, legumes and pulses, oil seed flours and oil seed protein products, animal source food, fats and oils, fruits and vegetables (Codex, 1991). The composition, nutrition and health claim as well as the ingredients and any additives are found on the outer packaging (Koo et al., 2018).

When considering the nutrition facts label, it is expected that the ingredient list of a baby food product will be short and contains only natural food items without any additives, preservatives or any artificial colors and flavors. This is what a parent will look for when purchasing ready-to-eat baby food, in addition to the product providing the suitable nutrients required at their infants' or toddlers stage of life. Additional ingredients that are declared acceptable include ones for fortification purposes, such as Vitamin C being added to fruits and fruit juices; in addition to iron and zinc which are added to cereals, bakery items and snack food. However, some of the undesirable additional ingredients include salt, sugar and fructose corn syrup (IFT, 2003).

According to the United States Department of Agriculture (USDA), there are no specific ingredients to avoid while purchasing baby food. In general, baby food has less to no additives and preservatives already, but parents should look out for the main added ingredients that should also be avoided in adult food. Many consumers find it easier to directly purchase organic food since they will be free of unwanted ingredients, such as pesticides, growth hormones and antibiotics. Ready-to-eat baby food is convenient and results in less food waste. It is still a developing field while manufacturers are still coming up with new ideas and strategies to make it healthy and safe while ensuring a variety of products and flavors (Buchanan, 2021).

As a whole, the nutrition labels found on the packages are similar to those of adult food; however, differ in the emphasis on the major food groups. Infant food labels highlight the presence of the good ingredients in the food, such as vitamins and minerals; while adult-oriented food labels highlight the presence of unhealthy or bad ingredients such as fat, saturated fat and cholesterol content. Serving sizes also increase with age and are adjusted in meals based on age (IFT, 2003; Gerber, 2021).

There are some factors that are required to be listed on the nutrition facts label in bold, and others that need to be pointed out somewhat as the product containing it or the product being free of it. Of the main concerns to be listed are the following:

1. Food Allergens

Previously, the dietary approach to allergy prevention was the complete avoidance within the maternal diet as well as during the early childhood period (Mahan et al., 2016), since the infants gut and immunity would still be considered as immature (Abrams et al., 2013). If the infants' or toddlers' parents both have food allergies, this puts the child at risk of developing a reaction towards one of the most common food allergens (Nutricia, 2020). They include, but are not limited to, cow's milk, eggs, wheat, soy, peanuts, tree nuts, fish and shellfish. They differ from country to country based on the ingredients consumed in their culture and it is crucial for parents to know them (Iweala et al., 2018). Therefore, it is important for commercial baby food manufacturing companies to include and highlight potential allergens on the ingredient list to help parents easily find and be more careful while purchasing the meals.

An infant at high risk of food allergies identifies as one with a first-degree relative with an atopic condition presented as an allergy or severe intolerance. However, this does not cancel the risk of having an allergic reaction among kids without allergies in their family tree. Guidelines have recommended that infants with non-IgE-mediated food allergies refrain from early introduction of allergenic food. However, since IgE-mediated food allergies are more prevalent and are not easily surpassed, the risk for developing an allergy from delayed introduction is more concerning than the notional advantage of deferring it (Canadian Pediatric Society, 2021).

The recommendations were to introduce each potential allergen alone over a period of 3 days, while monitoring the baby closely to catch any side effects emerging. If no negative signs or symptoms appear, introduction of that allergen along with other food is allowed (Lopez et al., 2020).

Allergists nowadays recommend the introduction of mixtures of different food at once, starting at 6 months of age and not before. In addition, pediatricians also no longer advise parents to wait for 3 days or longer between the introductions of different ingredients and see no benefit of waiting (Food Allergy Canada, 2019; Canadian Pediatric Society, 2021).

In a study conducted by Quake et. al (2022), gradual introduction of several types of allergens at the same time was done in powdered form and blended in baby food such as applesauce or puddings, and at 15 minute intervals for several days. The results indicated that a daily dose of multiple allergens, even in small amounts, may be effective against the prevention of allergies. This may be attributed to how allergen consumption increases polyclonal T-cell memory subsets, increasing Th1 receptor diversity, which forms a better barrier against potential allergens when compared with single-ingredient early food introduction.

2. Heavy Metals

Metals are naturally occurring elements that enter our food supply through pollution into the air, water and soil, as well as by leeching into food from the packaging material (AAP, 2021). It is favorable to be consuming some types of metals, such as iron and zinc; however, it is crucial to avoid consumption of food contaminated with other types of metals, such as lead, mercury, cadmium and inorganic arsenic (FDA, 2021). Combining an infants' low immunity and low body mass with any high exposure to these metals, puts them at a very high risk of life-long and lethal side effects (AAP, 2021).

They are neurotoxins for infants which can lead to irreversible damage to the brain, causing impairment in cognitive development, reduced IQ, learning disabilities and behavioral problems (Sadeghi et al., 2014; Hirsch, 2018).

In addition to being a known carcinogen, heavy metals may target the kidneys, liver, and all the major systems such as the immune, reproductive, developmental and central nervous system causing irreversible damage (European Commission, 2009; CDC, 2017; EPA, 2021).

Generally, several heavy metals are found in soils, sediments and ground water. For example, rice readily absorbs inorganic arsenic from the environment 10 times more than other grains do. Arsenic is highly toxic even when taken in low doses; however, it is sternly regulated in drinking water, but not in infant rice cereal which is highly available in the market (Houlihan, 2017). Beech-Nut Nutrition formerly announced the recall of one lot of its Stage 1: Single Grain Rice Cereal, due to an end-result obtained after routine sampling which found that samples from that batch had a naturally occurring inorganic arsenic level above the limit set by the FDA. This occurred even after the rice flour used was tested and confirmed as safe (FDA, 2021).

In Lebanon, Libnor (2008) has standards written up to test for some heavy metals in foods, including arsenic, mercury, lead and cadmium using different methods like atomic absorption spectrometry and electrothermal atomization. The reference values are found in the table below:

Figure 4: Reference values for certain heavy metals (Tahtouh, 2020; FDA, 2020)

Heavy Metal	Reference Value
Arsenic	0.5 – 3 μg/ kg bw/ day
Aluminum	1 mg/ kg bw
Mercury	4 μg/ kg bw
Cadmium	25 μg/ kg bw
Nickel	2.8 μg Ni/ kg bw

Chromium	0.3 mg/ kg bw/ day
Lead	3 μg/ day

3. Chemical additives and contaminants

Chemical additives used in plant and animal farming are classified as pesticides, antibiotics and hormones. They are known as growth promoters and are used legally and illegally in food producing animals to help boost production and reduce feed amounts used while maintaining an ongoing food supply. Normally, the least amounts possible should be used in order to ensure the safety of the product before human consumption; however, the huge demand may coerce farmers to add larger amounts for a faster production and therefore a faster yield and revenue. Generally, the more you consume food items that contain residues of any of the three chemical additives, the higher the risk of negative side effects on the organs, reproductive and immune system will be (Jeong et al., 2010; Deakin University, 2020).

Upon their usage on food producing animals, hormonal, anti-biotic and pesticide residues are left either in their meat or in the by-products derived from those animals. Side effects upon human consumption may include breast enlargement, ovarian cysts, breeding of anti-biotic resistant strains of bacteria and can generally be lethal to humans in the same way they are lethal to agricultural pests (Barreiro *et al.*, 2015; WHO, 2016; Deakin University, 2020; Sosan *et al.*, 2020).

4. Toxins

Some plants and animals may produce substances that are harmful or poisonous to humans when absorbed, inhaled or ingested, these are known as toxins. Mycotoxins are naturally occurring toxins derived from molds and fungus that are poisonous for both infants and adults, since their accumulation in the bodily organs causes several types of cancers, growth retardation and neural tube defects in a developing fetus (Haesaert, 2015). According to the Food and Agricultural Organization of the United Nations (FAO), at least 25% of the world's food harvests are considerably contaminated with mycotoxins (Park et al., 1999; Chilaka et al., 2020).

Aflatoxins are toxins derived from molds that have been classified as a major carcinogen which affects an infants' growth and may lead to the development of Kwashiorkor. It is most prevalent in cereals and grains such as rice, which is one of the main foods first introduced to an infant during the weaning period (Haesaert, 2015; Chilaka *et al.*, 2020). Even though the processing of food can decrease the toxin amount, they can still survive and be found in the final product (Chilaka *et al.*, 2020).

The FDA (2021) reviews all cases one-by-one in order to pinpoint whether any product violates laws, standards or regulations in order to take any necessary action of halting the import/ export/ purchase/ recall cycle. Since most toxic elements are naturally occurring and cannot always be avoided, their goal remains to reduce the exposure to toxic products as much as possible and to continue updating and expanding this area for the baby-food producing companies.

In 2009, Heinz company recalled a batch of "Mixed Baby Cereal – Stage 2" products due to the possibility of them being contaminated by Ochratoxin A. This type of mycotoxin is produced by fungi that grow on certain crops such as grains, and it has been classified as a potential carcinogen (Harrington, 2009).

Food Safety Requirements and Certifications

Besides producing nutritious food, the second goal of commercial baby food is to provide meals that are safe and ensure good quality constituents while following all the necessary food safety steps and objectives. There are many different techniques to be followed to produce safe, shelf-stable food, as well as many different food safety systems to help set the standards by which the manufacturer must execute the production based on. These consist of, but are not limited to the following:

i. Good Manufacturing Practice (GMP)

In terms of complementary feeding products for infants, effective execution of the good manufacturing practices (GMPs) is crucial in producing food items that are safe, provide complete nutritional adequacy while maintaining consistent quality. Following the proper steps is critical for all foreign or local manufacturers since importers are also responsible to guarantee that the products they are importing are risk-free and have undergone the same procedures required to ensure the safety of the same food items followed in their country.

Whenever batches are produced, samples should be chosen according to a sampling plan and tested for chemical, microbiological and physical hazards. In the case of non-conformity, the manufacturer is responsible to conduct a report in order to identify the source of error, as well as initiate a preventive or corrective action to avoid the recurrence of the non-conformity (Canadian Government, 2006).

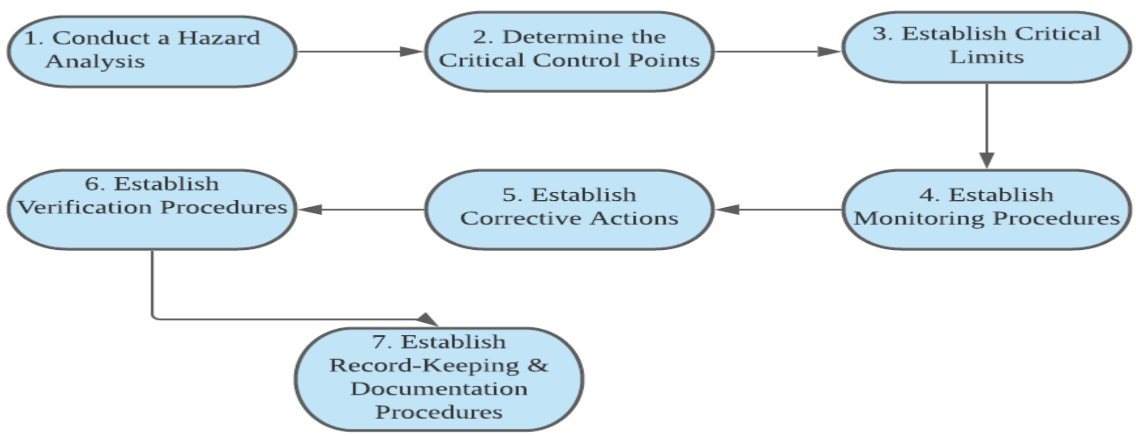
GMPs are a combination of manufacturing and managerial regulations that cover issues such as those of personal hygiene as well as the sanitation of the facility, the flow of design and construction of a food establishment along with the maintenance of equipment, and lastly, the workflow process and production when manufacturing food. Adapting these regulations helps the company excel by reducing the possibility of contamination or manufacturing errors; however, failure to implement them could result in food recalls, food bans, fines and ultimately placing the consumer at risk. The GMP policies are generally broad and unrestricted in order to permit the producer to mold them in a manner that fits the type of food the firm produces, to eventually reach the production of safe food (Ngadi, 2012; ISPE, 2021; FDA, 2020).

ii. Hazard Analysis Critical Control Point (HACCP)

HACCP is a management system that follows up with the safety of food from “farm to fork”, meaning from the very first step of raw material collection all the way to consumer consumption. The system is based on identifying, analyzing and controlling any biological, chemical or physical hazards at any stop in the production process and applying strict rules to prevent the hazards from occurring. To be able to begin working on the HACCP plan, an industry must have the pre-requisite programs as a solid base to evolve from – these often include the GMPs. They include having a linear product flow to ease the work and decrease any possible contamination between raw and cooked food, supplier control by only dealing with reputable suppliers that follow the same food safety guidelines, having an updated cleaning and sanitation program in place, training the employees on food safety and personal hygiene matters as well as a well-built pest control system.

The 7 principles to be followed are listed in the flow chart below, in order.

Figure 5: A flow chart showing the 7 steps of conducting a HACCP system (FAO, 1997; HACCP Alliance, 2016; FDA, 2017; Food Standards Agency UK, 2017).



1. Conduct a Hazard Analysis

The first step will help determine any biological, chemical or physical hazards that can be introduced or already present at any point during the production process that may potentially cause any injury or illness to the consumer. A general tip used to identify the hazards generally requires determining the likelihood of hazard occurrence with the severity of any adverse health effects that may occur if the hazard is found in the food.

2. Determine the Critical Control Points (CCPs)

A critical control point is determined for the hazards in order to prevent or eliminate them or to reduce them to a safe and acceptable level. This is often referred to as the “kill-step” since it is the last chance to prevent a hazard from causing an injury or illness.

3. Establish Critical Limits

The critical limit defines the maximum and minimum boundaries that a hazard must remain within to ensure the safety of the food product without causing any illness. This measure is applied to each found CCP in order to prevent.

4. Establish Monitoring Procedures

Monitoring is based on documenting any measurements or remarks to determine whether a CCP is under control and whether the critical limits are being met or non-conformity may occur.

5. Establish Corrective Actions

When deviations occur, there are corrective actions to be done to ensure that dangerous food does not reach the consumer, and that the same deviation doesn’t continue to occur regularly. It is crucial for future production to investigate how the nonconformity occurred and what made it happen, as well as determining how to correct it.

6. Establish Verification Procedures

Verification procedures are important to determine whether the HACCP plan is operating according to the proper regulations and steps. They are completed at the beginning of the

HACCP plan in addition to throughout the implementation of the plan and not just at the end; this is to correct any mistakes along the way to prevent reaching a disaster end product.

7. Establish Record-Keeping and Documentation Procedures

Record-keeping and documentation procedures must be put in action for when the need to review or trace back a food item is needed. The documents required to keep contain a summary of the hazard analysis including their control measures and critical limits, the projected HACCP plan with the division of responsibilities among the team, all the filled records required for the verification procedures and any records kept throughout the plan implementation (FAO, 1997; HACCP Alliance, 2016; FDA, 2017; Food Standards Agency UK, 2017).

iii. ISO 22000

The ISO 22000 is a food safety management system that was developed by the International Organization for Standardization in order to have standards that can be implemented and applied worldwide. Food establishments normally take on its implementation in order to provide safe food, products or services with a consistent formula. The standards also help them face upcoming issues with a preventive approach by having a plan in motion for any potential hazards including how to prevent and eliminate them using risk-based thinking.

The conditions listed in the ISO 22000 include the HACCP plan, prerequisite programs, operation prerequisite programs and a traceability system all to prevent the entrance of hazards throughout the production resulting in severe losses. Traceability is applied to be able to follow-up through the production stages with an item in question even after it is produced, packaged and possibly delivered to the consumer. It is also important to make sure that the product is delivered safely to its desired destination after dispatch from the main company (ISO, 2018).

For example, Gerber is one of the international leading baby food brands which aims to improve the quality of an infants' life while providing carefully manufactured meals that meet their needs and help them to grow healthily. They have developed a system where they can trace back their fruit and vegetable crops to the fields in which they were grown, and they continue to use the same reputable supplier that provides the highest quality crops that ensure safety. This is crucial since non-reputable suppliers may provide produce that is contaminated with environmental contaminants, pollutants or heavy metals (Gerber, 2021; IFT, 2003).

Food Safety Regulations and Standards

Baby food is vital for infant growth and cognitive development and should be prepared in a safe environment with safe and varied ingredients to certify that they are reaching the proper nutrition without putting them at any risk of illness. It is important for baby food production companies to ensure that testing is done routinely for any potential chemical or microbiological hazards as well as having minimal food recall incidents. In Lebanon, food production companies generally use a mixture of international standards and food safety programs (PRPs, GMPs, ISO 22000) and national standards (Libnor); however, Lebanon doesn't have a baby food production company.

i. Lebanese Regulation and Standards (LIBNOR)

As per the Lebanese Standards Institution (LIBNOR) and according to the standard NL 458:2001, titled "Canned Baby Food", complementary baby food is used during the weaning process as a stepping stone for infants to reach regular food. They normally consist of fruits, vegetables, meat, chicken and fish; either as single ingredients or mixed.

Canned baby food can be classified into completely mashed, partially mashed or powdered baby food. They should also conform to certain requirements depending on their contents, such as:

a. Always use clean, high quality ingredients that are suitable for an infant's digestion
b. Meals containing meat, chicken or fish should be free of bones, scales or skins
c. Table salt should not be used in fruit-based dessert; while sodium in other food items should not exceed 200 mg per 100 g serving
d. Vitamins and minerals are added based on the regulations listed by the country they will be sold in, and based on the advisory lists provided by the Codex Alimentarius Commission (CAC), while keeping the sodium levels derived from vitamins and minerals within limits
e. Ionizing radiation should not be used on the raw material or the final product

Thickening agents, emulsifiers, pH adjusting agents, antioxidants and flavors to be added are listed as allowed additives and have specific limits to be respected. The final product should also be free of any hormone or antibiotic residues, pharmacological drugs, and should contain as little pesticide residues as possible. The final product should be tested for the total aerobic plate count, the total number of coliforms, *Staphylococcus Aureus*, *Salmonella spp.*, and anaerobic sulphite reducing bacteria.

The product should be packed in suitable, tightly sealed containers that preserve its quality. It should also be stored away from heat and humidity sources as well as other pollutant sources. This ambient atmosphere should also continue throughout transportation where the product is protected from contamination or damage (Libnor, 2001).

ii. American and Canadian Regulations and Standards (CODEX Alimentarius)

The CODEX Alimentarius Commission; International Food Standards (CODEX) – which is reviewed by the Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO).

According to the Codex standard for canned baby food, under the name Codex Stan 73 – 1981 (or CXS_073), baby food is found as a strained product which attains the consistency that does not require further chewing, or a junior product that has a consistency that encourages infants and children to chew. They can further be classified into:

1. Ready-to-eat food which are normally processed by heat before or after being sealed in containers
2. Powdered food which only require adding water or suitable milk to be ready. The final consistency can be either strained or junior

Further preparation recommendations include:

a. Always use clean, high quality ingredients that are suitable for an infant's digestion
b. Meals containing meat, chicken or fish should be free of bones, scales or skins
c. Table salt should not be used in fruit-based dessert; while sodium in other food items should not exceed 200 mg per 100 g serving
d. Vitamins and minerals are added based on the regulations listed by the country they will be sold in, and based on the advisory lists provided by the Codex Alimentarius Commission (CAC), while keeping the sodium levels derived from vitamins and minerals within limits
e. Ionizing radiation should not be used on the raw material or the final product

Thickening agents, emulsifiers, pH adjusting agents, antioxidants and flavors to be added are listed as allowed additives and have specific limits to be respected. The final product should also be free of any hormone or antibiotic residues, pharmacological drugs, and should contain as little pesticide residues as possible. The final product should be tested for the total aerobic plate count, the total number of coliforms, *Staphylococcus Aureus*, *Salmonella spp.*, and anaerobic sulphite reducing bacteria.

The product should be packed in suitable, tightly sealed containers that preserve its quality. It should also be stored away from heat and humidity sources as well as other pollutant sources. This ambient atmosphere should also continue throughout transportation where the product is protected from contamination or damage (Codex, 2017).

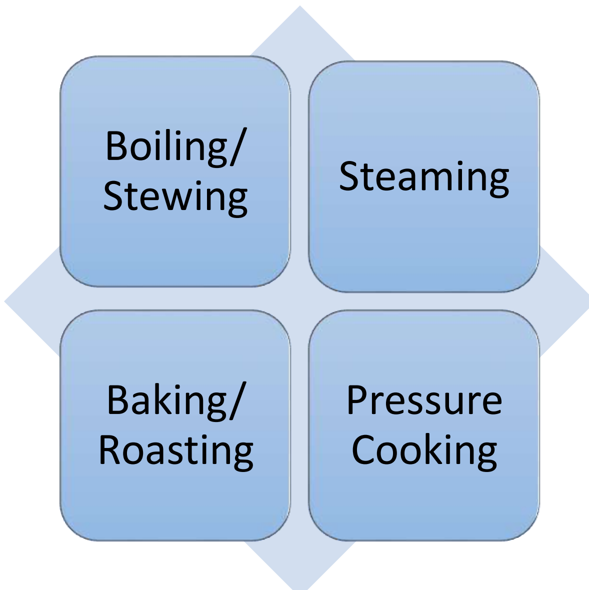
Cooking Methods and Their Effect on Nutritional Composition

When discussing cooking methods, several factors affect the type of cooking technique to be chosen as well as the heat treatment. In general, it depends on the type of food the manufacturer is dealing with, the desired end-product shelf-life, and the packaging material it will be put in.

To begin with, manufacturers must know that certain micronutrients are affected by the cooking method chosen. Vitamins and minerals are organic micronutrients that are provided through a healthy and varied diet. Whether we were discussing the fat-soluble (A, D, E, K) or the water-soluble (B, C) vitamins, they contain antioxidants, phytochemicals, in addition to playing a very important role against several cancers and chronic co-morbidities such as diabetes, cardiovascular disease and obesity. Even though they are needed in small amounts compared to the macronutrients, their insufficiency often leads to problems in growth, development, maintenance and deficiency syndromes (Lee *et al.*, 2017; Buratti *et al.*, 2020).

Fruits and vegetables are considered as the top source of vitamins and are internationally administered as one of the first foods to a baby. However, they are given cooked rather than raw to prevent choking hazards from occurring and to accommodate the babies developing motor skills. On the other hand, many studies have proven how heat treatments can affect the nutritional composition of fruits and vegetables after cooking (Lee *et al.*, 2017; Buratti *et al.*, 2020).

Figure 6: Some of the most used methods for cooking baby food (USDA, 2017)



Some vitamins are more prone to destruction during the cooking process, such as the water soluble ones since they leach into the water when immersed in it; while others are oppositely changed to have a higher concentration upon entry of water and expansion. However, the vitamins most affected are displayed in the following table as well as why they are altered (Lee *et al.*, 2017):

Figure 7: Selected vitamins along with their effect after heat treatment (Lee et al., 2017)

Vitamin C	Temperature sensitive and easily degraded during cooking at elevated temperatures for a long time. Steaming retains higher

	concentrations of it. Vitamin denaturation begins between 49 – 70 ºC (Kalfayan, 2015)
Vitamin E	Higher retention of this vitamin is present in cooked vegetables rather than raw ones, since heat treatment causes the release of more Vitamin E and destroys tocopherol oxidase. Vitamin denaturation begins between 210 – 278 ºC (ISERD, 2014)
Vitamin K	Heat causes this vitamin to be released from the chloroplast, resulting in a higher concentration in cooked vegetables rather than raw ones. Relatively it is heat stable.
Vitamin A	Heat treatment may destroy the vitamins precursors (carotenoids) while blanching allows it to be more retained.

A study done by Lee *et al.* (2017) analyzed the vitamin C content of 10 different vegetables – that were cleaned, washed, cut and cooked (for 5 to 20 minutes) – using the HPLC method. The vegetables included broccoli, chard, mallow, potato, sweet potato, carrots, spinach, zucchini, crown daisies and pellia leaf. The highest content of vitamin C between the raw vegetables was the broccoli, while the lowest observed was in carrots. After boiling, however, chard completely lost all its content, all the rest had decreased values except carrots which had increased. Following the blanching method, most of the vegetables retained nearly all the vitamin C they had prior to cooking, except that of zucchini which had slightly increased. Once steamed, the vitamin C in chard was once again undetectable, while most of the other vegetables had retained some of it except zucchini and broccoli which had slightly increased. After microwaving, all the vegetables had increased in vitamin C content. The results were all attributed to the fact that vitamin C is water soluble micronutrient that is temperature sensitive and easily degraded during cooking. The retention rates can be explained by the difference in vegetable cultivar and growing conditions. In conclusion, steaming and microwaving had showed the highest rates of retention, possibly due to the vegetables not being immersed in water, along with a relatively shorter cooking time while microwaving.

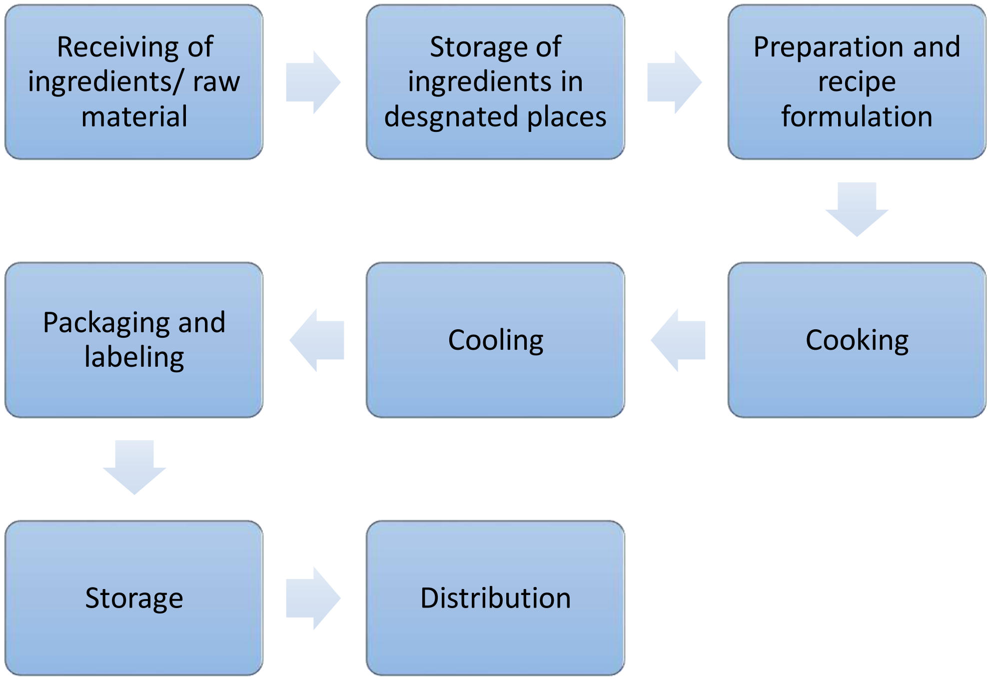
Another study done by Bureau *et al.* (2015) had been tested for vitamin C content of 13 different vegetables that had been blanched and frozen at -20 ºC. The cooking methods chosen were boiling, pressure cooking, steaming and microwaving while the vitamin C detection method was microcolorimetric one. The results observed showed that steaming and microwaving retain, and in some cases increase the vitamin C content, while boiling and pressure cooking greatly decreased the content by 51% and 21% respectively. The results were explained by variation based on shape and tissue structure.

A study done by Buratti *et al.* (2020) also tested for the vitamin C contect of cauliflower using the HPLC method. The cauliflower was washed, peeled and drained before trying the several cooking methods like boiling, steaming and microwaving. The results showed that as time increased while the food was on heat, the losses had greatly increased. However, the samples showed a high retention value for steaming and microwaving.

Food Safety throughout the Cooking Process

Food processing was developed as a solution to make food safe and transportable, while retaining its quality and nutritional composition throughout the storage process. In olden times, short-term solutions included cooking, curing and smoking of food; nowadays, pasteurization and other heat treatments have been introduced to reduce the spoilage and pathogenic microorganisms' presence in food. To ensure the safety of the product derived after the processing steps, all the stages followed must be considered, beginning from receiving the raw material and ingredients all the way to when the product reaches the consumers home (Knorr *et al.*, 2019).

Figure 8: The stages followed while manufacturing food (Ngadi, 2012)



i. Receiving

Dealing with certified, reputable suppliers eliminates any risk of contamination from pathogenic microorganisms or the formation of any harmful toxins at this step. Control measures receiving the products under suitable temperatures, storing them quickly in the appropriate storage along with visual inspection to check for any visible deformities or packaging problems.

ii. Storage

Along with storing each item in the appropriate temperature, storage must also take into consideration any risk of cross-contamination and keep any ready-to-eat items away from raw food items (especially of animal origin).

iii. Preparation

Activities such as thawing, mixing, cutting, slicing, chopping or blanching are introduced at this step, mostly in temperature controlled working conditions. Pre-planning the required amount of food, along with the ingredients needed can help minimize working in conditions that encourage microorganism growth.

iv. Cooking

This is considered the kill-step for any microorganisms that may have been introduced during the previous steps. Reaching specific temperatures within a particular time is the most effective method for reducing or eliminating any microorganisms.

Boiling/ Stewing: immersing the vegetables in water on high heat until it softens. However, the combination of heat and water raises the risk of nutrients leeching out of the vegetables and remaining in the water.

Steaming: Food is cooked through a steamer placed above a pan filled with water over high heat. A better method since there is no immersion of vegetables in the water.

Baking/ Roasting/ Broiling: Cooking food at high heat in the oven. It has little nutrient loss and makes the food easier to digest.

Sautéing: Cooking food with a small amount of oil over medium or high heat.

Pressure Cooking: Uses minimum water content so it retains most of the nutrients. However, it is more time consuming and requires equipment that may not be available in every household (USDA 2017).

v. Cooling

This step is done rapidly to control bacterial growth since improper cooling of potentially hazardous food may lead to a food borne illness. Cooked food held at improper temperatures for too long provides the desired milieu for the growth of spore-forming bacteria which release toxins that won't be destroyed upon reheating (FDA, 2013).

Production of Baby Food

i. Goals in the Market

Just like any adult food sold, baby food is also affected by similar factors in the market such as economic and demographic ones. In addition, other factors that may influence the baby food industry include methods of breast-feeding along with the time it goes on for, the increasing number of consumers available and the competition between the major companies in order to always provide the best, most nutritious, safest and updated formulas suitable for infants (IFT, 2003). In the Lebanese market, the most prevalent brands include Hipp, Bledina and Nestle: Cerelac.

The goals as well don't differ much from those of the adult food market in which they both work to satisfy and meet consumer needs while also providing the product at a feasible price and still producing revenue. However, the major difference is crucial to ensure continuance since one mistake may cost the company their reputation – this difference is the safety of the product and its purity. The safety referred to entails both microbiological safety and the suitability of the meal based on age and motor-skill development of the infant or toddler. In general, most infant food has proven to be shelf-stable when stored under the right conditions and attain a variety of choices that is further developing and expanding. Once opened, the jar can be re-closed and stored in the fridge at 1 – 5º C for 2 to 3 days remaining fresh and ready for consumption at a later time (IFT, 2003; AAP, 2021).

The line of baby food covers several types such as juices, shakes, instant cereal to which formula or breast milk is added to complete, bakery or snack items and pureed food. Purees are normally either made up of a single food item or a variety of combinations to form a breakfast, main meal or a dessert (IFT, 2003). For this study, we will be covering the production methods of pureed food.

The first step in infant food production is to understand the market and its needs. In addition to that, the food developer must understand the rules and policies related to the product they will be preparing and why it was put there. Product safety is the number one concern among mothers all over the world when choosing food for their baby; this is why the manufacturer must emphasize the safety of the product in terms of quality, microbiology and purity. A pure baby food product is one that is free of additives, preservatives, and only contains ingredients to increase the healthiness and suitability of it. Policies and regulations are placed when choosing raw ingredients for production, the manufacturer must abide by the strict specifications in order to ensure the same standards with each batch (IFT, 2003).

ii. Produce Used

An issue that manufacturers face is that of seasonal fruits and vegetables. Luckily, some of these produce can be stored in controlled environments out of their season, while some can withstand freezing to extend shelf-life and validity. Furthermore, manufacturers can also work with suppliers from different geographical regions that can continue providing the produce all year long. However, some other types of produce should still only be cultivated during their season and require exclusive preparation and processing steps (IFT, 2003).

For frozen food to retain the nutrients they contain, they must be picked once they have ripened and should be frozen as soon as possible after being picked since this is when the vitamin and mineral content is concentrated at its peak. Freezing will then also help to retain vitamins and minerals since the produce is still holding its shape and ripeness as oppose to non-frozen produce which begins to lose its nutrients as it continues ripening when unused. The loss of nutrients that occurs after harvesting and freezing is minimal and does not differ much in comparison with using fresh produce (Ellis, 2020).

According to the USDA, you can freeze almost any food as long as you freeze it early on. The only disadvantage is that lengthier freezing times (exceeding 12 months) may result in lower quality produce with a dull color; even though its safety remains unaffected since freezing prevents and inactivates the growth of microorganisms. Throughout the freezing process, the nutrients are also unaffected (USDA, 2013).

To further ensure the quality post-freezing, the manufacturer must handle the produce well before freezing. Fruits and vegetables must be washed thoroughly, drained and then cut into the desired shape required for usage. Even though freezing inactivates the enzymes responsible for changing the quality, color and flavor of the produce, they are re-activated after thawing; this is why blanching is vital to ensure high-quality products.

This can be done by placing the produce in boiling water or exposing them to steam for three minutes and then left to cool for a few minutes in an ice bath before packaging and freezing. The packaging must be in tight freezer bags or containers that have been vacuumed to eliminate the entry of air (OSU, 2015).

iii. Methods Undertaken

Previously, fruit purees were produced by first cooking the fruits for a long time in order to become soft enough to be squeezed through a mesh screen, where seeds, skins and stems couldn't go through. This process however, proved to be ineffective and non-nutritious since it reduced the vitamin and mineral content of the produce while also degrading its flavor and dulling its color.

This is when international baby food production companies started to apply different processes that ensure a better quality of the product while keeping the nutrient content at least 95% intact by greatly decreasing the heat treatment time. This concept was based on blending the fruits and vegetables before cooking, and then heating the resulting puree in order to deactivate the oxidation-causing enzymes. Afterwards, the puree is further homogenized to eliminate any lumps before packaging (Alimentos, 2021).

The production of pureed food can be made from both fruits and vegetables in addition to other food groups. According to Alimentos (2021), fruit purees are made from uncooked fruits. They must first be carefully chosen to be of good quality and ripeness, then are washed, peeled and de-seeded either manually or using machinery. The equipment used normally crushes the fruit so that the juice is separated from the pulp which releases the seeds that are then removed by straining. Later on, the fruits are blanched in order to ensure that the more sensitive fruits do not undergo oxidation and change color. Following this, the fruits are then blended together to form a paste, which is further homogenized to reach the desired baby food consistency. Afterwards, the product is pasteurized by heating the product for a short period of time at very high temperatures in order to ensure killing any microorganisms. Once the pasteurization is complete, the product is left to cool down before packaging into aseptic containers. The resulting product is shelf-stable for 18 months as long as it is unopened, covered and stored in a cool dry place away from sunlight.

Once it is time for the packaging, there are 3 methods that are mostly used, and are displayed in the following table along with their advantages and disadvantages.

Figure 9: The definitions of the different processing techniques along with their advantages and disadvantages (IFT, 2009; Food Buddies, 2018; ABMA, 2020; Lematec, 2021, Gokhale et al., 2012).

	Definition	**Advantages**	**Disadvantages**
Aseptic	The final step of aseptic food processing where sterilized products are filled in sterilized containers under hygienic conditions to ensure the elimination of microorganisms	No refrigeration or freezing required Less energy usage due to quicker time Less nutrient losses	Increased production cost for manufacturer and consumer Increasing the recycling load

Retort	Thermal process which results in increased shelf life and good nutrient retention and sensory attributes. One of the most used techniques in the food industry.	Fewer nutrient losses due to rapid heat transfer and reduced processing time No requirements for refrigeration or freezing	Requires expensive specialized equipment
Hot-filling	Heating the product to 90 ºC to eliminate microorganisms. Then filling the product into containers and capping them, followed by inverting them in order to allow the caps to sterilize for around 13 minutes. Then they are cooled down	Increased shelf-life No requirements for refrigeration or freezing Less nutrient losses	Most-time consuming Expensive machinery and energy usage

Packaging Material & their Characteristics

i. General Information

The proper packaging of any food item is part of the requirements of a complete food safety plan. The packaging forms a barrier between the food and any incoming physical, chemical or biological hazards such as bacterial contamination. It also helps to extend the shelf-life of a food item and allows for an easier transportation process, which in turn can help in reducing food spoilage and waste (Claudio, 2012).

However, food handlers cannot be 100% rid of the minute substances that may migrate from the packaging material into the food, which will be consumed by the people. As per the Food and Drug Administration (FDA), these substances are referred to as "indirect food additives" or "food contact substances" (FDA, 2014).

Besides glass, some of the different types of packaging material are:

a. Paper: the most economic to produce, lightweight and allows for simple printing. They are recyclable; however, the printing ink can be stuck to the material which increases the exposure risk of consumers to endocrine disruptors such as phthalates, benzophenones and mineral oils
b. Steel or Aluminum: are malleable, impermeable and can be recycled
c. Plastic: highly moldable into any desired shape, lightweight, cheap, durable and are require an easy sealing procedure (Claudio, 2012)

ii. Glass Jars

Worldwide, the most commonly used material for packaging is glass, especially for baby food products as it preserves taste (Panighello *et al.*, 2020). Other types of packaging material normally pose a risk for different kinds of chemical exposure or migrating substances from the package into the food; however, glass is generally recognized as safe (GRAS) by the FDA as a package that holds food safely since it is chemically inert (Claudio, 2012).

Normally, hot food can directly be packaged in jars and closed with metal lids. As it cools, the metal lid flattens towards the inside since the cooling process creates a vacuum effect. This is an additional safety feature that reassures consumers that the packaging has not been tampered with and is of good safety standards (Canada Government, 2015).

Composition Food Safety: Contaminants

According to the Food and Drug Administration (2014), one of the populations at risk of developing any kind of food-borne illness is the infant population, specifically those less than one year of age. This is attributed to the fact that the immune system – the body's natural form of defense against foreign invaders – is still developing and cannot completely eliminate any microbiological enemy.

ii. Microbiological Safety

a. *Staphylococcus Aureus*

Staphylococcus aureus spp. is a type of bacteria commonly found harmlessly on the skin or in the nose (CDC, 2018), yet however, it can come in through cuts, sores or wounds which can lead to a Staph infection. The bacteria can also enter by touching contaminated surfaces, from person to person or from one area in the body to another via contaminated hands or fingernails. The infection in turn can lead to boils, blisters, pneumonia, sepsis in extreme cases and several types of skin infections (Rogue, 2019).

Another way that S. aureus spp. may enter the body is through a food infection, as it releases harmful toxins in contaminated food which can cause food poisoning in the host. Symptoms normally include vomiting, diarrhea and stomach pain starting 30 minutes to 8 hours after consumption. The infection normally lasts a day, but for an already susceptible infant, the dehydration caused from diarrhea and vomiting may require an extended hospital stay (Rogue, 2019).

A study done by Gutiérrez *et al.* (2012) tested for the presence of *S. Aureus* in 442 samples collected from food contact surfaces in dairy, meat and seafood industries. The samples were collected prepared and incubated before testing. Results showed that 27 of those samples tested positive for contamination (6.1%) indicating the presence of non-hygienic practices in 4 dairy industries, 6 meat industries and 17 seafood industries. Due to poor hygienic practices, the pathogenic contamination of food is increased while the elimination process from the food industry becomes very hard. This is due to its attachment to food contact surfaces and the formation of bio-films, which can survive cleaning and disinfection.

S. aureus bacteria die upon cooking at the right temperatures and if handled and prepared in the right manner; but its toxin survives, making food safety steps crucial to avoid contamination. Washing hands before handling food items, avoiding touching the face or skin and covering cuts and sores with bandages then gloves is the right way to prevent the transfer of the infection to the food (CDC, 2018).

b. *Clostridium Botulinum*

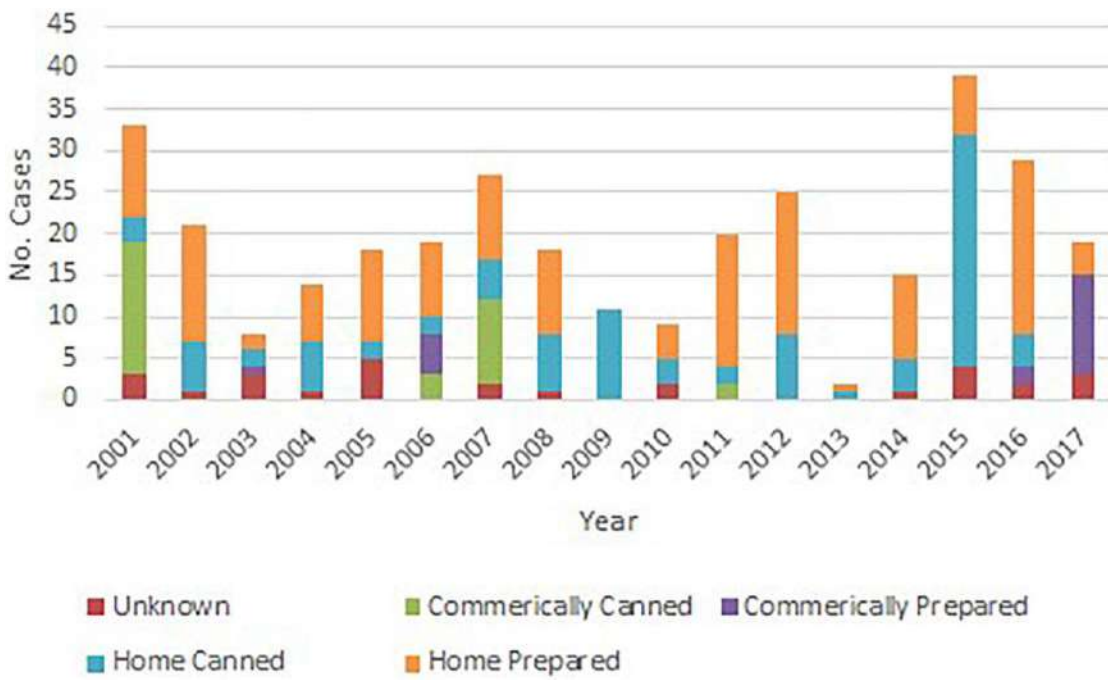
Although foodborne botulism is rare, it is a potentially fatal intoxication. It normally occurs after consumption of food contaminated with neurotoxins (the botulinum toxin), but never transmitted from person to person. *Clostridium botulinum* produces spores that cannot be killed upon heating, making them more dangerous since they can grow and produce toxins. However, infant botulism differs in that it occurs after consumption of the *C. botulinum* spores that germinate to release toxins in the infant's body after ingestion. This is due to the underdeveloped defense mechanisms in an infant's gut and normally wouldn't occur with an adult. There are several food sources in baby food that could be contaminated, but the spotlight remains on honey, since studies have shown that it was associated with several outbreak cases (Cronan, 2020). The WHO (2021) states that honey should not be introduced into the infants' diet until they are older than 12 months old. In a study done in Poland by Grenda *et al.* (2018), 240 honey samples were tested for *C. Botulinum* by incubating the samples under anaerobic conditions at 30 ºC for seven days. 136 samples (56%) showed strains that were confirmed as *C. Botulinum*, while 66 samples (27.5%) were confirmed to contain *C. Perfringens*. Some reasons for such a high level of contamination could be due to the honey extractor size, the apiarist wearing the same footwear outdoors and in the extraction room, contamination of the soil samples with *C. Botulinum*, in addition to the availability of hand-washing facilities in the extraction room or lack thereof.

Symptoms of foodborne botulism normally appear within 12 to 36 hours after consumption and can affect the nervous system and the respiratory system. Early symptoms include weakness, fatigue, dizziness and dry mouth which can lead to difficulty swallowing and speaking. More developed symptoms may include abdominal swelling and descending paralysis leading to respiratory failure. In most cases, if the proper treatment wasn't available rapidly, the intoxication is fatal.

The spores produced by *C. botulinum* are widely found in soil and sea water, and they can survive in a low oxygen atmosphere with certain storage temperatures and preservative factors such as those of home-canned or home-bottled food. However, a highly acidic environment coupled with low storage temperatures is toxic to the spores. The most high-risk home-canned food includes beets, carrots, green beans, zucchini, potatoes and spinach. The WHO (2018) states that to prevent foodborne botulism, the kill-steps to focus on are during heating and sterilization. The inactivation of the bacteria before it can produce spores is very important by heat treatment, however, the very high temperatures used in commercial canning can also kill the spores produced (Patrick, 2014).

A literature review done by Luquez *et al.* (2021) showed that in 16 years – between 2001 and 2017 – 326 lab cases of *C. Botulinum* were reported, averaging between 19 cases per year. After collecting food recalls from the patients and testing the necessary food items at the time, it was concluded that 47% (154 cases) were attributed to food prepared and cooked at home, 29% (94 cases) due to home-canned food, 10% (31 cases) due to commercially canned food, while 6% (20 cases) were related to commercially prepared food. The outbreaks over these years also had a fatality rate of 5% (17 cases) after being infected with *C. Botulinum.* Due to the danger and lethality of the microorganism, one case alone can pose a threat to public health and is considered an emergency where immediate action should be taken to remove the suspected food from the market to prevent an outbreak. The following graph further explains the division of the cases and how they were spread out across the 16 years.

Figure 10: A bar graph showing how the number of cases were spread between 2001 - 2017 according to the modes of contamination (Luquez et al., 2021)



The FDA (2017) issued an announcement about a food recall triggered by a potential *C. Botulinum* outbreak. A brand of ready-to-eat baby food pouches called “PC organics” was recalled due to a manufacturing error that resulted in the pouches containing excess water, which in an appropriate environment could support the growth of C. botulinum, posing a health risk to consumers. This could have lead to a dangerous outbreak among infants which could have resulted in either severe illness or death, in addition to destroying the companies’ reputation and losing the trust of their customers (Global News: Canada, 2017).

c. Aerobic Plate Count

The Aerobic Plate Count (APC) is used to test for the presence of bacterial populations on a sample; however, it does not differentiate between types of bacteria. The testing method hypothesizes that once the agar used to test a food product contains the suitable nutrients under appropriate mesophilic temperatures (25 to 40°C), each cell will form a visible colony, indicating the presence of a bacteria.

Normally, large numbers of bacterial colonies indicate poor safety of food; however, fermented products have a desirable high APC count. On the contrary, a low APC does not mean the product is free of pathogens or toxins, which is why other tests are still applied. The test is done to assess the adherence to good manufacturing practices (GMP) during production, organoleptic adequacy and to obtain information regarding the shelf-life stability of the product (Murray-Brown, 2021; FDA, 2021).

d. Coliforms

Coliforms are a group of strongly connected, mostly harmless microorganisms that are naturally found in soil and water; however, are also found in the digestive tract of animals. The resulting coliform count in food does not generally point to the presence of a pathogen but rather is an indicator of unsanitary working conditions during preparation or unsafe practices after food production. Normally, a high count signifies working in a manner that allows cross-contamination during food handling and questions in turn the quality of the final product obtained. They are also easy to detect and can be helpful in testing the safety of water (Hong Kong Government, 2017; FDA, 2020).

e. Anaerobic Sulphite Reducing Bacteria (Clostridia)

Many of the bacteria found in raw milk, fresh water sediments or soil can be deactivated by pasteurization – which is a heat treatment that can kill pathogenic microorganisms by exposing them to high heat for a short period of time. However, spore-forming bacteria are left unaffected and pose a threat to the safety of the food by remaining present after pasteurization. The majorities of these bacteria are anaerobic and belong to the *Clostridium* species, which is how they became to be known as Clostridia and anaerobic sulphite reducing spore-formers. Of the most prevalent members is *Clostridium Perfringens*, and it has been isolated from infant food including powdered infant formula. In the food industry, it has become routine to test for the presence of anaerobic spore-forming bacteria using oxidation and reduction reactions (Muyzer *et al.*, 2008; Doyle *et al.*, 2018).

Lebanon doesn't have a baby food brand that parents can rely on and trust to use for feeding their baby. This is attributed to the fact that the nation is used to importing most of its good; however, under the circumstances Lebanon is currently living in, several local brand are emerging to cover all the essential needs among consumers. The production of local baby food can help the economy since the product will develop a competitive edge worldwide as there are no current Lebanese stews sold commercially anywhere. The purpose of this study is to assess the need of establishing baby food production companies in Lebanon by conducting interviews with pregnant women and mothers who can share their specific needs, concerns and previous experiences with ready-to-eat baby food. This study will be also be routed towards evaluating the impact of different processing techniques on microorganisms and shelf-life stability of several produced prototypes that will be made using different ingredients. Lastly, there is a lack of vitamin C content calculation in the research available based on the changes that may have occurred post production; this study will include laboratory testing to check vitamin C content, sugar quantity, moisture assessment and pH.

Materials and Methods

1. Data Collection and Interview Section

    a. Patient Selection and Recruitment

150 females were recruited, of which there were mothers and pregnant women. They were chosen randomly with no regards to their socio-economic status or any other factors. The participants were informed about the purpose of the study before their voluntary approval to join. The data collection took place in Lebanon; and due to the country being on lockdown at the time, some participants were called on the phone and asked the interview questions along with their experiences and concerns about baby food based on previous encounters and/ or knowledge; while others were interviewed face-to-face. Mothers whose youngest child was above 4 years old were excluded since the target was infants and toddlers, and to avoid memory recall bias.

    b. Interviews

After the consent of the participating women and appropriate supervisors was taken, the data collection began with the 150 contributors. It took place throughout several months across the year 2021. It consisted of 18 questions concerning separate but related topics to grasp the struggles, concerns and challenges that women went through when initiating baby feeding as well as what they look for when purchasing commercial baby food. The questions covered some basics concerning the female participant such as her working condition, the baby's age in case the contributor was a mother, and the rest of the questions were dispersed between food safety related ones, food preparation and food initiation topics. They were also asked about the current ready-to-eat baby food jars available in the Lebanese market and whether they have or would try them, what they would try and whether it was recommended. At the end of the questionnaire, the women were asked whether they would consider Lebanese made organic baby food that included meals like the famous Lebanese stews.

c. Data and Statistical Analysis

The different variables and data were put into SPSS 26.0 version for Windows (SPSS Inc., Chicago, IL, USA). All variables will be analyzed as scale, and the descriptive analyses based on frequencies and percentages. Bar graphs and pie charts will be constructed to show the different percentages for each individual question in order to compare the results better and more efficiently. Correlations were also calculated in order to make inferences based on the mothers' answers and how this helps manufacturers understand the current market needs and demands. The results were analyzed based on the value obtained from the Pearson correlation and the correlation strength tables where the alpha followed was 0.05. A correlation value of less than 1 was a negative one, while a value of greater than 1 was a positive value; and lastly, a correlation of 1 was null.

2. Sample Production and Microbiological Testing Section

To properly understand the feasibility and difficulty of preparing local, Lebanese made baby food meals that are nutritionally suitable and safe for babies, several prototypes must be made. The manufacturing experiment took place in the kitchen of the School of Agricultural Engineering for Mediterranean Countries (ESIAM), one of the branches of the Saint-Joseph University located in Taanayel, Beqaa – Lebanon. These ready-to-eat prototypes were prepared following all food safety rules and regulations of concern for a small business production space. The equipment, machines, surfaces and ingredients used were all cleaned and sterilized before production took place; the final product obtained in jars were also sterilized using different methods. Seven baby food samples were produced and varied between nutritious Lebanese stews or familiar fruit or vegetables mixtures with a twist. They are listed below:

- Frozen Fruit Mix: containing frozen apples, pears, bananas and lemon juice
- Fresh Fruit Mix: containing fresh apples, pears, bananas and lemon juice
- Hummus and Veggies: containing courgette, potatoes and chickpeas
- Lentil Soup: containing water, lentils, chard and lemon juice
- Homogenized Lentil Soup: containing water, lentils, chard and lemon juice
- Loubiye B Zeit: containing green beans, tomatoes and olive oil
- Fresh Vegetable Mix: containing carrots, courgette and green beans

a. Materials to be Used

i. Chemicals and Detergents

Dishwashing soap was used to clean all the utensils, surfaces, outer machinery parts, removable machinery parts and to scrub the outer skin of the produce before sanitizing them. The detergent used was “Fine” from the company “Spartan” which is a Lebanese established company in cooperation with the United States of America. The material safety data sheet (MSDS) is found online on Spartan's website.

Quaternary Ammonium (Quat) compounds were used as a disinfectant for all utensils, surfaces, outer machinery parts, removable machinery parts and to spray on the outer skin of the produce. The disinfection steps normally follows the washing and not the other way around, since cleaning with detergent normally gets rid of any dirt, dust, food crumbs, germs or other contaminants from surfaces and objects, while disinfection kills any remaining bacterial residues or germs (Medline Plus, 2020; CDC, 2021). To prepare the disinfectant, 25 mL of Quat solution was diluted in 1 L of water and had an efficacy of 40 ppm.

ii. Food Ingredients

The apples and pears used in the fresh fruit mixture were obtained from a company in Lebanon called "AgriFresh" which sells its produce already washed, sanitized, peeled, cut and ready-to-eat. The company is also ISO 22000:2005 certified and is considered a reputable supplier. The apples and pears used for the frozen fruit mix, bananas, lemons, green beans, tomatoes, carrots, courgette, potatoes and chard were all obtained from a local produce store. The apples, pears, lemons, tomatoes, green beans, carrots and courgette were washed with detergent and sanitized with Quat before cutting or peeling or squeezing in the case of the lemons. The bananas were only sprayed with Quat then peeled with cleaned and sanitized hands. The chickpeas and lentils used were purchased from a Lebanese based company called "Hboubna" which holds the First Quality Worldwide certification as detailed on their website. The olive oil was purchased from the Lebanese brand “Boulos” which is also ISO 22000:2005 certified. The water used was potable bottled mineral drinking water obtained from an ISO 22000:2005 certified company to ensure no microorganisms enter through a water source.

iii. Utensils, Pots and Machines Used

For the prototype production, food-grade kitchen utensils and objects were used such as spoons, forks, knives, spatulas, peelers, cutting boards, pots, pans, buckets, lemon squeezer and certain small and large machinery. All the equipment used was washed before starting with the production process, left to air dry or dried using a clean new kitchen cloth; then were all spray with the Quat sanitizer prepared. They were also washed and sanitized between uses or before moving from one task to another.

The jars used to fill the produced baby food in were all washed, and then placed in pots of boiling water to sterilize them before filling them. They were then left to air dry on a sanitized cooling rack, away from the cooking area.

b. Methods Followed

To produce the frozen fruit mix baby food, 2 methods were followed for either making blanched batches, or non-blanched ones. This was done in order to observe the changes between both jars in terms of appearance, taste, quality, consistency and microbiological testing. The frozen fruit mix ingredients were frozen directly after blanching.

i. Non-Blanched Method

The fruit mixture used was apples, pears and bananas mixed with 5% of their total weight in lemon juice to eliminate enzymatic browning and to reduce the pH. Enzymatic browning is an undesirable chemical reaction that occurs in fruits and vegetables once they are exposed to oxygen. This is due to the presence of polyphenol oxidase (PPO) enzyme in fruits and vegetables that is normally hidden, but becomes exposed to oxygen upon tissue damage such as peeling, cutting or slicing. The fruits gradually begin turning brown as time passes due to the PPO getting oxidized into quinones that form the brown pigment called melanin. This generally affects the quality of the fruit in a negative way and is most common in a number of fruits including pears, apples, bananas, mangos and avocados. One of the factors that affect the activity of the PPO enzyme is adding ascorbic acid to reduce the pH of the food in order to subsequently reduce the enzymes activity; thus, reducing enzymatic browning (Washburn et al., 2017; Moon et al., 2020).

pH is the measure of how acidic (<7 pH) or basic (>7 pH) a solution is. It is the measurement of the acidity or alkalinity of a solution. It is vital to have an acidic milieu in canning, or jarring to ensure that certain microorganisms will not be able to survive or grow, such as Clostridium Botulinum (Garden-Robinson et al., 2018). The FDA states that a food or mixture must attain a pH of 4.6 or lower in order to be considered safe for canning or jarring without the use of pressure processing (FDA, 2020).

As previously mentioned the apples and pears were already washed, sanitized, peeled, cut and were ready to use. The bananas were cut and added to the mixture, then were blended for 3 minutes. Once the blending was done, the lemon juice was added and stirred and an observed lighter color change was seen. The puree was then transferred to the homogenizer for 7 minutes in order to remove any remaining lumps. Afterwards, the pH was checked to ensure that it was less than 4.6, indicating a safe environment that did not encourage microorganism growth – the obtained value was a pH of 3.8.

Once the consistency required was reached, the contents were emptied into the sterilized jars one by one and closed tightly with the lid immediately after filling. The closed jars were then placed in a presto pot of boiling water to further sterilize for 15 minutes at 87 – 90 ºC.

ii. Blanched Method

The fruit mixture chosen was also apples, pears and bananas mixed with 5% of their total weight in lemon juice to eliminate enzymatic browning and to reduce the pH. The blanching took place as hot water blanching, by immersing the same amount of fruits at a time in boiling water for a total of 3 minutes while measuring that the temperature of the pot to reach 87 – 90 ºC per batch. The fruits were then removed using a perforated spoon and placed in a sieve until all the fruits were done blanching. They were then transferred to the blender for 3 minutes, followed by adding the lemon juice. The mixture was then moved into the homogenizer where all the lumps were removed after homogenizing for 7 minutes, then immediately filled in the jars and tightly closed with the lids. The jars then had to undergo further heat treatment, but several methods were tried to conclude which would be the most effective after testing. The methods are displayed in Figure 10.

Figure 11: The time and temperature reached for each batch sample of blanched baby food fruit jars undergoing heat treatment as pasteurization or sterilization.

	Time (minutes)	Temperature Reached (ºC)
Pasteurization (Boiler Pot)	15	80
	20	85

	25	88
Sterilization (Presto Pot)	8	-
	10	-
	12	-

iii. Pasteurization

Briefly defined, pasteurization is the process of heating food items at a mild temperature (below 100 ºC) for a short period of time to prevent the growth of spoilage microorganisms. It was first used to pasteurize milk, but has expanded to becoming an effective preservation method in a huge variety of food products, of which are canned or jarred fruits and vegetables. The method has excelled further since it poses no risk of negative side effects, and it retains the quality of the food that was present prior to pasteurization (Peng *et al.*, 2017).

iv. Sterilization

High-pressure processing, also known as, sterilization, is a method that has been used for several years in order to inactivate the spores that result from spore-forming pathogens and in order to produce food that is shelf-stable for extended times. The most known microorganism that manufacturers worry about is *Clostridium Botulinum* since it is one of the most resistant and hard to get rid of, however, it is eliminated during sterilization for 3 minutes at 121 ºC. These are normally the values followed when undertaking the process, or for longer periods of time whenever the temperature is lower (Ramos *et al.*, 2018).

v. Other Preparation Methods

The recipes that did not require blanching were prepared differently based on its requirements. The different procedures followed are listed in Figure 11.

Figure 12: The different preparation techniques used for the production of each samples' end product

Sample	Home-blended/ Homogenized	Cooking	Sterilization/ Pasteurization
Fresh Fruit Mix	Home-blended and homogenized	-	There were batches sterilized and some pasteurized
Frozen Fruit Mix	Homogenized	-	Pasteurized
Hummus & Veggies	Home-blended	The hummus was boiled separately from the vegetables before they were mixed in order to blend	Sterilized
Loubiye B Zet	Home-blended	The green beans were boiled and	Sterilized

		then mixed with the tomato and olive and cooked in order to blend	
Fresh Lentil Soup	Home-blended	The lentils were boiled and then mixed with the water, chard and lemon juice to cook in order to blend.	Sterilized
Homogenized Lentil Soup	Homogenized	The lentils were boiled and then mixed with the water, chard and lemon juice to cook in order to blend	Pasteurized
Fresh Vegetable Mix	Home-blended	The vegetables were boiled and then mixed together in order to blend	Sterilized

In addition to the previously mentioned pH of the fresh fruit mixture, the following pH values were recorded for the following samples:

- Frozen Fruit Mix: 3.34
- Homogenized Lentil Soup: 4.17
- Hummus & Veggies: 4.2

c. Sample Testing

The samples underwent a series of testing procedures that included texture assessment in addition to liquid consistency, sensory evaluation and microbiological testing.

i. Texture Assessment/ Liquid Consistency

To ensure a successful and safe feeding for babies, the right texture and consistency must be chosen. This way, rather than tiring the baby and the mother during mealtime, it will go smoothly and stress-free; resulting with the baby growing in a nutritious and healthy way. Before reaching normal solid food, babies must go through a variety of textures and consistencies gradually, to prevent any choking hazards or complications. Apart from the several existing textures and consistencies, mixing between them may form a new texture. They can also easily be altered to better suit the needs of individuals with special needs or concerns by either thinning them or making them thicker (Holt International, 2021).

As the tongue function is developing, infants can then be able to consume thicker purees, or ones with small, soft lumps. In this case, if any snack items are to be introduced, they should have textures that melt or dissolve in the mouth without requiring any mastication.

Once the front teeth and molars start developing, the infant can begin to handle more complex food of multiple consistencies (IFT, 2003).

The tables below list the type of solid food textures, liquid consistencies and the order that should be followed when beginning to feed a baby.

Figure 13: Solid food textures available for gradual baby feeding and their description (Holt International, 2021)

Solid Food Textures	
Texture Type	**Description**
Pureed	Extremely thick, smooth liquids that don't require chewing and are lump-free
Minced	Contain small lumps that are easy to mash without teeth and require minimal chewing and no biting – they are moist and soft
Soft or bite sized	Can be cut without a knife and can easily be mashed without biting, but require chewing – moist
Regular	Normal textures like chewy/ crispy/ crumbly/ dry/ hard that require biting and chewing

Figure 14: Liquid consistencies available for gradual baby feeding and their description (Holt International, 2021)

Liquid Consistencies	
Consistency Type	**Description**
Thin	Fast flowing liquid like water
Slightly thick	Slightly slower flowing liquid and thicker than water
Mildly thick	More thicker than water and can flow off a spoon easily
Moderately thick	Smooth liquid without lumps that requires no chewing or processing
Extremely thick	Smooth liquid without lumps that doesn't require chewing but flows very slowly and is thickest

Figure 15: Suitable food textures at meal time for each age group of growing infants (Holt International, 2021)

Age	**Suitable Food Texture**
0 – 5/6 months	Thin liquids through the breast or a bottle

5 – 6 months	Smooth pureed food
7 – 9 months	Thicker smooth pureed food or food that dissolves with saliva or soft food like bananas or well-cooked vegetables
12 – 14 months	Thicker smooth pureed food or food that dissolves with saliva or soft food like bananas or well-cooked vegetables
14 – 18 months	Soft meats and mixed textures
18 – 24 months +	Mixed textures, meats, raw fruits and vegetables

The texture aimed at during this food production targeted age groups falling between 5 months to 14 months of age, meaning the soft pureed food with a slightly more liquid consistency than a solid or very thick puree. These can either be fed through a spoon, a cup, a syringe or a straw. In order to test the final consistency and viscosity of the produced baby food, a spoonful will be spread out on a blank A4 white paper in order to see if the paper would turn watery, if the product would contain lumps or if it easily breaks apart indicating the presence of too much water.

ii. Sensory Evaluation

In order to predict or determine whether a manufactured good may be accepted by consumers – especially if it is a new product in the market – it is important to conduct a sensory evaluation to evaluate the degree of liking of a product. After taking into consideration the quality of the surrounding consumers based on ethical, political and socio-economic status, as well as the sensory characteristics, the need of the item comes into question. The evaluation can both be done by trained panelists or untrained ones that have a vast knowledge in the product undergoing testing.

Before consumption, the appearance plays a major role in consumer acceptance in terms of shape, color, packaging and how it is served. Visually, the consumer will either be satisfied and excited or won't be eager to try anything new. Afterwards, the flavor and texture of the food item are put to the test. It is crucial for all these attributes to come together in a way that boosts its flavor and consumer liking (Fiorentini *et al.*, 2020) (Jiyun *et al.*, 2019).

The sensory evaluation to be used in this production lot will consist of several factors that should be rated on a numerous scaled from 1 to 9 where each number indicated a liking level. The characteristics rated are split into ones related to the 5 senses, and ones related to different taste factors and attributes. The numerical scale consisted of:

1 = dislike extremely

2 = dislike very much

3 = dislike moderately

4 = dislike slightly

5 = neither like nor dislike

6 = like slightly

7 = like moderately

8 = like very much

9 = like extremely

iii. Microbiological Testing

Baby food is a form of nutrition that is condensed in terms of nutrients and various ingredients; this in turn causes an increased risk of potential bacterial growth and food borne pathogens. When mixed with the physiological fact that babies are among the most susceptible groups of people to food borne illness, it raises the need for sample testing and ensuring the safety of the food before consumption (Sadek *et al.*, 2018).

For proper microbiological testing to occur, the samples must be prepared, handled, collected and delivered correctly and under suitable conditions; otherwise the testing will give unreliable results that cannot be representative of the sample. All the steps must be taken under aseptic conditions and using sterile containers and utensils. The samples must be collected from each new batch prepared of each new item or from the same mixture if it were prepared differently. It is required that each sample is collected at random from the initial batch and must contain at least 100 g or a serving size of the product to be tested and it should be titled in reference to its contents or production method (FDA, 2018).

The baby food samples collected were sent to the Microlabs microbiological laboratory in the American University of Science and Technology located in Ashrafieh, Lebanon. They were delivered within the next 24 hours after production and were kept in ambient room temperature away from sunlight or heat, as they didn’t require refrigeration. The samples chosen were one representative from each batch of the frozen fruit mix recipe created and were 8 jars as follows:

1. Blanched and pasteurized baby food for 15 minutes (Labeled as B/Pt 15)
2. Blanched and pasteurized baby food for 20 minutes (Labeled as B/Pt 20)
3. Blanched and pasteurized baby food for 25 minutes (Labeled as B/Pt 25)
4. Blanched and sterilized baby food for 8 minutes (Labeled as B/St 8)
5. Blanched and sterilized baby food for 10 minutes (Labeled as B/St 10)
6. Blanched and sterilized baby food for 12 minutes (Labeled as B/St 12)
7. Non-blanched and sterilized baby food for 12 minutes (Labeled as NB/St 12)
8. Non-blanched and sterilized baby food for 15 minutes (Labeled as NB/St 15)

They were all tested for *Salmonella* spp., total aerobic plate count, total coliforms, *S. Aureus* and anaerobic reducing sulphite bacteria as per the LIBNOR standards (2001).

iv. Laboratory Testing

Several procedures were done in order to further test the chemical composition of the baby food prototypes prepared, of which there was moisture determination, checking of the pH, checking for ºBrix and Vitamin C analysis.

a. Moisture Determination

Moisture assessment is important while manufacturing a new product in order to determine its safety and shelf-life stability. It is defined as how much water a product contains, and affects the basic physical properties of a product including its weight, density and viscosity. While there are many methods to determine the moisture content of a food item, the easiest and most used one is to check the weight loss that happens in the sample after drying. The sample is first accurately weighed on a balance and then placed in an oven and heated for a specific time suitable for the sample type. Once it has dried, it is then re-weighed in order to obtain the value of which the first value will be subtracted from; the resulting value is the moisture found in the total weight (Marmelstein, 2009) (FAO, 2020).

The 7 different recipes of baby food samples were each weighed in aluminum plates to be placed in the oven, at an initial weight of 5 g. They were then placed in the oven at 130ºC for 2 hours in order to dry. Once done, the samples were re-weighed and the new temperatures were recorded directly after removing them from the oven, and after 1 hour.

b. pH Reading

The pH is a measure of free acidity in food, and its meter ranges from 0 to 14; any value that is above 7 is alkaline, while a value below is acidic and a pH of 7 is neutral. In order to be classified as a food having low pH, the value must be ≤4.6. The perks of having a low pH for food is that it helps get rid of bacteria that cannot survive in acidic environments; in addition to destroying spoilage microorganisms like yeasts and molds when the acidity is combined with boiling water. One of the most critical microorganisms to avoid during the production of canned or jarred food is *Clostridium Botulinim* and its spores, since they can survive in the absence of oxygen and with a pH great than 4.6. The spores may also be controlled at a step during the production process of pressure cooking, but having a low pH further ensures safety (Andress et al., 2006).

Besides proper handling, washing and cleaning of fruits and vegetables, many of them already have a lower pH, which helps limit the bacteria that can contaminate them.

Manufacturers might also attempt to lower the pH of food naturally by adding lemon juice, vinegar or anything acidic while making sure not to change the flavor of the food (Oladipo et al., 2009).

The pH of each of the 7 recipes prepared was read twice in order to ensure accuracy and was then recorded. This was done using a tabletop pH reader where the electrode is inserted in the sample to be tested and gives you a result in less than one minute.

c. ºBrix Recording

Measuring the ºBrix is done to determine the sugar content of a sample. One degree Brix is equivalent to 1 g of sucrose in 100 g of a solution and resembles the strength of the solution as percentage by mass. Manufacturers should become familiar with the previous ºBrix values acquired for the crops they are using in order to make sure the new reading is correct and the food is safe. This value is calculated since it is directly related to the products taste, quality and nutritional composition. The ºBrix is determined by testing the sample on a device known as a refractometer. It measures by refraction, which is when light enters a liquid at an angle and changes direction. The reading is given as an already recognized refractive index (nD) (Instrument Choice, 2020) (Kleinheinz *et al.*, 2013).

The USDA (2020) provides a technical procedure manual for the ºBrix method where it provides long and detailed tables on how to infer the ºBrix of a sample from the nD refractive index value read on the refractometer (Appendix C).

d. Vitamin C Analysis

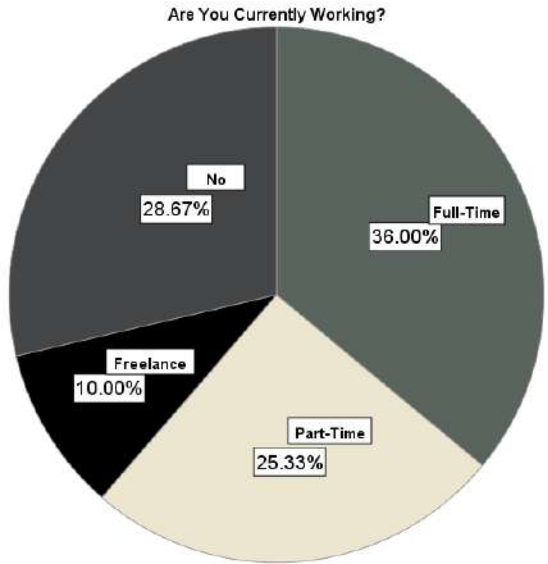
Found in fruits and vegetables, vitamin C is an essential nutrient in the human diet; however it is easily reduced or destroyed by exposure to heat and oxygen during the processing, packaging and storage of food. This is why it is important to test for the presence of vitamin C in the produced baby food prototypes since it is expected that they will have a good content due to the usage of vitamin C rich food. Nevertheless, the heating done during the production of baby food may have affected its content (British Nutrition Foundation, 2004).

Vitamin C, also known as, L-ascorbic acid, is also a powerful reducing agent. This is why its determination in food is based on its oxidation to dehydroascorbic acid by several oxidizing agents, including the dye, 2,6-dichloroindophenol. This dye is blue in color when in neutral solutions but will turn pink when placed in acidic solutions. Hence, this dye was used in the duplicate titration of the baby food samples in order to determine the vitamin C content available in each sample.

Results and Discussion

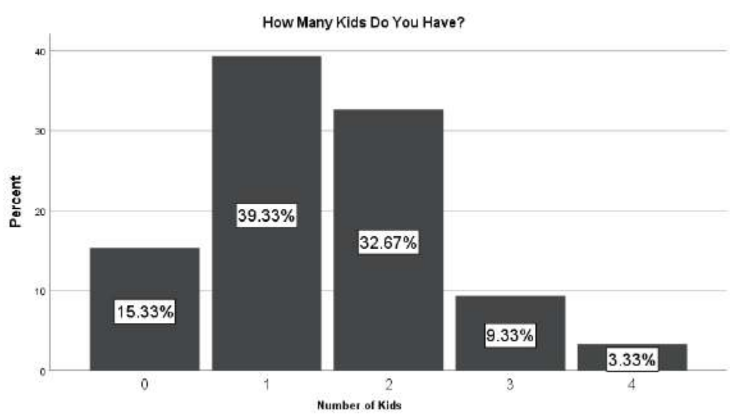
1. Data Collection and Questionnaire Section

Figure 16: Pie chart showing the 150 participants' job status



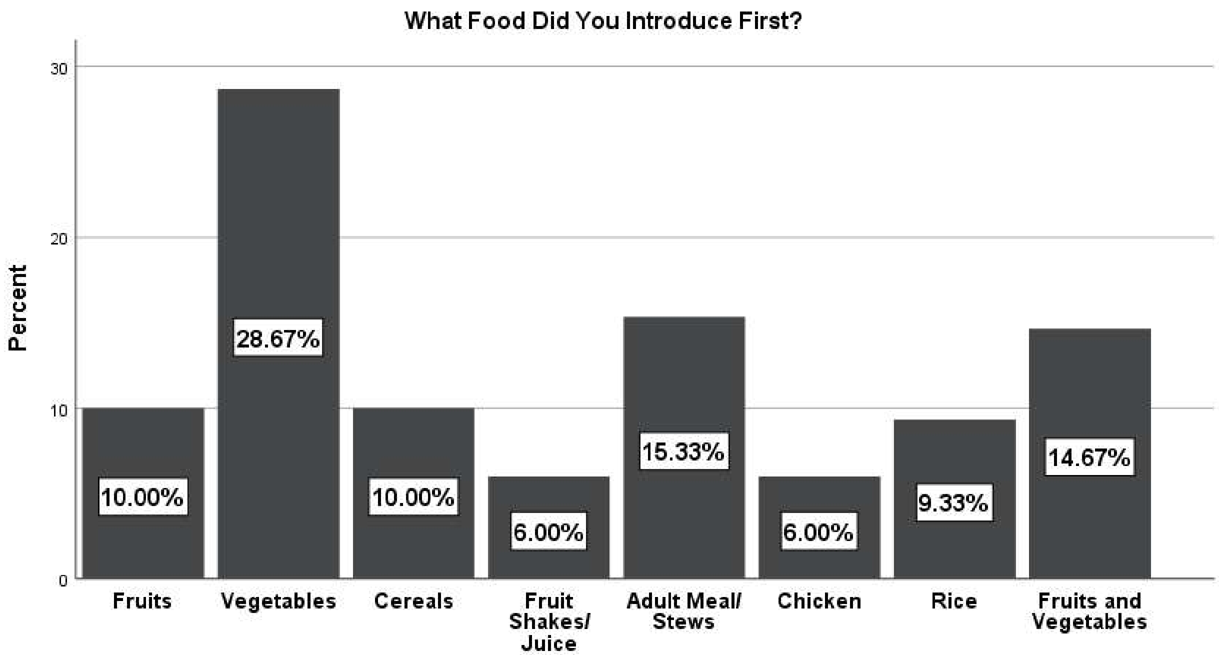
Among the 150 women that completed the questionnaire, their job statuses varied. 36% of them had full-time jobs, 25.33% had part-time jobs, 10% worked freelance, while 28.67% were unemployed. This factor gives us an indication of how much time the mom could have in terms of completing house chores, taking care of her kids and cooking for them as well as a glimpse into the purchasing power of the family.

Figure 17: Bar graph showing the number of kids each mother has



Most (39.33%) of the participants had only one kid, while 32.67% of them had two kids, 9.33% had three kids, 3.33% had four kids and 15.33% were still pregnant and had no kids. The participants' kids ages ranged between the youngest child being 1 month old and the eldest being 11 years old while having children in between that allowed the mother to be eligible to participate.

Figure 18: Bar graph showing the variation between the first foods introduced to the interviewees kids



The foods that parents choose to introduce to their kids vary from one family to another based on their beliefs, as well as the acquired knowledge from their pediatricians, friends, family members and what is advertised in the media. Of the interviewed mothers, 28.67% chose to start off their infants' diets with vegetables, 15.33% chose mashed adult meals or stews, 14.67% chose a mixture of fruits and vegetables, 10% chose to start with cereals such as Cerelac or home-made porridges, another 10% chose plain fruits, 9.33% chose to start with rice, while 6% chose to start with fruit shakes or juices, and lastly, another 6% chose to start with boiled mashed chicken. The collected data proved how diverse the market demands can be since any successful manufacturer should aim to provide the different kinds of prevalent needs.

Several moms were hesitant about the timing of food introduction as well as the type of first food to be chosen. Opting for the single ingredient introduction at a time was the most dominant amongst them and the recommended approach by most of their pediatricians. Evidently, the chosen item would be a non-allergenic, easy to digest, soft and easily mashed fruit or vegetable. This highlights the need for the production of single ingredient, mashed fruit or vegetable – and other food types – baby food made from the organic Lebanese crop, to compete with the currently available brands.

Around the world, parents struggle with the concept of solid introduction of food to their infants since they will probably be making long-term choices and preferences. To understand Australian mothers' understanding of the Australian Infant Feeding Guidelines (AIFG), Begley et al. (2019) conducted a study to explore experiences with the introduction of solid food. Seven focus groups with 42 mothers each of infants between the ages of 4–18 months were chosen. Results showed that the mean age of solid food introduction was at 4.3 months of age, beginning at as low as 1.2 months old. Furthermore, almost 50% of the sampled mothers were aware of the AIFG, but did not correctly know the recommended age for food introduction. Some of the first foods given based on recommendations include iron fortified cereals, cooked and pureed meat, fish, poultry and legumes. Then, secondary foods introduced include fruits, vegetables and dairy products (Queensland Government, 2019).

In Europe, complementary feeding also begins at approximately 6 months of age, however, there are no recommendations for an exact age since it depends on the infants' readiness. In addition, there is no recorded evidence against the introduction of allergenic food early on. The recommendations are to start with foods that provide nutritional adequacy and are rich in iron (especially for those born with low iron stores). Once the infant begins eating, food must be pureed in order to reduce the risk of choking, while the type can progress to self-fed finger food at 7 months old (EFSA, 2019).

In the United States, the American Academy of Pediatrics (AAP) recommends complementary food introduction at the age of 6 months and states that any introduction before 4 months old is too early since the gastrointestinal tract is still considered immature (Chiang et al. 2020). It is also recommended to offer a variety of fortified infant cereal as the first food such as multi-grains instead of plain rice (CDC, 2021).

In Canada, at 6 months of age, breastfeeding should still be the main source of nutrition; however, it should be supplemented by the introduction of solid food in order to meet the growing needs of the infant. The food introduced should be energy-dense and rich in iron and should be given in two to three feedings along with a snack or two.

Many of the foods given to a 6 month old infant could be similar to what the family is having on that day, but differ in the salt or sugar content. The food should include a large variety of fruits, vegetables, dairy products and different protein sources (Government of Canada, 2015).

Figure 19: Bar graph showing the mothers' cooking knowledge

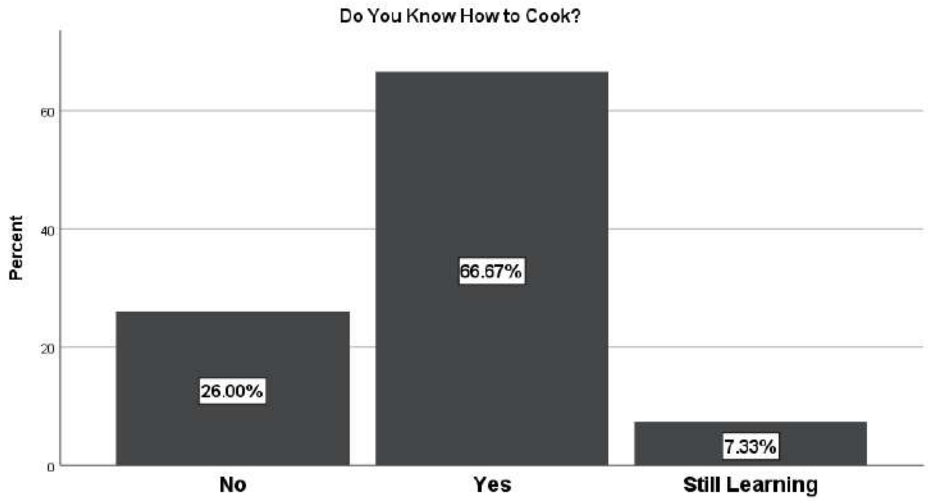


Figure 20: Pie chart showing the mothers' knowledge in cooking based on food safety measures

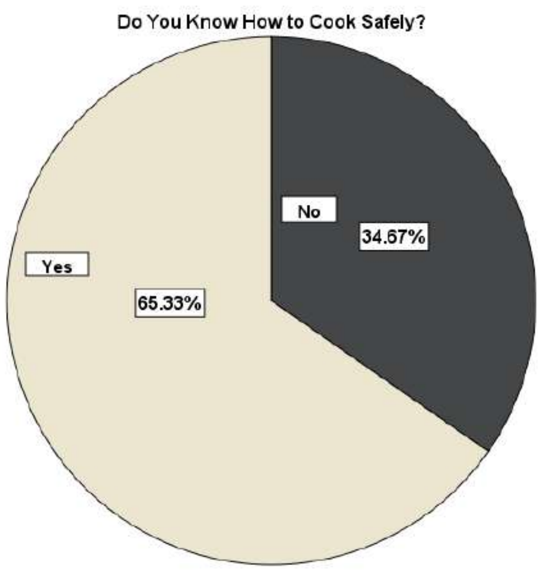
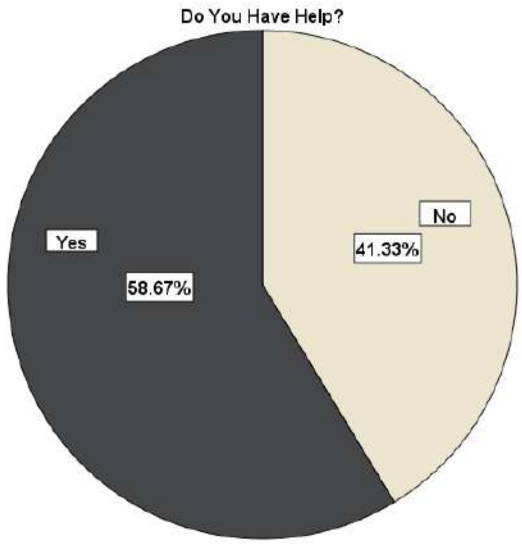
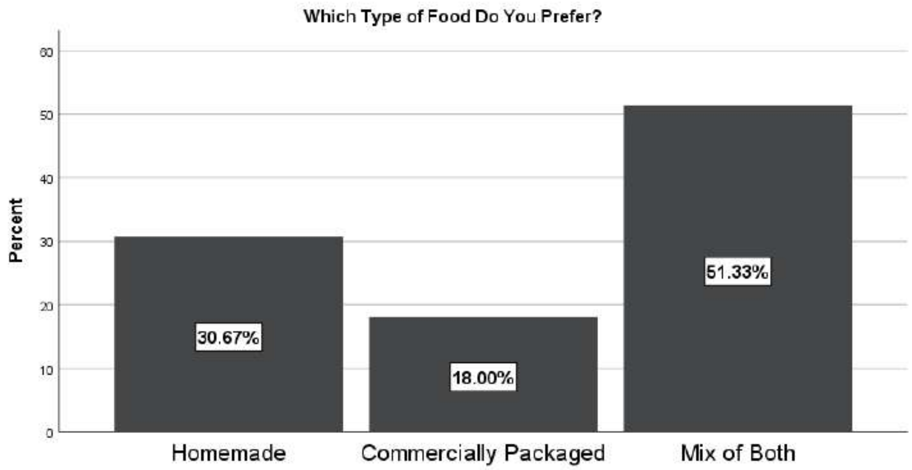


Figure 21: **Pie chart showing whether the mothers have help around daily chores**



When asked whether the moms knew how to cook, 66.67% answered that they do, 26% answered that they don't, while 7.33% answered that they are still currently learning. However, when they were asked about their knowledge in cooking according to the food safety standards, the percentages differed to show that 65.33% knew how, but 34.67% did not. Furthermore, they were asked if they received any help around the house whether with daily chores, cooking, cleaning, or taking care of the kids; the results indicated that 41.33% had no help at all and completed all the work on their own, 58.67% had help from a family member, close relative or a domestic worker at home.

Figure 22: Bar graph showing the participants preference between home-made baby food, commercial RTE baby food or a mix of both



To begin with, concerning the mothers' ideal baby feeding habits, beliefs and preferences, they were each asked what food type they would choose to feed their infants. 30.67% chose to go for home-made meals, 18% preferred the ready-to-eat baby food available across stores and pharmacies, while 51.33% chose to mix between both home-made meals and ready-to-eat baby food.

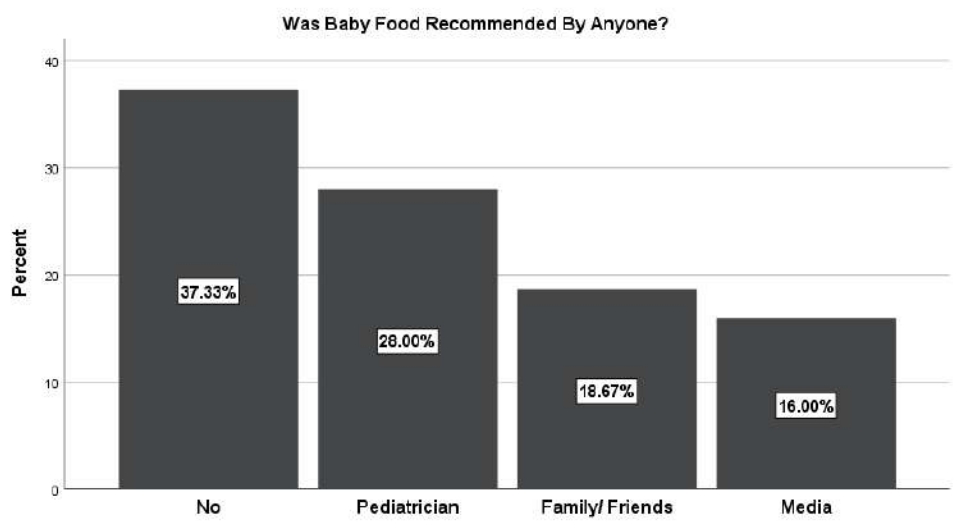
The repeated answer was that when they had time, several of the moms preferred to purchase and choose their own fruits and vegetables, prepare them in the suitable manner according to their kids' age, and produce their own baby food jars. This points to the need for the production of Lebanese baby food brand which relies on locally grown organic produce, which provides meals that are more home-made, nutritious and easy to administer.

Figure 23: Table indicating the different percentages of the most preferred baby food brands purchased in Lebanon

Statistics

	Do You Purchase Bledina?	Do You Purchase Hipp?	Do You Purchase Cerelac?	Do You Purchase Other Brands?
Mean	.41	.49	.25	.18

Figure 24: Bar graph showing whether the brands chosen were recommended by the participants pediatricians, family/ friends, the media or no one



When the moms' were asked about their purchase habits of baby food from the Lebanese market, their answers varied between Bledina, Hipp, Cerelac and other brands. The most purchased brand was Hipp, followed by Bledina then Cerelac. The mothers chose to mix and match between the brands, but on average, 49% purchased Hipp, 41% purchased Bledina, 25% purchased Cerelac, while 18% chose other imported or local brands to purchase, such as Ella's Kitchen, Gerber, Little Meli Solids, or just preferred anything organic on the market. They were also asked whether these brands were recommended by anyone or just their choice; 28% had gotten the recommendations from their pediatricians, 18.67% had gotten the recommendations from family members or friends, 16% had chosen the products due to the advertisements they saw on the media, while 37.33% had chosen the products on their own without any recommendations.

As part of launching a new product and completing the proper branding strategies for it, a manufacturer must learn how to secure a spot for themselves in the market by gaining the trust of both the consumer, and any potential catalysts for purchasing a specific type of food. In this case, pediatricians' trust is vital for the success of baby food since they will recommend this product if it proves to be effective while causing no harm. The media always plays a huge role when parents are deciding on which brand to purchase since they will be conducting extensive research about the different brands along with their pros and cons.

Figure 25: Pie chart showing whether the participants were affected by the economic crisis in Lebanon

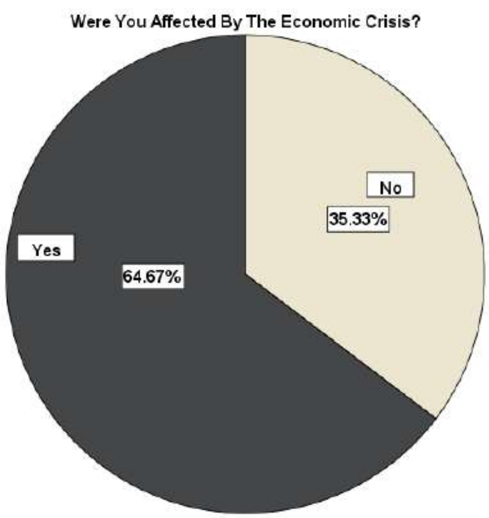
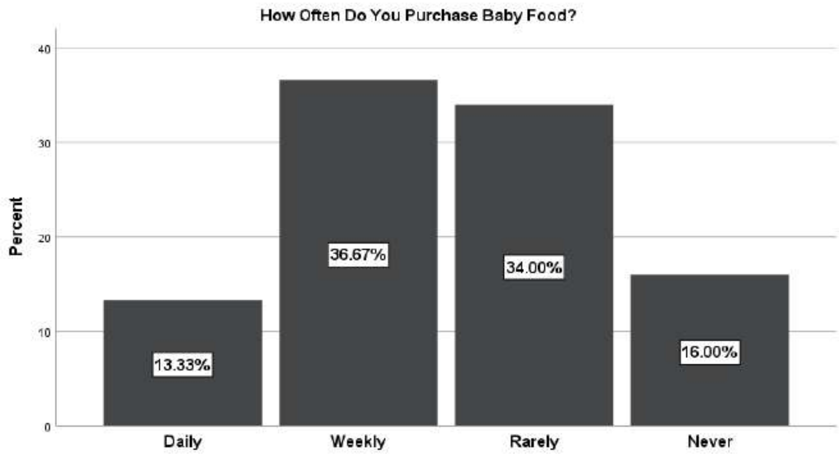


Figure 26: Bar graph showing the purchasing frequency of baby food among mothers



When asked whether their purchasing power was affected recently by the economic crisis that Lebanon is going through, 64.67% of the mothers answered that they were while 35.33% were not affected and were doing fine. The participants who were affected also worried about the increasing expenses of food among other basic needs and whether they would continue to be able to provide the same quality and nutrition to their families; however, they claimed that they would sacrifice other items in order to maintain the same class for as long as possible, especially for their infants and toddlers.

Most of the interviewed mothers' already had experiences with different types of baby food brands and had purchased and fed their babies from ready-to-eat meals at least once. However, when asked about their purchase frequency, the answers varied among them. 13.33% purchased ready-to-eat baby food daily, 36.67% purchased them weekly, 34% rarely purchased them few times per year or on special occasions, while 16% of the mothers never purchased them. Yet, the major factor in continuing to purchase in whatever manner they used to was greatly affected by the economic crisis and has hindered their purchasing power.

Figure 27: Table showing the distribution of ready-to-eat commercially produced meals purchased by mothers

Statistics

	Do You Purchase Fruits?	Do You Purchase Vegetables?	Do You Purchase Meals With Meat, Chicken or Fish?	Do You Purchase Meals Without Meat, Chicken or Fish?	Do You Purchase Desserts or Snacks?
Mean	.61	.54	.43	.35	.58

When asked about what ready-to-eat baby food they would either purchase (or consider purchasing for the pregnant women), the answers ranged between different mixtures of meal types. They averaged among 61% that would purchase fruits, 54% would purchase vegetables, 43% would purchase meals containing meat, chicken or fish since they are convenient for when there is no time to prepare a balanced nutritious meal at home, 35% preferred meals that did not contain meat, chicken or fish; lastly, 58% of the mothers found it suitable to purchase desserts for their kids rather than making them at home since they are convenient and can be used on the go.

Apart from the fact that Lebanese stews and meals are rich in flavor, they contain a huge variety of vegetarian dishes that still provide natural protein sources found in the food. Based on the market preferences observed here, mothers tend to go towards the natural ingredients when purchasing ready-to-eat food, while sticking to cooking any meat, chicken or fish containing dishes. This sheds light on the need for the traditional Lebanese meals to be produced in a suitable way and prepared as baby food.

Figure 28: Table showing the different criteria that mothers look for when purchasing baby food

Statistics

	Mean

Do You Look for Quality When Purchasing Baby Food?	.80
Do You Look for Quantity When Purchasing Baby Food?	.35
Do You Look for Safety When Purchasing Baby Food?	.61
Do You Look for Certification When Purchasing Baby Food?	.27
Do You Look for Color When Purchasing Baby Food?	.25
Do You Look for Ready-To-Eat Meals When Purchasing Baby Food?	.31
Do You Look for Nutrition Facts When Purchasing Baby Food?	.63
Do You Look for Organic Food When Purchasing Baby Food?	.52
Do You Look for Texture When Purchasing Baby Food?	.47
Do You Look for Non-allergenic Ingredients When Purchasing Baby Food?	.43
Do You Look for Certain Packaging When Purchasing Baby Food?	.25
Do You Look for the Price When Purchasing Baby Food?	.29

The criteria based on which parents choose to purchase their children's food are crucial to both the health of their kids, and market continuity. The means statistically obtained in the above table indicate the percentage of the 150 participants that look for the criterion in question as they were asked about whether they look for each specific one or not. The percentages of the criteria's in question are stated in descending order: product quality (80%), nutrition facts (63%), product safety (61%), being organic (52%), product texture (47%), non-allergenic meals (43%), quantity (35%), product being ready-to-eat (31%), product price (29%), brand certification (27%), product color (11%) and product packaging (11%). Once the safety of their infants is in question, the mothers' tend to overlook several factors, such as the price of the food, in order to provide the safest and most nutritious meals, even if they had to pay a bit more for them. When they find a good brand that they trust, parents choose the preferred brands products without thinking twice while being certain that they know what textures and quantities are right for their kids at that age frame. They expect the packaging to be convenient at all times, whether in jars or pouches, in a way that makes it easy for them to reheat the food if needed or to directly feed their infant.

Figure 29: Table indicating the participants' preferred packaging type

Statistics

	Do You Prefer Packaging in Jars?	Do You Prefer Packaging in Pouches?	Do You Prefer Packaging in Powdered Boxes?	Do You Prefer Packaging in Cans?
Mean	.81	.41	.41	.09

The mothers' were also asked about their packaging preferences and the data collected was dispersed among 5 common packaging types. The lead choice that was picked by almost all mothers (81%) was in a jar, it proved to be of most convenience in terms of seeing the food through the transparent glass, the ease of reheating the food if needed in a bain-marie, the convenience of being able to take it around on long trips and being able to feed their babies easily, as well as the variety that existed in jars. The rest were dispersed between 41% also favoring pouch packages, 41% preferring the powdered form packaging that requires reconstitution or ready-to-eat dry snacks. Lastly, only 9% of the women chose cans as one of their preferred packaging types since they claimed that most food already exists as canned and are considered safe to consume, so there shouldn't be any difference when choosing safe food for their babies.

Figure 30: The varying answers chosen by mothers' concerning whether they would add or change anything to baby food

Statistics

	Mean
Would You Prefer Baby Food Free of Preservatives?	.52
Would You Prefer Baby Food With More Variety?	.47
Would You Prefer Baby Food All Organic?	.40
Would You Prefer Baby Food With More Flavoring?	.09
Would You Prefer Baby Food More Homemade?	.32
Would You Prefer Baby Food at a Lower Price?	.37
Would You Prefer Baby Food as it is?	.19

This question aimed to group the mothers' concerns with the current baby food available on the market and whether they were satisfied with them as they were or they preferred to make changes. Most of the participants (81%) saw that baby food needed a change of some kind in order to fully satisfy all their needs and requirements while only 19% would leave it as it is without changing anything in its formulation. Of the options chosen to be changed, 52% voiced their concern in purchasing baby food that is fully free of any additives, preservatives, salt or sugar, since they feared that it contained trace amounts; 47% saw that there needed to be more variety in the available baby food items on the market, 40% requested that the baby food line become all organic. 37% of the mothers' asked saw that baby food could use a slight decrease in price since it is a necessity and not a luxury, given that they will be purchasing them on a daily basis as a minimum of two packages per day – or they can offer daily bundles that result in a discounted price when purchasing several packages at once. 32% would rather that the formulation in terms of recipe or ingredients become more homemade and contain stews that a typical Lebanese family would consume at home, while on the contrary, 9% of the mothers that faced problems when initiating feeding for their kids' claimed that it would be better to have a small amount of salt, sugar or natural seasonings to add flavor to the meals so their kids would better tolerate them and finish the required portion.

Figure 31: The resulting answers of the mothers' when asked where they see baby food in 10 years

Statistics

	Mean
Are You Concerned About Additives?	.40
Are You Concerned About the Prices?	.43
Are You Concerned About Product Safety?	.51
Are You Concerned About Products Being Out of Stock?	.25
Are You Concerned About Accessibility?	.22

Are You Concerned About Nutrition Facts?	.50
Are You Not Concerned About Baby Food?	.11

A huge part of deciding what to purchase as a parent is choosing the food allows them to put aside their concerns and trust in the product they are buying. When asked about their main concerns regarding baby food, the participants chose several options that worry them and affect their purchase frequency. 51% were worried about the safety of the product in question, 50% were concerned about the nutrition facts and ingredients of the food, 43% were affected negatively by the increased price of the ready-to-eat meals, 40% were stressed about the additives that could have been added to the food, 25% were concerned that the product will become out of stock or will not be accessible anymore (22%) due to the economic crisis. However, 11% of the participants completely trusted the baby food business and did not voice any concerns about them.

Figure 32: Table showing the participants' predictions of baby food for the next 10 years

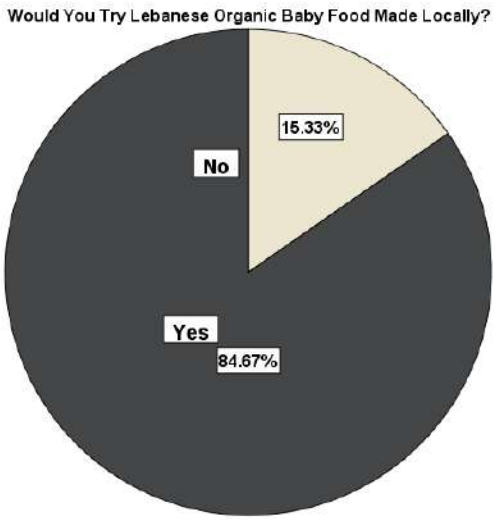
Statistics

	Mean
Do You See Baby Food in 10 Years as Healthier?	.31
Do You See Baby Food in 10 Years With a Bigger Variety?	.41
Do You See Baby Food in 10 Years as Local Brands Going Worldwide?	.23
Do You See Baby Food in 10 Years as The Same?	.29
Do You See Baby Food in 10 Years as Only Locally Made?	.17

Do You See Baby Food in 10 Years as All Organic?	.27
Do You See Baby Food in 10 Years as Unaffordable?	.19
Do You See Baby Food in 10 Years as a Home-Delivery Service?	.24
Do You See Baby Food in 10 Years as Only in Pouches?	.08

When asked where they see baby food in 10 years, only 29% answered that they see it continuing as it is now without any changes or developments. However, many of the participants had broader visions for the future of baby food; including the 41% that saw there being a much larger variety is stock, 31% claimed that baby food will be more likely made in a healthier way or only made organic (27%). Many stated their assumptions – in case Lebanon remained in this crisis and the world continued to shift towards an age where everything is based on online interactions – which entailed 24% of baby food business shifting towards home delivery services, along with new local brands emerging and becoming internationally renowned and sold (23%). However, 19% expected baby food to become unaffordable, and 17% predict that local brands will surface, yet stay local. Lastly, 8% see the future packaging of baby food reserved only for pouches and nothing else.

Figure 33: Pie chart showing whether the participants would be willing to try Lebanese organic baby food



Lastly, the question that greatly contributes to the purpose of this study relies on asking the participants if they would be interested in trying locally made Lebanese meals and stews that are specifically made to meet the needs of their infants and growing children. 84.67% were very excited about the idea and would love to try them since it is easier to get their children's palates used to the Lebanese flavors early on rather than facing problems with their introduction later on resulting in picky eaters. Also, Lebanese meals are a great combination of most of the major food groups – carbohydrates, protein, fats and vegetables – so they would greatly nourish and benefit their kids reach the growth requirements. However, only 15.33% chose that they wouldn't try local Lebanese made meals since they have lost trust in Lebanese manufacturing companies and food safety standards due to all the outbreaks, poisonings and food safety scandals that emerge every once in a while. They would rather choose the international brands that follow strict external standards and that are being tested internationally.

After all the variables and their values were inputted in SPSS, several correlations were calculated and tested out in order to understand the needs and demands.

When trying to correlate between the baby food types preferred and whether it was recommended by anyone to purchase a certain baby food brand, the Pearson coefficient was 0.409 which translates to a positive correlation. This correlation was significant since the alpha value was 0.000 which was within the limit for being significant (0.01). So the relationship between having the preferred food type was affected by the recommendation or lack thereof by either a pediatrician, family members or friends, or by the media.

When calculating the relationship between what type of baby food the participants preferred and whether it was recommended by their pediatrician specifically, the Pearson coefficient was 0.162 which was a positive correlation indicating that the pediatricians recommendation is very effective in the type of meals the mother chooses for her infant. In addition to that, the alpha value was 0.048; meaning it remained within the limits not exceeding 0.05 – indicating that this correlation was significant.

The correlation between whether the participants would purchase a new locally made organic brand and their preference of purchasing baby food with more variety was a significantly positive one. The calculated Pearson coefficient was 0.176 indicating a weak positive relationship, while the alpha value of 0.032 remained within the 0.05 level limit. This can be translated by saying that the participants' who would prefer that baby food would be available in more variety would definitely try the different types of organic baby food made in Lebanon.

The correlation between whether the participants would purchase a new locally made organic brand and their concern of the nutrition facts label while purchasing baby food was a significantly positive one. The calculated Pearson's coefficient was 0.167 indicating a weak positive correlation, with an alpha value of 0.042 indicating that the relationship was significant at the 0.05 level. This indicates that even the mothers who are worried about the constituents of the purchased baby food in terms of nutrition would trust and purchase a Lebanese-made organic brand.

To further discuss these results based on the conversations had with the participants, the women who have full time jobs (36%) had less time to prepare meals from scratch for their infants as oppose to the 64% who claimed to have more free time since they were either unemployed, worked part-time or worked freelance. Also, mothers who had more than one baby have changed the steps they have followed; for example, many of the mothers who solely introduced home-made food to their first baby ended up introducing commercially made food to their second baby since it was less time consuming and just as nutritious.

2. <u>Sample Production and Microbiological Testing Section</u>

i. Sample Testing

The following sample testing was done for the fresh fruit mixtures only:

a. Texture Assessment/ Liquid Consistency

The produced baby food was spread across a blank A4 paper in order to view its consistency, and what was obtained was a slightly waterier product than it is thick. This may be due to a number of factors that could have resulted in excess water in the sample, such as improperly draining the fruits after blanching, adding too much lemon juice, or the natural water in fruits that leeches out upon blending.

According to Table 6, such a consistency is known as mildly thick and is suitable for infants from the ages of 5 months to 9 months. However, it is still suitable beyond 9 months but infants can then move on to thicker liquids in order to keep progressing their motor skills forward.

b. Sensory Evaluation

The 4 forms that were filled by the food producers after tasting the end product judges the taste according to several criteria. The manufacturers were asked to rate each factor on the numerous scale listed above from 1 to 9. The averages of the obtained results for each factor are listed below:

- Astringency: 3
- Bitterness: 3.5
- Cohesiveness: 4.25
- Color: 8.25
- Creaminess: 6
- Earthy/ musty: 3
- Fruitiness: 7.75
- Salty: 2.25
- Shininess: 7.75

- Sourness: 4.25
- Stickiness: 2.25
- Sweetness: 7.75
- Viscosity: 5.5
- Wetness: 5.5

c. Microbiological Testing

When testing food for microbiological contamination, it is very important to choose a sample that is representative of the whole batch in order to ensure that the results are valid and accurate. This is why the baby food produced was placed in jars right after homogenization, and then one jar of each batch was sent for testing.

Each sample was tested for 5 parameters; total aerobic plate count, total coliforms, *Staphylococcus aureus*, anaerobic sulphite reducing bacteria and *Salmonella* spp. The designated units and allowed limits for each parameter are listed below:

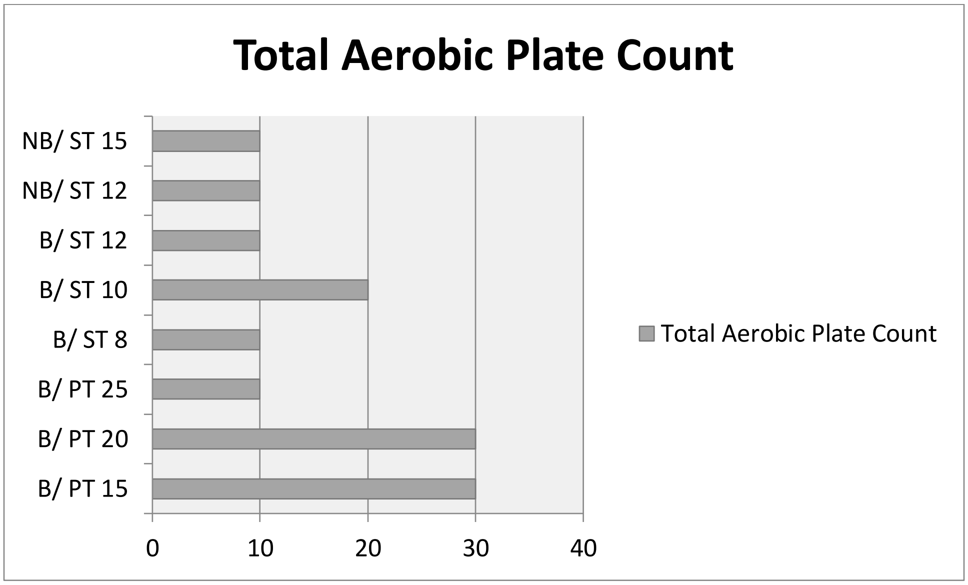
Figure 34: The suitable units and allowed limits for each microbiological parameter tested

Parameter	**Unit**	**Allowed Limits**
Total Aerobic Plate Count	CFU/g	n=5; c=2; m=10^3; M=10^4
Total Coliforms	CFU/g	n=5; c=1; m=1; M=10

Staphylococcus aureus	CFU/g	n=5; c=2; m=10; M=100
Anaerobic Sulphite Reducing Bacteria	CFU/g	n=5; c=0; m<10
Salmonella spp.	/25g	n=5; c=0; m=absence

The results obtained for each microbiological parameter each were in conformity with the related technical requirements as specified by the Lebanese standard "Formulated Supplementary Foods for Older Infants and Young Children (NL 456:2004)". The allowed limits stated are also in accordance with the same Lebanese standard (NL 456:2004).

Figure 35: Bar graph showing the results obtained for each sample after testing for the total anaerobic plate count



The total aerobic plate count obtained from the samples B/ Pt 25 and NB/ St 15 were both below 10, however, the laboratory does not indicate values below 10 as long as they are still in the acceptable range. For this graph, they were considered as having 10 as a result when in fact during testing, they were 0.

Figure 36: Bar graph showing the results obtained for each sample after testing for total coliforms

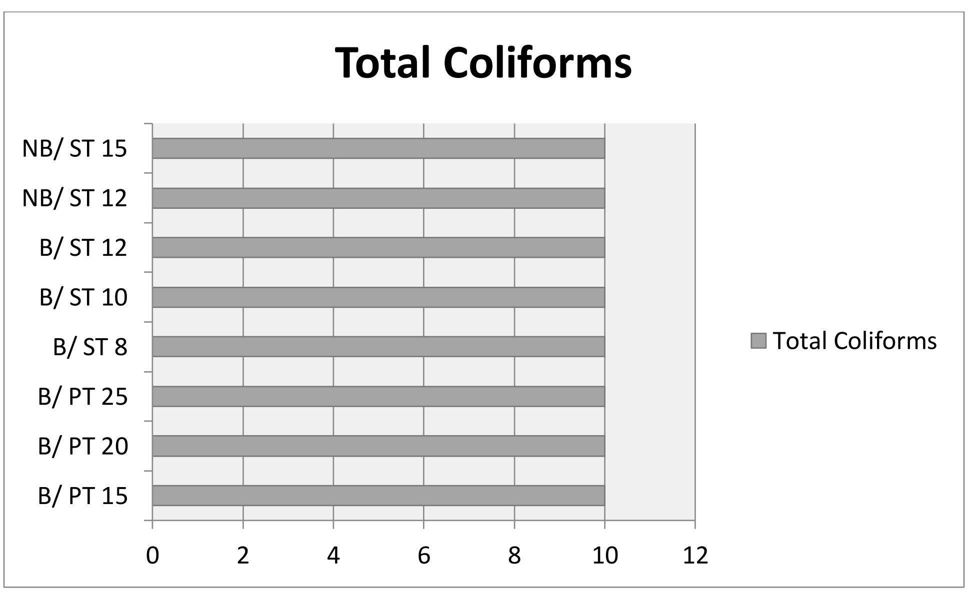


Figure 37: Bar graph showing the results obtained for each sample after testing for Staphylococcus Aureus

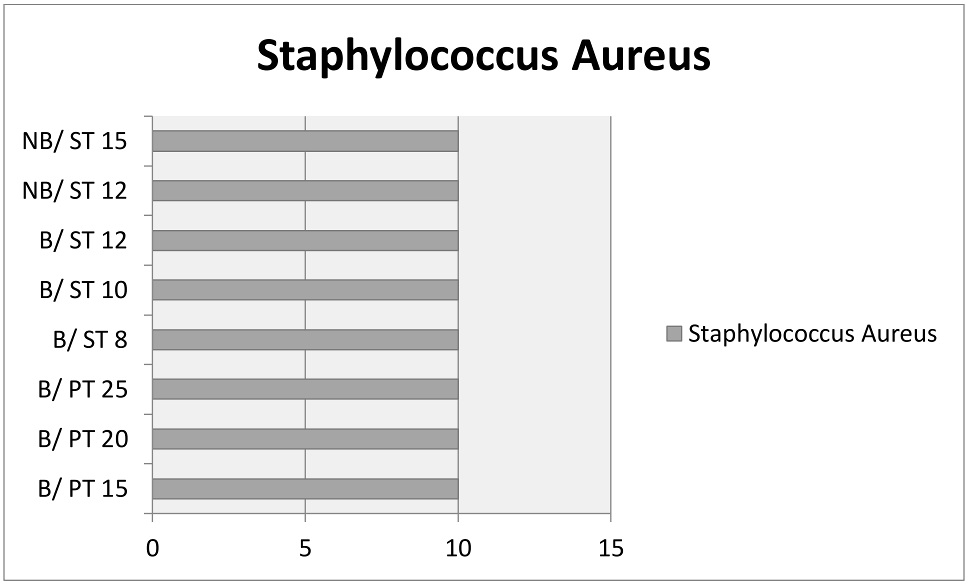


Figure 38: Bar graph showing the results obtained for each sample after testing for anaerobic sulphite reducing bacteria

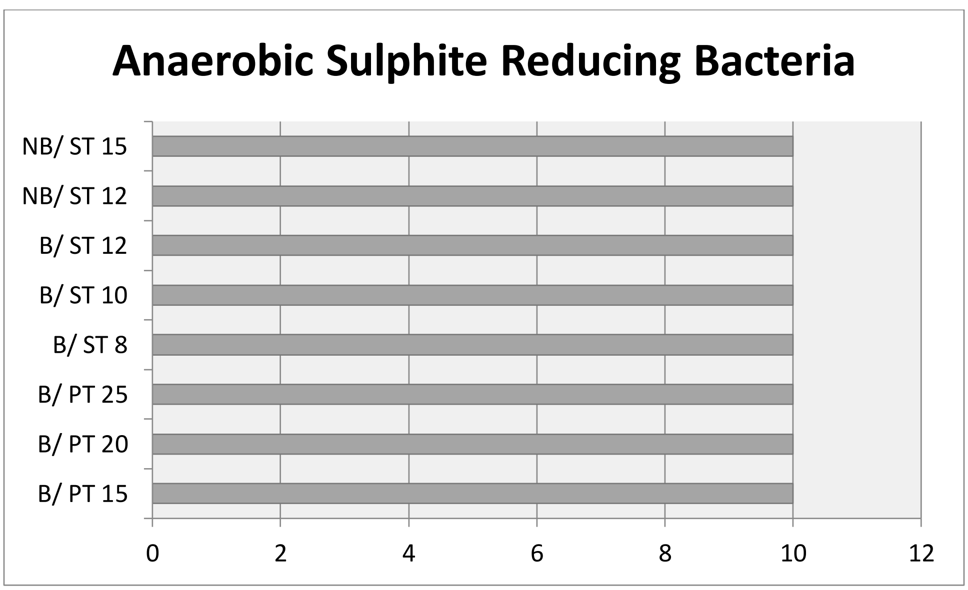
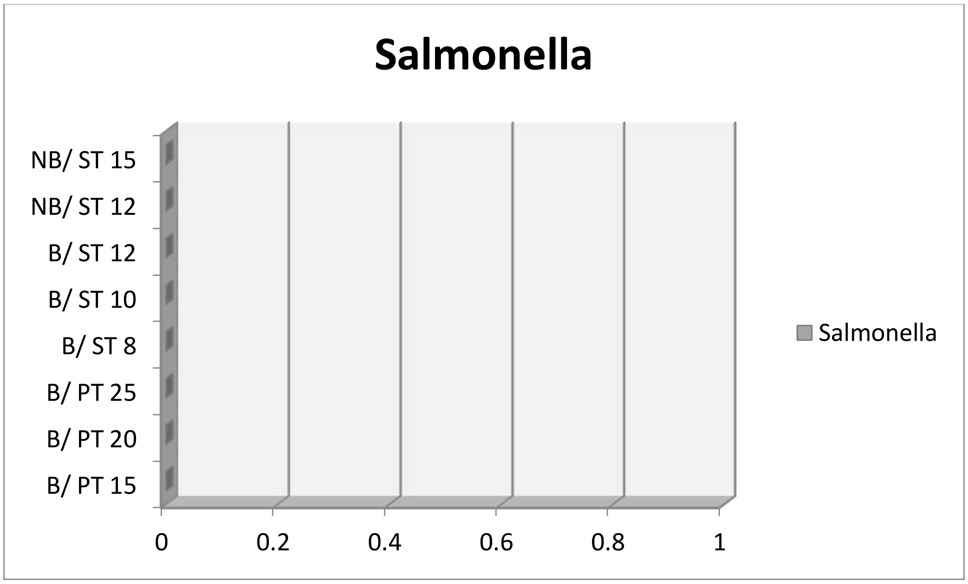


Figure 39: Bar graph showing the results obtained for each sample after testing for Salmonella spp.



d. Laboratory Testing

i. Moisture Determination

Figure 40: The calculated moisture content of the samples after drying

Sample	**Initial Wt + Aluminum Plate**	**Wt Immediately after Oven**	**Wt after 1 Hour**	**Moisture Calculated**
Hummus & Veggies 1	7.61 g	2.97 g	2.97 g	4.64 g
Hummus & Veggies 2	7.63 g	2.97 g	2.97 g	4.66 g

Fresh Lentil Soup 1	7.37 g	3.05 g	3.05g	4.32 g
Fresh Lentil Soup 2	7.44 g	3.05 g	3.05 g	4.39 g
Lentil Soup Homogenized 1	7.60 g	3.21 g	3.21 g	4.39 g
Lentil Soup Homogenized 2	7.54 g	3.19 g	3.19 g	4.35 g
Loubye B Zeit 1	7.54 g	2.9 g	2.9 g	4.64 g
Loubye B Zeit 2	7.56 g	2.9 g	2.9 g	4.66 g
Frozen Fruit Mix Homogenized 1	7.67 g	3.09 g	3.1 g	4.57 g
Frozen Fruit Mix Homogenized 2	7.54 g	3.06 g	3.08 g	4.46 g

Fresh Apple/ Pear/ Banana Mixture 1	7.38 g	3.21 g	3.22 g	4.16 g
Fresh Apple/ Pear/ Banana Mixture 2	7.54 g	3.22 g	3.22 g	4.32 g
Fresh Carrot/ Courgette/ Green Beans Mixture 1	7.55 g	2.79 g	2.79 g	4.76 g
Fresh Carrot/ Courgette/ Green Beans Mixture 2	7.51 g	2.75 g	2.75 g	4.76 g

Note that the weight of the empty aluminum plate is 2.4g.

To calculate the moisture percentage, the following formula is used:

$$\text{Moisture content} = \frac{Mass\ before\ drying - mass\ after\ drying}{Sample\ mass} \times 100$$

Once done for each of the samples, the following results are obtained:

- Hummus 1 = 89.2%

- Hummus 2 = 88.3%
- Fresh Lentil Soup 1 = 86.9%
- Fresh Lentil Soup 2 = 86.0%
- Lentil Soup Homogenized 1 = 86.5%
- Lentil Soup Homogenized = 86.6%
- Frozen Fruit Mix 1 = 86.2%
- Frozen Fruit Mix 2 = 86.4%
- Loubiye B Zeit 1 = 89.2%
- Loubiye B Zeit 2 = 89.2%
- Fresh Fruit Mix 1 = 83%
- Fresh Fruit Mix 2 = 83.9%
- Fresh Vegetable Mix 1 = 91.7%
- Fresh Vegetable Mix 2 = 92.1%

When a food has a high water activity, this indicates that it also has a high moisture content value (Chen, 2019). Generally, this indicates that this type of food can support the growth of bacteria, yeasts and molds due to containing a large percentage of water. Any value above 85% moisture content normally correlates to being a potentially hazardous food that provides the right milieu for bacteria to grown and has a lot of water activity as per the FDA (2014).

ii. pH Reading

Figure 41: The duplicate pH readings of each of the baby food samples

Sample	pH Reading 1	pH Reading 2
Hummus & Veggies	5.85	5.85
Fresh Lentil Soup	5.63	5.62
Lentil Soup Homogenized	4.77	4.75
Loubye B Zeit	5.35	5.35
Frozen Fruit Mix Homogenized	3.83	3.83
Fresh Apple/ Pear/ Banana Mixture	4.18	4.19
Fresh Carrot/ Courgette/ Green Beans Mixture	5.61	5.61

All the readings of the samples indicated that they were all acidic since they were below 7. However, a low acid canned/ jarred food, according to the FDA (2020) is any food that has a pH before canning of less than 4.6, or less than 4.7 for items containing tomatoes or tomato products. These values can be reached by adding acids or acidic food items such as lemon or vinegar to the recipe. If the pH of the food was higher and couldn't be reduced by adding acidic food, it would require heating at high temperatures during the canning or jarring process to ensure that any spores have been killed and the microbial load has been reduced (McGlynn, 2016).

In order to successfully complete a safe canning/ jarring procedure, it is vital to consider the time and temperature of the processing time where the package will be heated in order to reach "commercial sterility". However, to decide on the suitable time and temperature, the pH, thickness, viscosity, the packaging and the cooking temperature are all factors that affect these values.

- Low-acid Foods: When jarring food that has a pH above 4.6, improperly executed processing can lead to the survival of any *Clostridium Botulinum* spores since they are very heat resistant. The proper heating procedure is when the food is placed in a pressure-cooker at high temperatures for a significantly long time. The temperature begins at 115 °C at the least, while the time varies based on the temperature but ranges between 20 minutes to several hours. Mostly, low acid foods include most vegetables, meat, chicken and fish.

- High-acid Foods: Since the risk of the *C. Botulinum* here is much less, the heating time is greatly reduced and no pressure cooking is required. Normally, they are divided into 4 categories of pH levels in order to deduce the temperature to be used to be able to kill the microorganisms and halt the effect of the spores.

    - pH ≤ 3.5: 79.5° C

- pH 3.5 – 4.0: 85° C
- pH 4.0 – 4.3: 90.5° C
- pH 4.3 – 4.5: 99° C

The time required to reach these temperatures generally varies and ranges between two to ten minutes in a boiling pot of water with the sealed containers completely covered in the water. High-acid foods generally include jams, jellies, most fruits and pickled food (McGlynn, 2016).

During the thermal processing (pasteurization/ sterilization) or freezing procedures done, the equilibrium between water and buffer solutions begins to split based on the severity of the pressure and temperature chosen; this generally affects the pH level and has a strong effect on the changes that may occur during thermal processing of the product (Reineke *et al.*, 2011).

The production of the 7 samples was done under safe conditions where the pH was tested before the items were filled into the jars. The frozen fruit mixture attained a pre-jarring pH of 3.34 while the fresh fruit mixture had a pH of 3.8. Both mixtures still maintained a similar pH after several months in a jar which was below the limit of 4.6. The fruit samples were the only ones that had a pH below 4.6 potentially due to their naturally low pH as raw ingredients that was further reduced by adding lemon juice to the recipe. This indicates that these samples are safe from any spores that may have been present during the production process.

The homogenized lentil soup had a safe pH as well at 4.77 which is also due to the addition of lemon to the mixture; however, the fresh lentil soup that was not homogenized but used the same recipe had a different pH, which was 5.63 (It was also 4.17 pre-jarring). This may be attributed to the organic material decomposition process. Decomposition is when organic matter begins to disassemble when in water, and since organic compounds are unstable and can be easily oxidized, they are released as carbon dioxide (CO_2) in the water. Having CO_2 in water affects the pH level by decreasing it (USDA, 2020). When the lentil soup, in this case underwent homogenization, the ingredients were further homogenized, which allowed the pH to decrease more than the non-homogenized lentil soup.

iii. ºBrix Recording

Figure 42: The refractive index recording and the ºBrix of each sample

Sample	Refractive Index Reading (nD)	ºBrix
Hummus & Veggies	1.3544	5.8
Fresh Lentil Soup	1.3420	5.3
Lentil Soup Homogenized	1.3429	6.2
Loubye B Zeit	1.3407	6.8
Frozen Fruit Mix	1.3429	12.6

Homogenized		
Fresh Apple/ Pear/ Banana Mixture	1.3414	14.2
Fresh Carrot/ Courgette/ Green Beans Mixture	1.3518	6.8

When soluble solids exist in fruits and vegetables, they normally affect the sweetness of it, and these soluble solids are measured in °Brix. These can include, but are not limited to, sugars, pectins, amino and organic acids. However, sugar is the most ubiquitous one, which is why the °Brix has come to be known as the measurement of sugar content where 1 °Brix is equivalent to 1 gram of sugar in a 100 g solution. Samples are tested using a refractometer where 3 drops of the sample are placed on its measuring prism in order to measure the refractive index of the solution in nD (Kleinheinz et al., 2013). Several tables exist in order to later on convert the value obtained in nD, to a °Brix value which is proportional to the sugar content of the sample (USDA, 2020).

The value obtained value is normally used by farmers as an indicator of the crop quality, especially that are easy to read and interpret and not expensive. Certain factors that can affect the °Brix value obtained include the maturity or ripeness of a crop at the time of testing, since ripe fruits and vegetables contain more sugar than immature ones. Other factors that might affect the resulting value include the water used and the soil, this is why there may be a variation for the same crop tested from batch to batch, or between market to market (Kleinheinz et al., 2013).

Therefore, in 100 g of the solution, the resulting values obtained indicate that the hummus and veggies sample contains 5.8 g sucrose, the fresh lentil soup sample contains 5.3 g sucrose, the homogenized frozen fruit mix sample contains 12.6 g of sucrose, the loubiye b zeit sample contains 6.8 g of sucrose, the fresh fruit mix sample contains 14.2 g sucrose, the homogenized lentil soup sample contains 6.2 g of sucrose and the fresh vegetable mix sample contains 6.8 g of sucrose. The value in grams is also equivalent to the percentage of sugar in the sample size of 100 g since 1 ºBrix is equivalent to 1% Brix (USDA, 2020).

A higher Brix level normally indicates better nutrient content and an enhance flavor of the produce. ºBrix measurements range from 0 – 32% with fruits and vegetables ranging between 12 – 18%; where a brix level of 18 translates to a healthy crop. Once the produce is dried – for example in the case of grapes to raisins – the ºBrix value will increase from around 20 to 80 (Kleinheinz et al., 2013).

iv. Vitamin C Analysis

Figure 43: The different values used of DCPIP to titrate the baby food samples

Sample	Titration 1 (DCPIP used)	Titration 2 (DCPIP used)
Hummus & Veggies (0.5 g)	1 mL	1 mL
Hummus & Veggies (1.0 g)	1 mL	1 mL

Hummus & Veggies (1.5 g)	1.5 mL	1.2 mL
Hummus & Veggies (2.0 g)	1.7 mL	1.6 mL
Fresh Lentil Soup (0.5 g)	0.7 mL	0.6 mL
Fresh Lentil Soup (1.0 g)	1 mL	1 mL
Fresh Lentil Soup (1.5 g)	1 mL	1.2 mL
Fresh Lentil Soup (2.0 g)	1.5 mL	1.5 mL
Lentil Soup Homogenized (0.5g)	1.5 mL	1.2 mL
Lentil Soup Homogenized (1.0g)	1.7 mL	1.7 mL
Lentil Soup Homogenized (1.5g)	1.7 mL	1.8 mL
Lentil Soup Homogenized (2.0g)	2 mL	2 mL
Loubye B Zeit (0.5g)	0.6 mL	0.7 mL
Loubye B Zeit (1.0g)	0.5 mL	0.6 mL

Loubye B Zeit (1.5g)	0.9 mL	1 mL
Loubye B Zeit (2.0g)	1.5 mL	1.3 mL
Frozen Fruit Mix Homogenized (0.5g)	0.7 mL	0.6 mL
Frozen Fruit Mix Homogenized (1.0g)	1 mL	1 mL
Frozen Fruit Mix Homogenized (1.5g)	1.2 mL	1.2 mL
Frozen Fruit Mix Homogenized (2.0g)	1.3 mL	1.3 mL
Fresh Apple/ Pear/ Banana Mixture (0.5g)	1 mL	1 mL
Fresh Apple/ Pear/ Banana Mixture (1.0g)	1 mL	1 mL
Fresh Apple/ Pear/ Banana Mixture (1.5g)	1.6 mL	1.4 mL
Fresh Apple/ Pear/ Banana	1.5 mL	1.7 mL

Mixture (2.0g)		
Fresh Carrot/ Courgette/ Green Beans Mixture (0.5g)	0.5 mL	0.5 mL
Fresh Carrot/ Courgette/ Green Beans Mixture (1.0g)	1 mL	1.1 mL
Fresh Carrot/ Courgette/ Green Beans Mixture (1.5g)	1.5 mL	1.5 mL
Fresh Carrot/ Courgette/ Green Beans Mixture (2.0g)	2 mL	2 mL

The redox titration was done with the 2,6-dichloroindophenol (DCPIP) titrant since it is known to be specific in its oxidation and can only do so with vitamin C. DCPIP is normally dark blue in color in neutral or basic solution, yet is reduced to a colorless compound by acidic solutions. However, in vitamin C testing experiments and once the suitable dye is added, the DCPIP turns light pink when enough has been put in indicating the completion of the titration and the oxidation of all the ascorbic acid. If more DCPIP continues to be added to the mixture, the solution will turn pink-red.

To calculate the vitamin C of samples, it is important to know that ascorbic acid and DCPIP react in a 1:1 ratio of moles, so the known amount of DCPIP used indicates the quantity of ascorbic acid present.

- One mole of DCPIP is 290.08 g
- One mole of ascorbic acid is 176.13g (Smirnoff, 2000; AIS *and* UCSC, 2015)

Conclusion

Providing nutrition and safe baby food is an essential part of any parents' life who is taking take of their growing infant; it is not a luxury to survive without. Year by year, people are beginning to rely on convenience in everyday tasks rather than doing everything on their own from scratch, just like our elders did. The market is continuously growing and the needs are endlessly changing and evolving; this highlights the importance in studying the current demand and the feasibility of providing for it. The results obtained in this result, even though were based on a small sample size, can be generalized to the Lebanese population since it was done on mothers' from all around the region and not localized from one place. Further market studies and recipe testing can be done to expand the scope of this study and supply the marketplace with its needs.

Limitations

Due to Covid19 sweeping the entire nation into lockdown, this study had several limitations. The questionnaire had to be addressed through phone calls or an online survey more than in person, which greatly reduced the sample size and did not help put the interviewee at ease by person to person contact. Also, in the questionnaire administered to the mothers', it would have been useful to ask them about the purchase frequency before the crisis occurred in order to compare that with the frequency after the crisis to better grasp the current market and determine how successful a new item would be at this time.

In addition to the Corona viruses' effect, Lebanon has been going through the worst economic crisis in history along with fuel shortage, electricity and water cuts, as well as the unavailability of all raw food ingredients. The homogenizer used in the execution of the recipe was only available at one university site which was far away from all the manufacturers; this in turn affected the baby food production cycle by limiting the manufacturing to one recipe rather than several varied ones, in addition to not being able to reach a larger sample during the tasting period.

Appendixes

Appendix A

The interview conducted between the participants and the interviewer contained 19 questions that covered several factors in order to collect information. The following questions were asked:

1. Are you currently working?
2. How many kids do you have?
3. How old is/ are your kids?
4. What was or would be the first food introduced to your baby?
5. Do you know how to cook?
6. Do you know how to cook based on food safety measures?
7. Do you have help around the house with chores?
8. Would you prefer pre-packaged food or home-made food for your baby?
9. Do you have a specific brand of baby food you would prefer to purchase?
10. Was this brand recommended by anyone (pediatrician, family, friends)?
11. Was your purchasing power affected by the economic crisis?
12. How often do you purchase baby food?
13. What type of baby food are you most likely to purchase or are purchasing?

14. What criteria do you look for when purchasing baby food?

15. What type of packaging do you prefer?

16. Would you like to add or change anything in the formulation of baby food?

17. What is your major concern about baby food?

18. Where do you see baby food in 10 years?

19. Would you be interested in trying Lebanese made organic baby food, such as traditional Lebanese dishes?

Appendix B

The sensory evaluation used to assess the baby food samples was based on several criteria that needed to be graded by the manufacturers after tasting. The numbers they were meant to score upon were divided as:

9: Like extremely
8: Like very much
7: Like moderately
6: Like slightly
5: Neither like nor dislike
4: Dislike slightly
3: Dislike moderately
2: Dislike very much
1: Dislike extremely

	1	2	3	4	5	6	7	8	9	Comments
Astringency										
Bitterness										

Cohesiveness										
Color										
Creaminess										
Earthy/ Musty										
Fruitiness										
Salty										
Shininess										
Sourness										
Stickiness										
Sweetness										
Viscosity										
Wetness										

	1	2	3	4	5	6	7	8	9	10	Comments

Appearance											
Aroma											
Flavor											
Texture											
Overall											

Would you buy this product?

□ Yes □ No

Appendix C

The °Brix interpretation chart is provided on the USDA's website. It helps convert the obtained values in nD from the refractometer to °Brix values which are also equivalent to the % sucrose in 100 g of a sample. The following is an excerpt of the 24 page manual of values, including the values obtained from the samples tested in this study.

Figure 44: an excerpt of the °Brix values by the USDA

Refractive Index at 20 Degrees C	Percent Sucrose or Degrees Brix	Apparent Specific Gravity @ 20/20 Degrees C	Weight/Gal. in air at 20 Degrees C	Pounds Solids per Gallon
1.3407	5.3	1.02088	8.495	0.450
1.3408	5.4	1.02128	8.499	0.459
1.3410	5.5	1.02168	8.502	0.468
1.3411	5.6	1.02208	8.505	0.476
1.3413	5.7	1.02248	8.509	0.485
1.3414	5.8	1.02289	8.512	0.494
1.3416	5.9	1.02329	8.515	0.502
1.3417	6.0	1.02369	8.519	0.511
1.3419	6.1	1.02409	8.522	0.520
1.3420	6.2	1.02450	8.526	0.529
1.3428	6.7	1.02652	8.542	0.572
1.3429	6.8	1.02692	8.546	0.581
1.3431	6.9	1.02733	8.549	0.590
1.3518	12.6	1.05090	8.745	1.102
1.3542	14.1	1.05726	8.798	1.241
1.3544	14.2	1.05769	8.802	1.250
1.3545	14.3	1.05811	8.805	1.259
1.3547	14.4	1.05854	8.809	1.268

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