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Nutrient density of the infants diet after the addition of supplementary foods

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NUTRIENT DENSITY OF THE INFANTS DIET AFTER THE ADDITION OF SUPPLEMENTARY FOODS

by

Savita Bector

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DEDICATION

This thesis is dedicated to my parents, Dr. Chhajju Ram Bector and Mrs. Meena Kumari Bector in appreciation of their belief in my ability to achieve.

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ABSTRACT

The recommendation of the American Academy of Pediatrics Committee on Nutrition is to delay the introduction of supplementary foods to the infants diet until 4-6 months of age. However, it is found that supplementary foods are introduced prior to four months.

In this study 48 mother, of infants under four months of age and receiving formula and supplementary foods, were interviewed for food intake of the infant. Results from the study indicate that early introduction of supplementary foods has little influence on the total mean energy and nutrient intake. Formula was found to be the major source of energy and nutrients with only a small percentage from supplementary foods.

No significant difference was found in energy and nutrient intake by ethnicity, gender of baby or age. Although the percent intake from supplementary foods increased with age. Demographics were not related to the age of introduction of supplementary foods.

CHAPTER ONE

INTRODUCTION

Infancy is a period of rapid growth and development. During the first few days of life all newborns lose weight. This is due to free water diuresis (23). But by the seventh to the tenth day of life, birth weight is usually regained (39). Thereafter, growth occurs at a very rapid rate. A typical infant doubles his or her birth weight in four to six months and triples it in a year (38,52). Also during the first year of life, the infants length increases by fifty percent (39). In order for the infant to develop properly, adequate nutrition is especially important during this time (4). Inadequate intake or an excess of nutrients may predispose the infant to health problems later in life (34). Breast milk and formula are an important source of nutrients during the entire first year with baby foods providing additional amounts of nutrients (29,59).

The recommendation of the American Academy of Pediatrics Committee on Nutrition (1) is that for the first four to six months of the infants life, the infant should be fed only on breast milk or a single given formula (8). Adequate intakes of breast milk or formula will meet all known nutritional requirements of the infant for the first four to six months of life. Supplementary foods should be introduced into the infants diet between the age of 4 to 6 months (58). By the age of four to six months, infants are physiologically mature to tolerate supplementary foods. However, it has been found that the majority of the infants in the United States are fed foods other than milk by one month (31), six weeks (58) to two months of age (18) even though professional advice is to delay introduction until the age of four months. The earlier introduction of supplemental foods will effect the nutritional quality of the infants diet. Although there are various research studies on weaning of the infant and nutritional intake after four months, research is limited in the area of the effects of early introduction of supplementary foods on the nutritional quality of the infants diet. The purpose of this study is to investigate the impact of early introduction of supplemental foods on the nutrient density of the infants diet. In specific, energy, protein and the essential amino acids, fat and the carbohydrate contents of the diet will be studied.

The objectives of the study include: 1) To investigate the distribution of the age of introduction of supplementary foods, 2) To investigate the nutrient intake of the infants in relation to the Recommended Dietary Allowances, 3) To determine the percentage of energy and nutrients provided by the formula and supplementary foods, 4) To investigate the caloric distribution of the diet, 5) To compare the nutrient intake by ethnicity, gender and age and finally 6) To address the types of supplemental foods that are fed to the infant and the rationale of the mother for giving them.

OPERATIONAL DEFINITIONS

Supplementary Foods: Foods other than formula given to the infant. This includes all liquids, semi-solids and solids. Will also be referred to as non-milk foods in the context of this paper.

CHAPTER TWO

LITERATURE REVIEW

During the period of infancy, adequate nutrition is crucial as it substantially influences growth, development and morbidity. This section presents a review of literature regarding infant feeding practices, infant nutritional requirements, digestion and absorption and infant nutritional assessment.

INFANT FEEDING PRACTICES

During the first year of life, breast milk or formula are an important source of nutrients. The American Academy of Pediatrics (1) recommends that for the first four to six months of life, the infant be fed on breast milk or formula. Baby foods or supplemental foods should be presented to the infant at the age of four to six months. At this age the infant is physiologically ready for other non milk foods. Majority of infants have "lost their extrusion reflux and have a decreased gastroesophageal reflux" (8,46). The ability to swallow non-liquid foods is established. The infant will also have a good neuromuscular control of the head and the neck and be able to sit unassisted or with some support. The infant is able to move food from the front of the mouth to the rear of the mouth. The intestine is developed immunologically and is less permeable to foreign proteins. The ability to digest and absorb other proteins, carbohydrates and fats is increased. The kidneys ability to handle the increased solute loads of protein and electrolytes is also developed (1,8,18,46,52).

Also at the age of five to six months, the infant "will be able to indicate the desire for food by opening the mouth and leaning forward, and to indicate disinterest or satiety by leaning back and turning away. Until the infant can express these feelings, feeding of solids will probably represent a type of forced feeding" (1,18). Therefore, the introduction of solid foods and other non milk foods to the infants diet is recommended at the age of four to six months (1,8,18,41). However, supplemental foods are often introduced into the infants diet prior to this age and may supply up to one third of the energy at three months of age and two thirds by the end of first year (58). The rationale for this early introduction of supplementary foods includes aggressive marketing of baby foods by the food industry, social pressures (18) and the belief of the parents that "feeding of solids will help the infant sleep through the night" (1,18,31,57). This belief has not been proven to be scientifically true. Research shows that bottle feeding of semisolids at night does not extend night sleeping (8,52). The mother may also interpret an infants crying or fussiness as a sign of hunger and that milk intake was inadequate. Therefore, she may provide supplementary foods to pacify the infant (52,58). Harm from an early introduction of non-milk foods has not been shown as long as the infants continue to receive either breast milk or formula (59). However, there are various arguments for withholding supplementary foods until the age of four to six months. These include the potential for gastrointestinal, allergenic, neurological and renal problems. At this time, the intestinal tract has not developed its defense mechanisms, kidneys are unable to handle high osmolar loads and the neuromuscular mechanism for chewing and swallowing are not developed (51,57). Supplementary foods high in protein and electrolytes will increase the solute load. In early infancy, the kidneys are not able to respond appropriately to this load, which is to produce a more concentrated urine. Therefore a higher plasma osmolality can result. Presently, it is not known with certainty if early introduction of supplementary foods will result in allergic reactions. According to Fomon and coworkers (18) and State Dept. of Public Health (52) the major objection to the early addition of supplementary foods is based on the possibility of interfering with developing sound eating habits and resulting in overfeeding the infant and also effecting the infants overall attitude towards food (41). Fomon (21), in his paper reported that there is also a difference between the breast fed infants and formula fed infants as to the age of introduction of foods other than milk. Bottle fed infants usually receive supplementary foods earlier than those who are fully breast fed (3). Fomon (21) reported that between the age of two and three months twenty six percent of the breast fed infants and fifty eight percent of the formula fed infants received foods other than milk. And between the age of four and five months, fifty one percent of the breast fed infants and eighty eight percent of the formula fed infants received foods other than milk. Marlin and coworkers (33) reported that 83% of formula fed infants were receiving solids by eight weeks compared to 31% of the breast fed infants. Among the non milk foods, cereals are introduced first, followed by strained foods, juices and vegetables. Only a small quantity of solid is needed to relieve hunger (4,33,58). Formula fed infants may be overfed as he or she is persuaded to consume more milk and supplementary foods due to an artificial end volume set by the mother and thus possibly resulting in a greater caloric intake than required (16). Normal infants are able to tolerate non milk foods by two weeks. However there are no advantages to this early introduction of foods. Sweetened beverages and artificially sweetened non caloric drinks should not be given to infants. Their usage will dilute the nutritional quality of the diet, provide empty calories and also promote a preference for sweet foods and drinks (46,52).

According to Rohr and Lothian (46) and Ferris and coworkers (16) when supplementary foods are added to the infants diet, they begin to replace formula as the major source of energy and nutrients. As a result of this, it can be stated that the nutrient density of the infants diet will be effected since the supplementary foods will contribute to the nutrient and energy intake of the infant. If supplementary foods of a lower caloric density than formula or breast milk are used then the infant might become energy and nutrient deficient. On the other hand, if the caloric density of the supplementary foods exceeds that of formula, it may result in the overfeeding of the infant. The addition of cereal to the bottle will increase the caloric density and distort the intake of calories, solute and water.

Infants nutritional intake is related to the feeding practices observed by the primary caretaker-the mother. Infant feeding practices, including the introduction of solid foods and other supplementary foods to the infants diet, may be affected by many non-nutritional factors such as socioeconomic status, ethnicity, maternal education and maternal employment (4,47,58,60,63). Wright and coworkers (63) in their study found that solids were introduced earlier by hispanics and less well educated women. Maternal employment was not found to be related to the introduction of solids. Andrew and coworkers (4) did not find a relationship between ethnicity, income and maternal education with the introduction of supplemental foods to the infants diet.

INFANT NUTRITIONAL REQUIREMENTS

There are three major determinants of nutrient and energy requirement in infants (10,15).

(a) Maintenance of existing body tissue: According to Beaton (10), the cost of maintenance of the existing body tissues, in proportion to body size does not differ between the infant and the adult. He states that once the body metabolic systems have matured in the full term infant, the process of tissues and metabolic turnover are similar in the infant and adult. "The turnover of the existing tissue components indicates the need for nutrients to replace the breakdown. Thus, with the smaller body size of the infant, the absolute amounts to be replaced are smaller but roughly proportional to body mass".

(b) Provision for growth/building of new tissues: During the first year of life, growth is the determinant for the requirement for energy, protein and other nutrients. Especially during the first month of life, body size increases at a rapid rate in proportion to the existing body mass. Between 8 and 28 days, the median growth rate may be about 10.0 gm/kg/day. This decreases to around 6.5 gm/kg/day by 42-56 days and by 84-112 days it drops to about 3.5 gm/kg/day. The rate decreases to about 1.0 gm/kg/day by the end of the first year (10).

(c) Consideration in requirement for individual variability: For all nutrients, there is a factor for variability of requirement among similar individuals. This is a biological phenomena and the extent of this variation is not known with certainty (10,65). The Recommended Daily Allowances (RDA) incorporate safety margins in the nutrient requirements to accommodate for this variability.

The estimation of nutrient allowances for the infant is based on the average amount of nutrient consumed by thriving infants breast fed by healthy well-nourished mothers. The average milk consumption for term infants is 750ml for the first 6 months (with coefficient of variation around 12.5%) and 600ml during the next 6 months when supplementary foods are given in addition to milk. Adequate intakes of human milk or formula will meet all the known nutritional requirements of the infant for the first four to six months of life. While all known nutrients are contained in the presently available formulas, the possibility of any unrecognized deficits may be avoided, as with breast milk, by introducing supplemental foods at four to six months (1).

Therefore the RDA for infants up to 6 months is based on the amount of nutrients provided by 750ml of human milk plus an additional 25% (two standard deviations) to allow for variance (22)

Adequate nutrient and energy intake is important for the proper growth and development of the infant. For infants of birth to six months of age 117 Kcal per kilogram body weight is recommended (12,53,64). Energy needs for growth and development is provided by the macronutrients mainly carbohydrates and fats. Protein may also provide energy but its primary role is to provide the amino acids required for synthesis of body proteins (12). The balance required between protein, fat and carbohydrates is also important (34). Each of these macronutrients will be discussed further.

Protein

Protein is an important nutrient during infancy. On the one hand, an insufficient protein intake will not promote normal growth and development, while on the other hand, a protein intake which exceeds the infants metabolic capacity for protein may also inhibit normal growth and development (27). It is recommended that 8 to 10 percent of total dietary energy be provided by protein (46,59). Axelsson and coworkers (5,7) reported that infants receiving formula have a significantly higher protein intake than the breast fed infants, as the formulas available on the market provide an excessive amount of protein.

In 1972, the average protein intake of infants of two to twelve months of age was found to be above the Recommended Dietary Allowance (RDA) for each age and reported to be in excess by 200% after five months. Breast milk, formula and cows milk together provide the RDA for protein. Baby foods provide an additional quantity, on the average of 24% of the total dietary protein from three to twelve months of age. In the 1986 survey, the protein intake of infants was reported to be lower than the 1970s, however, the average intake remained near or above the RDA. Baby foods provided fair amounts of protein after the fifth month and supplemented the protein from milk source to achieve the RDA. A criticism has been that the diet of the infants in the United States is excessive in protein. Starting at six months of age, the infants diets provided protein in excess of 12% of the RDA and continued to supply progressively greater amounts throughout the first year and reached more than twice the RDA at twelve months of age (29,42).

Protein is an essential nutrient as it is required for synthesis of new tissue, growth and formation of enzymes and hormones and antibodies (37,46,65). Protein is not stored in the body and is continually depleted. Therefore, it must be provided through the diet on a daily basis (66). Inadequate protein and amino acid consumption results in decreased cellular and organ concentration of protein and deterioration in the ability of cells to carry out their normal function (65). This results in increased morbidity and mortality. Excess protein intake for requirement is also disadvantageous. Animal studies have revealed that glomerular filtration rate and renal blood flow increase with high protein diets, thus accelerating the progression of glomerular injury and impaired renal function. Similar results have been also demonstrated in humans (65). Janas and coworkers (28) and Axelson and coworkers (5,6,7) have focused on the possibility of protein overnutrition in infants. The results from these studies indicate that excess protein intake in infants resulted in elevated blood urea nitrogen. Net protein utilization is inversely correlated with the blood urea nitrogen. Thus, the high values of urea seen in these studies indicates that the protein load exceeds the infants ability to utilize it for growth (51). The plasma concentration of the essential amino acids have also been reported to be significantly higher in the formula fed infants (6) than the breast fed infants. The question of a possible relationship between high protein intakes during childhood and renal damage was postulated.

Amino acids and nitrogen are the source of protein in the diet. The body is unable to synthesize nine amino acids (histidine, leucine, isoleucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine) in adequate amounts or at all for body needs (37,65). Therefore, these amino acids are considered to be essential amino acids and they must be provided through the diet in sufficient amounts.

Protein requirement is the greatest in infancy, especially the first six months of life (46). In the first year of life, the protein content of the body increases from 11 to 14.6 percent (12,22). From the time of birth to four months of age, the mean body protein accretion in the infant is 3.5 grams per day and thereafter the infant accumulates approximately 3.1 grams per day (12,17,22,53). For the first six months of infancy, weight gain should be 1.0 ounces per day and for the next six months it should be 0.5 ounces per day (51).

Infants use approximately 60 to 70 percent of the protein requirement for growth (12,46). It is very important that the infants caloric intake be adequate in addition to the protein. If caloric intake does not meet the requirement, then the protein will be utilized for energy. Due to this critical relationship between protein and energy metabolism, protein requirements are also expressed as grams of protein per 100 Kcal (46). Human milk provides 1.6 grams of protein per 100 Kcal. The biological value of human milk is higher than that of other proteins fed to the infant. Therefore, most formulas are adjusted to compensate for any amino acid deficiencies that may exist and provide 2.2 to 2.3 grams of protein per 100 Kcal (2,30,53). The American Academy of Pediatrics Committee on Nutrition (2) recommends a minimum protein intake of 1.8 gm/100 Kcal with a protein efficiency rate (weight gain/protein intake) at least 100% that of casein (53). The American Academy of Pediatrics Committee on Nutrition (2) has also proposed a maximum protein level of 4.5 gm/100 Kcal. There is no advantage to the normal infant when protein in excess of the 1.8 gm/100 Kcal is given. Also increasing the protein level increases the solute load.

The RDA (22), for protein has been set as an average intake of 2.20 grams per kilogram per day between birth and five months or 13 grams/day. This is met with an energy level of 117 Kcal/Kg/d for 0-6 months (53). Human milk protein has been used as the reference. It has been suggested that (15,20,22) the protein requirements of the infant, during the first six months of life will be met if the energy requirements are fulfilled, provided that the composition of energy contains protein in quantity and quality equal to that of breast milk. Protein intake greater than 5 grams per kilogram per day may cause dehydration and nonprotein nitrogen retention (8). Amino acid requirements are presented in Table 1.

Table 1: Suggested Requirements for Essential Amino Acids of the infant based on Breast Milk Composition (mg amino acid per gm protein)

Essential Amino Acid	Average	Range
Histidine	26	18 - 36
Isoleucine	46	41 - 53
Leucine	93	83 -107
Lysine	66	53 - 76
Methionine + Cysteine	42	29 - 60
Phenylalanine + Tyrosine	72	68 -118
Threonine	43	40 - 45
Tryptophan	17	16 - 17
Valine	55	44 - 77
Total Essential Amino Acids	460	408-588
Source: Beaton (10)		

Fat

Fat is a critical nutrient in infancy. It is the main source of energy in the infants diet and is vital for normal growth and development of the infant, who has a higher energy requirement per kilogram than at any other period of life (12,26,41,56). There is no RDA for fats. However, 40 to 50% of calories as fat appears to be necessary for growth and development of the infant (9,46). The American Academy of Pediatrics (2) recommends that the infant should receive a minimum of 30% of energy as fat. Human milk provides 40 - 50% of the total calories as fat (12,26,53,57) and most formulas provide 35 - 45% of energy as fat (12,53). Approximately 90% of the dietary fat is found in the form of long chain triglycerides (12,41). During the first year of life, the physiologic deposition of fat increases from approximately eleven percent body weight at birth to approximately twenty five percent at six months (59). Other than its importance as a source of energy, fats are also required for normal neurologic development, absorption of fat soluble vitamins and are an integral part of cell membrane and provide essential fatty acids (12,51,56). Infants fed a low fat diet show a decrease in subcutaneous fat with normal increase in length (12). The lack of appropriate dietary fat in infancy has also been related to chronic nonspecific diarrhea. This can be a result of substitution of formula with solid or other foods low in fat content (31). Just as a low fat diet is undesirable in infancy, a high fat diet can also be detrimental. An intake of more than 54% of energy as fat may result in ketosis or acidosis

(2,12,46).

Carbohydrate

In the growing infant, carbohydrates are primarily needed as a source of energy (53). Like fats, there is no set RDA for carbohydrates. It is believed that the optimal range of carbohydrates should not be less than 40% and should not exceed 60% of total dietary energy. Human milk and most formulas provide between 40 - 50% of energy as carbohydrates (2,53,56). Lactose is the principle carbohydrate in breast milk and most formulas and in early infancy it is the preferred carbohydrate source due to its two major advantages: (1) maintenance of lactobacilli in the gastrointestinal tract and thus preventing growth of undesirable bacteria (2) enhances absorption of calcium and magnesium (12,53). As cereals and other foods are added to the diet, in early infancy, consumption of complex carbohydrates (starch) and sucrose increases and the infant is not prepared to digest the starch (17,56). This will also displace some of the lactose intake.

DIGESTION AND ABSORPTION

The infants gastrointestinal tract begins its maturing process in utero at about 3 1/2 weeks of gestation. However, it is during the last semester of pregnancy that it increases in mass and matures physiologically. The development and the maturation of the gastrointestinal tract continues after birth and as the infant develops, the efficiency of digestion increases (62). This section will review the digestion and absorption of the macronutrients in early infancy.

Protein

The full term infant is capable of digesting and absorbing protein well (37). Protein digestion begins in the stomach with an acidic environment and the presence of pepsin (30). It has been suggested that there is a low level of acid and pepsin in the gastric secretions up to the end of the first three months of life (30). However, by six months of age the term infant secretes similar amount of hydrochloric acid as the adult. In the term infant, the gastric pepsins continue to be present in decreased amounts. The pepsin levels do not reach the adult levels until about two years of age (37).

Protein digestion occurs primarily in the small intestine and depends on the pancreatic proteases (trypsin, chymotrypsin, elastase and the carboxypeptidase) and the mucosal brush border cytosolic peptidases (17,30). It is suggested that in the new born infants, protein digestion in the intestinal lumen is relatively efficient (30). In the neonate, trypsin concentration in the duodenal fluid is similar to adult levels and chymotrypsin and carboxypeptidase levels are 10-60 percent of the normal adult. Enterokinase, an important enzyme in activating the proteases occurs at only 10% of the adult concentration. This does not seem to affect the efficiency at which protein digestion occurs (30). Active transport of amino acids in the small intestine is thought to be well developed. This is based on the presence of this mechanism in fetal life and has not actually been studied in the infant.

Feeding studies have indicated that the infant can digest and absorb sufficient quantities of protein through the diet, even with the limited digestive capacities. A ten day old infant can absorb approximately 1.95 grams protein per kilogram per day and a 4-6 month old infant can digest and absorb approximately 3.75 grams of protein per kilogram per day. Although these studies were demonstrated with milk protein, it is suggested that it should be applicable to other types of food protein (30).

A full term infant has the capability to digest at least 80% of its protein intake during the first month of life (37). Capacity to digest and absorb protein increases with the maturation of the gastrointestinal tract.

Fat

Full term infants do not absorb fat as efficiently as adults. Formula fed babies excrete between 5 - 20% of dietary fat up to approximately one year of age. Breast fed babies will excrete less than seven percent of dietary fat (62). The digestion of fat begins in the stomach with the action of lingual lipase (secreted by the ebners glands at the base of the tongue) and by the action of gastric lipase (56,62). Further digestion takes place in the small intestine through the action of pancreatic lipase and bile acids. In the infant, there is a decreased secretion of pancreatic lipase and the bile salts. It is half the adult value. This limits the capacity to digest and absorb fat (12,26,31,32,62). Regardless of this, the infant is able to achieve 70% absorption of dietary fat (32). For infants fed on breast milk alone 85 - 90% fat absorption may occur (12). This efficiency of absorption is thought to be caused by the enzymes lingual lipase or breast milk lipase (for breast fed infants). These two enzymes might be the principle ones responsible for fat digestion in the young infant (32).

Carbohydrate

The digestion of carbohydrates starts in the mouth by the action of salivary amylase on food. Gastric acidity inactivates the salivary amylase. Digestion of carbohydrates continues in the small intestine through the action of pancreatic amylase and disaccharidases - maltase, sucrase, and lactase. In the infant, the activity of the pancreatic amylase is undetectable or very low until the age of four to six months and does not reach a substantial level until one year of age.

One of the major differences with the addition of supplementary foods to the diet of the infant is the carbohydrate. Lactose is the major carbohydrate in breast milk and most formulas. However, during and after the addition of supplementary foods, the carbohydrate source becomes starch and sucrose. These classes of carbohydrates are different in their chemical properties and therefore require different carbohydrases for their digestion and utilization. Pancreatic amylase is required for the digestion of starch or glucose polymers. Since the activity of this enzyme is virtually absent or low until four to six months of age, the earlier introduction of non milk foods may be harmful resulting in maldigestion and inadequate caloric intake. Most infant foods contain substantial amounts of starch (12,17,31,32,36,48). Therefore, the introduction of cereals and other complex foods before four months is discouraged.

Some studies have shown that even with the pancreatic amylase deficiency, infants can tolerate small quantities of starches/cereals without deleterious consequences(32,48). This is thought to be the result of the presence of alternative enzymes in the infant causing starch and glucose polymer digestion. These enzymes are: mammary amylase, salivary amylase and small intestinal brush border glucoamylase. These enzymes may play a more important role in the infant to compensate for the absence of pancreatic amylase than they do in the adult where the pancreatic amylase is available and thus the role of these enzymes is accordingly decreased (32). However, further studies are necessary before general feeding of starches or glucose polymers can be recommended for the young infant (48).

ASSESSMENT OF NUTRITIONAL STATUS

Parameters useful in the evaluation of the infants nutritional status are anthropometric measurements (rate of growth), serum concentration of proteins (albumin and transferrin, prealbumin and retinol binding protein) (17) and analysis of actual dietary intake. Each of these will be discussed briefly.

(a) Anthropometric Measurements/rate of growth: Normal development is associated with the appropriate gain in weight and length. Growth in weight and length will not progress adequately if the diet is lacking in any of the essential nutrients. According to Fomon (17) and coworkers (19) the display of normal gains in weight and length, by the infant, over a sufficient period of time is indicative of adequate nutritional intake. Gains in length and weight per day of the reference infant are presented in Table 2 and body composition of the reference infant is presented in Table 3.

Table 2: Gains in Length and Weight per day of the Reference Infant

Age months	Male		Female	
	Length mm/day	Weight gm/day	Length mm/day	Weight gm/day
0 - 1	1.03	29.3	0.94	26.0
1 - 2	1.13	35.2	1.10	28.6
2 - 3	1.06	29.9	0.94	24.3
3 - 4	0.80	20.8	0.77	18.6
Source: Fomon, et al. (19)				

Table 3: Body Composition of the Reference Infant

		Birth	1 mo	2 mo	3 mo	4 mo
Male	Length (cm)	51.6	54.8	58.2	61.5	63.9
	Weight (gm)	3545	4452	5509	6435	7060
	Fat (gm)	486	671	1095	1495	1743
	FFBM* (gm)	3059	3781	4414	4940	5317
Female	Length (cm)	50.5	53.4	56.7	59.6	61.9
	Weight (gm)	3325	4131	4989	5743	6300
	Fat (gm)	495	668	1053	1366	1585
	FFBM* (gm)	2830	3463	3936	4377	4715
* FFBM = Fat Free Body Mass						
Source: Fomon, et al. (19)						

An accurate interpretation of an infants growth is determined through serial measurements rather than a single measurement at a point in time. Two measurements allow for calculation of growth during a set period of time while a one time measurement is an indication of size only (44,58). Growth charts or reference standards can be utilized to monitor an infants growth. These allow one to compare an individuals growth velocity against population norms for age (14,58). Weight for length provides an index for current nutritional status and length for age provides an index of past nutritional history (14,44,47). Generally, infants may be considered to be at a nutritional risk if their length or weight is below the fifth percentile (< 90 % of standard) or if their weight is greater than the ninety-fifth percentile (> 120% of standard) (44).

(b) Serum concentration of Proteins: Serum concentration of albumin is a relatively sensitive indicator of protein nutritional status in infancy. A moderate decrease in serum concentration of albumin may be interpreted as a protein deficiency, but not necessarily a severe protein deficiency (17,66). However, albumin has a slow half life of 2 weeks. Thus transferrin (half life of 8 days), prealbumin (with a half life of 2 days) and retinol binding protein (with a half life of 12 hours) have been proposed as better markers of protein nutritional status (13,14,23).

(c) Nutritional assessment can also be performed by analyzing the infants dietary intake for the actual nutrient consumption. This allows for the evaluation of the adequacy of the diet. Nutritional history can be collected through a 24 hour recall, food frequency questionnaire or a three to seven day food record (40,44). Each of these methods will be discussed briefly.

(1) 24 hour food recall: This method is commonly used for assessing the dietary intakes of populations. It is often used in combination with 1, 3, or a 7 day food records. By itself, this method cannot be used for assessing an individual child's nutrient intake in detail. However, it is useful for screening children as a group for nutritional adequacy as it will give some indication of the child's diet intake. The 24 hour recall method is commonly

used in the infant studies as a group.

(2) Food frequency questionnaire: This method allows for an evaluation of the frequency and the quantity of food consumed. A three day food record may also be done in addition to the questionnaire for an increased reliability of the evaluation.

(3) Three to seven day food record is the method that is commonly utilized to assess nutrient intakes of individual children. A three day dietary record can provide a reliable estimate of the individual consumption of almost all the nutrients, including protein and energy, in children, who report a more stable intake than adults (55).

Once the nutritional intake is obtained, it can be compared to the Recommended Dietary Allowances (RDA). If less than two thirds of the RDA occurs for a specific nutrient then the diet is considered to be inadequate (44). It is suggested that a combination of the nutritional assessment parameters be used for an accurate evaluation of an individuals nutritional status.

In summary, infancy is a crucial period in an individuals life span. It involves rapid growth and development. Adequate nutrition during this period is of utmost importance as it sets the basis for future life. For the first four to six months of life the infant should be fed on breast milk or formula only. Adequate consumption of breast milk or formula will meet all nutritional requirements of the infant. Supplementary foods should be introduced into the infants diet at 4 to 6 months of age when the infant is physiologically mature to tolerate them. Earlier introduction of supplementary foods has no advantage for the infant and may actually be harmful to the infant.

CHAPTER THREE

METHODS

RESEARCH DESIGN

A descriptive (comparative and relationship) design is used. This study was designed to investigate the impact of early introduction of supplementary foods on the nutritional quality of the infants diet. In specific, energy, protein and essential amino acids, fat and the carbohydrate content of the diet is addressed. The study also looks at the relation of income, maternal employment, maternal education, ethnicity and gender to the age of introduction of supplementary foods to the infants diet. Finally a comparison is done of the nutritional intake of the infants by ethnicity, gender and age.

SAMPLE CHARACTERISTICS AND RESEARCH PROCEDURES

The population under study was normal full term infants. The infants were: of birth to four months of age, full term at birth, bottle fed only (as it is easier to quantify formula taken by the infant than breast milk), receiving supplementary foods, lacking any obvious diseases and finally the mothers did not have any diseases such as gestational diabetes or toxemia during pregnancy. The sample population consisted of mexican/hispanics and caucasians by ethnicity only. The mothers of the infants were interviewed for the food intake of the infant using a questionnaire and a 24 hour food recall. Demographic data were also obtained. See Appendix A for the questionnaire. The questionnaire was developed to collect data for the research objectives and was tested prior to the actual data collection. Birth recumbent length and weight and current recumbent length and weight were obtained from the infants medical chart. In 10 cases, where the birth length and weight was not available in the chart, the mother was asked. In 2 cases, where the mother did not know the birth length and weight, the infants two week measures were obtained from the chart. However, the current length and weight were available in the chart for all infants, as they were taken by the nurse practitioners on the day of the well baby check visit and the interview.

Forty eight mothers participated in the study. A signed consent form was completed by each participant. The sample population was obtained from the Arizona Health Sciences Center Pediatrics Clinic, University of Arizona. The mothers were interviewed by S. Bector when they brought the baby to the clinic for a scheduled well baby check. A file number was assigned to each participant to maintain confidentiality. Data was collected in June and July of 1990.

DATA ANALYSIS

Nutritionist 3 computer program was used to analyze the 24 hour food recalls for the nutrient intake of the infant. Few additional foods, as required, were added to this data base from the nutrient information provided by the manufacturer. Lotus 123 and statistical analysis system (SAS) computer programs were used for statistical computations. Anthropometric analysis was performed using a computer program based on the CDC (Centers for Disease Control) Standard Deviation - Derived Growth Reference Curves Derived from NCHS/CDC Reference Population, NCHS Growth Curves for children, Birth - 18 years, United States.

Mean and standard deviations were computed for nutrients under study. The percentiles and the Z scores for length for age, weight for age and weight for length were determined for data at birth and at the time of the study. T test was used for determining the significance of possible differences in nutrient intake between groups by ethnicity, gender and age. Two by two analysis of variance was performed to determine interaction of ethnicity and gender and nutrient intake. Chi-square test was used to determine if the demographic data were related to the age of the introduction of supplemental foods.

CHAPTER 4

RESULTS AND DISCUSSION

The results of the study includes sections on 1) Age of introduction of supplementary foods, 2) Analysis of anthropometric data, 3) Nutrient intake of the infants in comparison to the Recommended Dietary Allowances, 4) Nutrient intake from formula and supplementary foods in relation to the total dietary intake, 5) Caloric distribution of the infants diet, 6) Types of supplemental foods fed to the infant and the various reasons given by the mothers for adding supplementary foods to the infants diet and 7) Comparison of nutrient intake by ethnicity, gender and age.

Age of Introduction of Supplementary Foods

The age of the infants in this study was of birth to four months. There were 19 males and 29 females. The frequency distribution of the age of the infants in the study at the time of data collection is presented in Figure 1.

The mean age of the infant was 2.67 months. All of the infants were receiving some form of supplemental food in addition to the formula. The mean age of the introduction of non-milk foods to the infants diet was 1.58 months. If the plain water category is disregarded as a supplemental food than the mean age of introduction of non milk foods to the infants diet is 1.7 months.

Figure 1: Frequency of Age Distribution of Infants at Time of Interview.

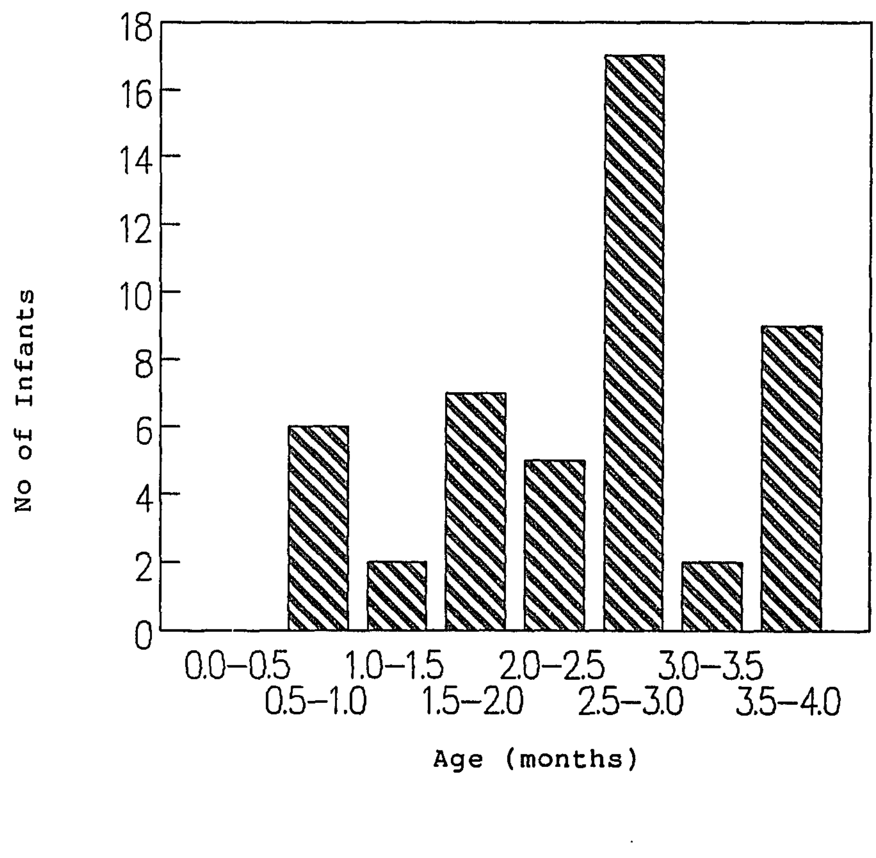


Figure 2 shows the frequency distribution of the age of introduction of non-milk foods. It has been previously reported that most infants in the United States are fed non-milk foods by one month (31), six weeks (58) and to two months of age (18). The results of this study confirm this. Seventy five percent of the infants in this study were receiving non-milk foods before two months.

Figure 2: Frequency Distribution of the Age of Introduction of Non-Milk Foods.

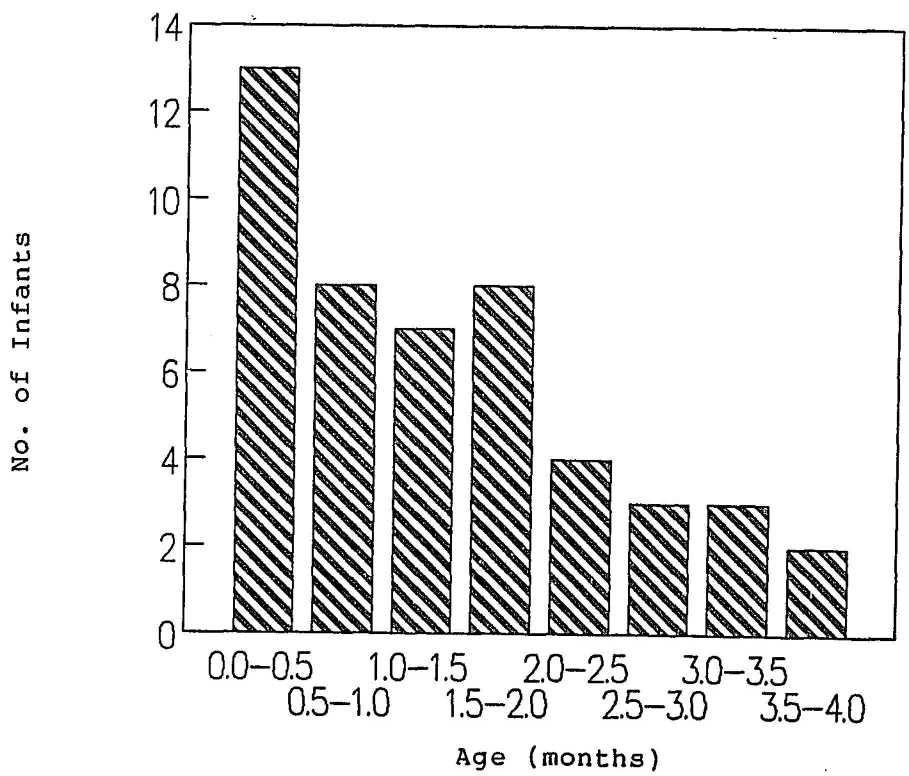


Table 4: The Relation of Demographics to the Age of Introduction of Supplemental Foods to the Infants Diet.

		n*	% of sample population	Mean Age supplemental food started (months)
Income	< 10,000	30	62.5	1.45
	≥ 10,000	18	37.5	1.78
Maternal Employment	Employed	14	29.2	1.73
	Not Employed	34	70.8	1.51
Maternal Education	Junior High	5	10.4	1.8
	High School	34	70.8	1.51
	College	9	18.8	1.57
Ethnicity	Mexican	22	45.8	1.82
	Caucasian	26	54.2	1.38
Gender of Baby	Boy	19	40	1.34
	Girl	29	60	1.73

* N = 48

The relation of demographic data to the age of introduction of supplementary foods is presented in Table 4. It was found that the age of introduction of non-milk foods was not significantly related to the income level, maternal employment, maternal education, ethnicity and gender of the baby. The lack of this relationship may be due to the small sample size. The income level in this study was categorized in two groups - less than 10,000 dollars and greater than or equal to 10,000 dollars. This division was based on the national poverty income level obtained from the Department of Economic Security in Tucson. In this study, 62.5 % of the sample was below the poverty level and therefore it would not be representative of the Pima county population.

Anthropometric Analysis

The mean birth recumbent length and birth weight were 51.27 cm and 3.57 Kg respectively. The mean recumbent length and weight at the time of data collection were 59.35 cm and 5.79 Kg respectively.

Table 5 shows the anthropometric data as a percentile of the National Center for Health Statistics Standards (NCHS). The Z score is also reported. The findings presented in Table 5 indicate that the means for this group of infants for length for age, weight for age and weight for length at birth and at time of data collection were either at or above the 50th percentile. The mean Z score also shows that the anthropometrics for this group of infants is slightly above normal. These results suggest that the infants were eating sufficient food for normal growth.

In comparing data against the NCHS standards the following guidelines are used for interpretation (24): Measurements between the 25th and 75th percentiles

Table 5: Anthropometric Data Presented as Percentile of the NCHS Standards.

	Length for age	Weight for age	Weight for Length
Data at Birth*	64.44 ± 27.78	65.14 ± 25.16	49.94 ± 31.94
Z-score*	0.53 ± 1.10	0.67 ± 1.12	-0.08 ± 0.86
Current Data*	53.11 ± 29.60	66.34 ± 25.05	65.46 ± 23.04
Z-score*	0.13 ± 0.96	0.59 ± 0.91	0.51 ± 0.79
* Mean ± SD, N = 48			

represents normal growth. Measurements between the 10th and 25th and 75th and 90th percentiles may or may not be normal growth, depending on the pattern of earlier and latter measurements and as well as the genetic and environmental factors affecting the child. Measurements above the 95th and below the 5th percentiles definitely require medical evaluation (24).

Nutrient Intake of the Infant in Comparison to the RDA

The adequacy of energy and nutrient intake was evaluated in two ways : 1) Comparing to the Recommended Dietary Allowances. Although the RDA's are not designed for evaluating the adequacy of nutrient intake of individuals, they can be used to determine how well the infants eat as a group. 2) Comparing to the recommended level per unit of body weight which takes into account the individual weights.

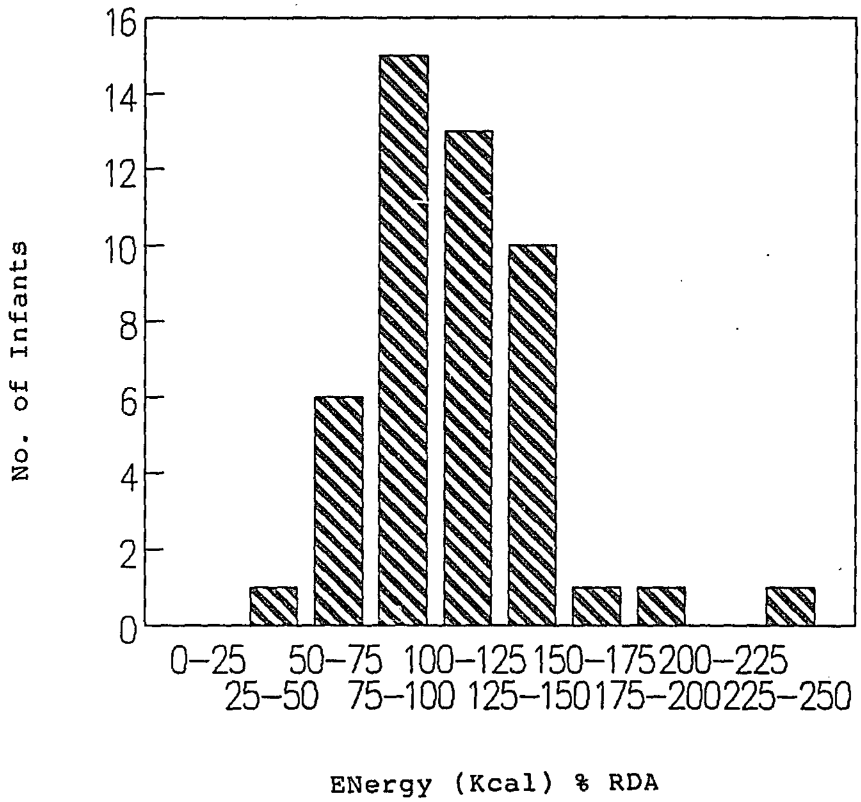
Table 6 shows the mean actual intake and intake percent of RDA for energy, protein and essential amino acids, carbohydrate and fat. The findings of this study indicate that the mean intake for energy, protein and the essential amino acids exceeds the RDA. The excess values are much greater for protein and the essential amino acids than for energy. Figure 3 shows the distribution of energy intake of the infants as percentage of the RDA. Fifty eight percent of the infants are within the 75% to 125% of the RDA for energy. Fourteen point six percent of the infants are below the 75% of the RDA and 27.1% of the infants are above the 125% of the RDA for energy. In assessing the 24 hour food recalls of these groups, the following is found: In the group of infants with an intake below the 75% of RDA, the infants are receiving inadequate formula, ranging from 13.5 ounces to 24 ounces (Mean 22 ounces) and the supplemental foods are replacing the important source of nutrients from the formula. Also of importance note is that the infants are receiving 3 ounces to 9 ounces (mean 5 ounces) of water or herbal tea per day, which has no caloric value. This is further contributing to the dilution of the nutritional quality of the infants diet. Had the infants been receiving formula in place of the water or herbal tea, the energy intake would be increased. Thus it is very important to educate the mothers to not replace formula with plain water, especially during the hot weather in Tucson. Water should be offered to the infant in addition to, not in place of, adequate volumes of formula.

Table 6: Mean Nutrient Values of Dietary Intake for Infants 0-4 months of age receiving supplemental foods.

Nutrient	Actual Intake*	% RDA*
Energy (Kcal)	726 ± 233	107 ± 34
Protein (gm)	18 ± 5	134 ± 41
Carbohydrate (gm)	83 ± 29	--
Fat (gm)	37 ± 12	--
Tryptophan (mg)	212 ± 68	169 ± 58
Threonine (mg)	695 ± 227	173 ± 56
Isoleucine (mg)	810 ± 262	166 ± 54
Leucine (mg)	1497 ± 467	188 ± 59
Lysine (mg)	1082 ± 340	185 ± 58
Methionine (mg)	395 ± 145	274 ± 100
Phenylalanine (mg)	726 ± 245	175 ± 59
Valine (mg)	877 ± 275	162 ± 51
Histidine (mg)	337 ± 111	173 ± 57

* Mean ± SD, N = 48

Figure 3: Energy Intake Distribution as Percentage of the RDA.



In the group of infants with an energy intake in excess of 125% of the RDA just the opposite is happening. These infants are receiving an average of 46 ounces of formula (ranging from 32 ounces to 72 ounces) with additional energy from the supplementary foods. This group of infants was also recieving additional water of 4 to 16 ounces (mean 4.5 ounces). However, since the infants were recieving adequate volumes of formula, the extra water did not affect the energy intake.

As a result of these findings, the current anthropometric data percentiles were compared for these two groups and the following was found. For the group of infants receiving less than 75% of the RDA the mean length for age percentile was 41.12 with a Z score of -0.24, the mean weight for age percentile was 46.39 with a Z score of -0.15 and the mean weight for length percentile was 51.47 with a Z score of 0.32. These findings indicate that with the exception of weight for length value, the infants were slightly below the 50th percentile which may possibly reflect inadequate intake.

In the group of infants with an intake greater than 125% of the RDA the mean length for age percentile was 58.29 with a Z score of 0.37, the mean weight for age percentile was 73.14 with a Z score of 0.94 and the mean weight for length percentile was 69.48 with a Z score of 0.71. This means that the infants were above the norms and this may possibly be related to the higher energy intake. These results indicate that both groups deviated from the norm, with the less than 75% of the RDA group being slightly below and the more than 125% of the RDA group being greater than the norms for growth. However, according to the NCHS standards, this deviation is within the normal growth range of 25th to 75th percentile and is therefore not a major concern.

In the group of infants between 75% to 125% of the RDA, the supplementary foods contributed to the nutrient intake from formula. Table 7 shows the mean energy intake per unit of body weight. Again, as a group, the infants exceeded the recommended intake of 117 Kcal/Kg. The mean intake of energy in this group of infants was 130 Kcal/Kg. However, since the sample of infants in this study is younger than the entire 0-6 month range (upon which the recommendations are made), it would be expected that the energy intake be higher than the RDA. Energy intake distribution was also assessed by kilogram body weight (see scatterplot Appendix C). It was found that 10.4 % of the infants had an energy intake below 88 Kcal/Kg and 27.1 % of the infants had an energy intake above 146 Kcal/Kg. These percentages are fairly similar to what is found with energy intake distribution as percentage of the RDA.

Table 7: Mean Energy and Protein Intake per Kg Body Weight From Total Diet, Formula and Supplementary Foods.

Diet	Energy (Kcal/Kg)*	Protein (gm/Kg)**
Total Intake	130 ± 48***	3.14 ± 1.10
Formula	119 ± 45	3.02 ± 1.10
Supplementary foods	10 ± 10	0.13 ± 0.19

* Recommended intake 0-6 months = 117 Kcal/Kg.
** Recommended intake 0-6 months = 2.2 gm/Kg.
*** Mean ± SD, N = 48

The mean protein and amino acid intake also greatly exceeded the RDA by 134% or more. See Tables 6 and 7. This is due to the fact that all of the infants in the study were receiving formula and most of the formulas are higher in protein and amino acids than breast milk. This is to compensate for any amino acid deficiencies that may result from the formulas. The essential amino acid composition of the formulas in comparison to breast milk is presented in Appendix B. Axelsson and coworkers (5,6,7) reported that infants receiving formula also have altered metabolic indices of protein metabolism in comparison to breast fed infants. Perhaps the quantity and the quality of protein in the formulas needs to be reevaluated.

Expressed as per unit of body weight, the mean protein intake for the infants in this study was 3.1 gm/kg. Although this level is still below the maximum recommended protein level of 4.5 to 5.0 gm/kg, it is suggested that there is no advantage to the normal infant when protein in excess of the requirement is given. The possibility of it being detrimental to the infants is presently the topic of research.

Nutrient Intake from Formula and Supplementary Foods

Table 8 shows the percentage of total energy and nutrient intake contributed by formula and supplementary foods. The findings indicate that formula was the primary source of nutrients. It provided an average of 93% of the total energy consumed and 96%, 99% and 87% of the total intake of protein, fat and carbohydrates respectively. Supplementary foods provided an average of 7% of the calories consumed and 4%, 1% and 13% of the total intake of protein, fat and carbohydrate respectively. Carbohydrate appears to be the major nutrient affected by the early introduction of non-milk foods. This is related to the types of foods that were introduced by the mother, which were mainly high in carbohydrate content and will be discussed in a latter section.

Table 8: Percentage of Total Energy and Nutrient Intake Contributed by Formula and Supplementary Foods.

Nutrient	Total Intake	% of Intake from Formula	% of Intake from Supplement
Protein (gm)	18 ± 5*	96 ± 6	4 ± 6
Fat (gm)	37 ± 12	99 ± 2	1 ± 2
Carbohydrate (gm)	83 ± 29	87 ± 12	13 ± 12
Energy (Kcal)	726 ± 233	93 ± 7	7 ± 7

* Mean ± SD, N = 48

Mean energy and protein intake from non-milk foods, expressed as unit of body weight, presented in Table 7 also show that the infants received most of their dietary energy and protein through the formula. The results from this study fall within the results reported by Marlin and coworkers (33) where formula provided 80 to 94% of the Kcal and 70 to 100% of the fat, 65 to 89% of the carbohydrate and 78 to 100% of the protein. However, Andrew and coworkers (4) reported supplementary foods as providing 27% of the caloric intake, which is much higher than what was found in the present study.

Caloric Distribution of the Diet

The mean caloric distribution of the diet is presented in Table 9. The percentage distribution of calories from protein, fat and carbohydrate was 9.81%, 45.81% and 44.44% respectively. The caloric distribution of the infants diet, from protein, fat and carbohydrate met the recommended distribution. This suggests that the addition of supplemental foods either replaced and contributed to the nutrient intake from formula and thus to the total energy intake, thereby keeping the energy distribution at the recommended level. Another possibility is that the supplementary foods contributed so little to the total intake that perhaps the caloric distribution was not affected.

Table 9: Mean Caloric Distribution of the Diet of Infants 0-4 months receiving supplemental foods.

Nutrient	Caloric Distribution*	Recommended Distribution %**
Protein	9.81 ± 0.96	8 - 10
Fat	45.81 ± 3.17	40 - 50
Carbohydrate	44.44 ± 3.75	40 - 50

* Percent of total energy intake. Mean ± SD, N = 48
** Source: Rohr & Lothian (46)

Types of Supplemental Foods Fed to the Infant

Table 10 shows the various non-milk foods that were fed to the infant. Fifty percent of the infants received baby cereal. Three main reasons were given by the mothers for introducing cereal. Thirty seven and half percent of the mothers stated that the baby was fussy and crying and not satisfied with the formula alone. Twelve point five percent of the mothers said that it was to get the baby to sleep through the night and an additional 6.3% of the mothers stated that the baby was drinking too much formula and the cereal was introduced to decrease the amount of formula taken.

Baby juices, sweetened water or plain water were given to either console the baby because he or she was crying by 14.6% of the mothers or because of the heat by 29% of the mothers. Six point three percent of the mothers said they started the baby on juices because the baby was drinking too much formula. Sweetened or plain herbal tea (Rosa de Castilla and mint) were given by 8.3% of the mothers for laxative purposes. The herbal teas were given by the mexican mothers and may be ethnic related.

Baby fruits and vegetables were given to fill the infant as the mothers felt that the formula was not satisfying the baby. The various reasons given by the mothers in this study are similar to those already cited in the literature and are not recommended as reasons for starting supplementary foods.

Sixty four point six percent of the infants in this study received a combination of two or more of the non-milk foods in addition to the formula. Sugar, karo (corn) syrup and honey were used as sweeteners for water and herbal teas. Use of sweeteners during infancy is not recommended. As it is possible that the use of sweetened foods during the early months of life may predispose the infant to a preference for sweet foods in later life and thus has implications for the subsequent development of dental carries and possibly obesity (4).

Table 10: Percentage of Infants Receiving Various Supplemental Foods.

Food	% of Infants
Baby cereal	50.0
Baby fruit	12.5
Baby vegetable	4.2
Baby juice	35.0
Sweetened water	23.0
Herbal tea	6.0
Plain extra water	66.7
Combination of two or more of the above foods	64.6

Comparison of Nutrient Intake by Ethnicity, Gender and age

There was no significant difference in nutrient intake between the mexican and caucasian infants. Also there was no significant difference between the boys and the girls as to their nutrient intake. These findings are similar to those reported by McKillop and Durnin (35) where no difference in energy intake was found between male and female babies of two to five months of age. Results of the comparisons in this study are presented in tables 11 and 12. A two by two ANOVA indicated that there was no interaction between gender and ethnicity and nutrient intake (see Appendix D). One possible reason for this might be that during early infancy the differences in intake by ethnicity and gender do not occur but surface as the infants get older.

Table 11: Comparison of Nutrient Intake of Infants 0-4 months by Ethnicity.

Nutrient	Mexican N = 22	Caucasian N = 26	t-value*
Energy (Kcal)	736 ± 275**	716 ± 195	0.291
Protein (gm)	17.84 ± 1.36	17.61 ± 4.53	0.145
Fat (gm)	37.93 ± 13.84	36.58 ± 9.92	0.393
Carbohydrates (gm)	83.43 ± 33.62	81.90 ± 25.26	0.179

* no significant difference
** Mean ± SD

Table 12: Comparison of Nutrient Intake of Infants 0-4 months by Gender.

Nutrient	Boys N = 19	Girls N = 29	t-value*
Energy (Kcal)	713 ± 302**	734 ± 180	-0.299
Protein (gm)	17.70 ± 7.01	17.73 ± 4.12	-0.018
Fat (gm)	37.30 ± 15.37	37.13 ± 8.97	0.049
Carbohydrates (gm)	79.11 ± 35.37	84.89 ± 24.51	-0.669

* no significant difference
** Mean ± SD

Table 13 shows the comparison of total energy and nutrient intake by age 0 to 2 months and 2 to 4 months. The results show that the mean energy and nutrient intake decreased with age but the decrease was not significant. Table 13 also shows the comparison of the percentage of intake from supplementary foods by age. Although the mean intake of energy and nutrients from the supplementary foods increased with age, the difference was not significant. The results again indicate that the supplementary or non milk foods contributed little in relation to the formula to the overall intake of infants birth to four months of age.

Table 13: Comparison of Total Energy and Nutrient Intake as Well as Percentage of Energy and Nutrient Intake from Supplementary Foods by Age.

		Energy (Kcal)	Protein (gm)	Fat (gm)	Carbohydrate (gm)
Total Intake	0-2 months (n = 15)	774 ± 227*	18.83 ± 5.62	40.69 ± 12.06	85.94 ± 25.26
	2-4 months (n=33)	704 ± 236	17.21 ± 5.28	35.61 ± 11.46	81.08 ± 30.90
	T-value	0.965	0.967	1.400	0.533
% Intake from supplement foods	0-2 months (n=15)	4.73 ± 4.48	2.07 ± 2.81	0.47 ± 0.64	9.53 ± 8.57
	2-4 months (n=33)	8.27 ± 8.05	5.15 ± 6.98	1.39 ± 2.14	14.76 ± 13.67
	T-value	-1.589	-1.644	-1.640	-1.359

* Mean ± SD, N = 48

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Results from this study suggest that the early introduction of supplementary foods or non-milk foods has little influence on the total mean energy and nutrient intake of infants birth to four months of age. Formula was the major source of energy and nutrients. It provided 93% of the total energy and 96%, 99% and 87% of the total protein, fat and carbohydrate respectively. Supplementary foods provided 7% of the calories and 4%, 1% and 13% of the total protein, fat and carbohydrate intake. Carbohydrate was the major nutrient effected due to the type of non-milk foods fed to the infant which were high in carbohydrates. The caloric distribution from protein, fat and carbohydrate was within the recommended levels. In a small group of infants, the addition of supplementary foods diluted or increased the energy content resulting in less that 75% of the RDA or greater than 125% of the RDA. Again formula was the major source of nutrients. It is in these groups of infants that the early introduction of supplementary foods may be of a special concern.

Overall, the mean energy and nutrient intake of infants exceeded the RDA, with majority of the nutrients coming from the formula. This indicates that perhaps mothers of formula fed infants need to be educated regarding the volumes of formula that should be fed to the infant in order to prevent overfeeding/underfeeding. This study also suggests that because most of the infants were receiving adequate formula, supplementary food is not necessary and provides no advantage to the infant. In fact the early introduction of supplementary foods may result in either under or overfeeding of some infants as found in this study, or have no effect on the intake of other infants. It is suggested that individual nutritional assessments be performed by the health professional during clinic visits to screen those infants that may be at risk due to early introduction of supplementary foods. Supplementary foods may dilute or concentrate the energy content of the diet, neither of which is desirable during this period of life when proper nutrition is of utmost importance.

It is also suggested that the mothers of the infants be educated regarding feeding of infants, especially with regards to the addition of supplementary foods. They should be encouraged to wait until the infant is ready at 4-6 months of age and not to use supplementary foods for non nutritional purposes. They should be informed of the possible consequences of diverging from the recommendations. The education should particularly be reinforced during the summer months, especially here in Tucson, when the mothers are tempted to feed non-milk liquids such as juices, sweetened beverages and water to the infant due to the heat. Mothers should be informed not to replace formula with other liquids.

Analysis of the anthropometric data indicated that the infants as a group were slightly above the norms and thus receiving sufficient food. However, growth deviated from the norm in the group of infants receiving less than 75% or greater than 125% of the RDA.

A difference was not found in energy and nutrient intake by ethnicity, gender and age. Although the percentage from supplementary foods did increase slightly with age. Demographic data such as income level, maternal education and employment, ethnicity and the gender of the baby did not effect the age at which supplementary foods were implemented.

Research in the area of early introduction of supplementary foods and its impact on the nutritional quality of the infants diet is limited and further similar studies are suggested.

APPENDIX A

Questionnaire

QUESTIONNAIRE

FILE NO.__

The purpose of this project is to investigate the nutrient density of the infants diet after foods other than milk are added to the diet.

1. Date of baby's birth ______

2. Length of your pregnancy ______ in weeks

3. Baby's sex? Male ( ) Female ( )

4. Baby's weight at birth ______

5. Baby's current weight ______

6. Baby's length at birth ______

7. Baby's current length ______

8. Is baby bottle fed only? Yes ( ) No ( )

9. What kind of milk or formula(s) does the baby take?
   Milk________, Formula_________, Both________(Give exact name)

10. How is the milk or formula prepared for the baby? Answer from the following:
    (a) Ready to feed
    (b) Mix _______ ounces of concentrated formula plus _______ ounces of water
    (c) Mix ______ tablespoons powdered formula or milk plus _____ ounces of water

11. How old was the baby when you first started feeding foods other than milk to him/her ______

12. For what reason(s) did you start feeding solids to the baby?
    ____
    ____

13. Do you give a vitamin/mineral supplement to the baby?
    Yes ( )
    No ( )
    (If yes, what kind - give name of the vitamin/mineral supplement)

14. What is your ethnic background?
    1. Caucasian ( ) 2. Mexican/Hispanic ( )

15. Who else lives with you? ______ Does he/she work outside the home? ____ What type of work does he/she do? ________________

16. Do you work outside your home? Yes ( ) No ( ) If yes, how many hours do you work outside the home ____What type of work do you do ______ ____________________

17. Approximately what is the yearly household income. Check one.
    1. Under $ 5,000/yr ( )
    2. 5,000 - 9,999/yr ( )
    3. 10,000 - 14,999/yr ( )
    4. 15,000 - 19,999/yr ( )
    5. 20,000 - 24,999/yr ( )
    6. Over 25,000/yr ( )

18. What was your highest level of education completed ___
    Grade school ( ) Junior high ( ) High school ( )
    College ( ) Graduate school ( )

19. Where do you seek advice on what and how to feed your baby?
    1. Doctor ( )
    2. Family ( )
    3. Other ( ) _______ indicate where

TWENTY-FOUR HOUR FOOD RECALL

FILE NO.__

TIME OF FEEDING	TYPE OF FOOD	AMOUNT TAKEN BY THE BABY

APPENDIX B

Essential Amino Acid Levels in Breast Milk verses Infant Formula

Table 14: Essential Amino Acid levels in Breast milk and Typical infant formulas.

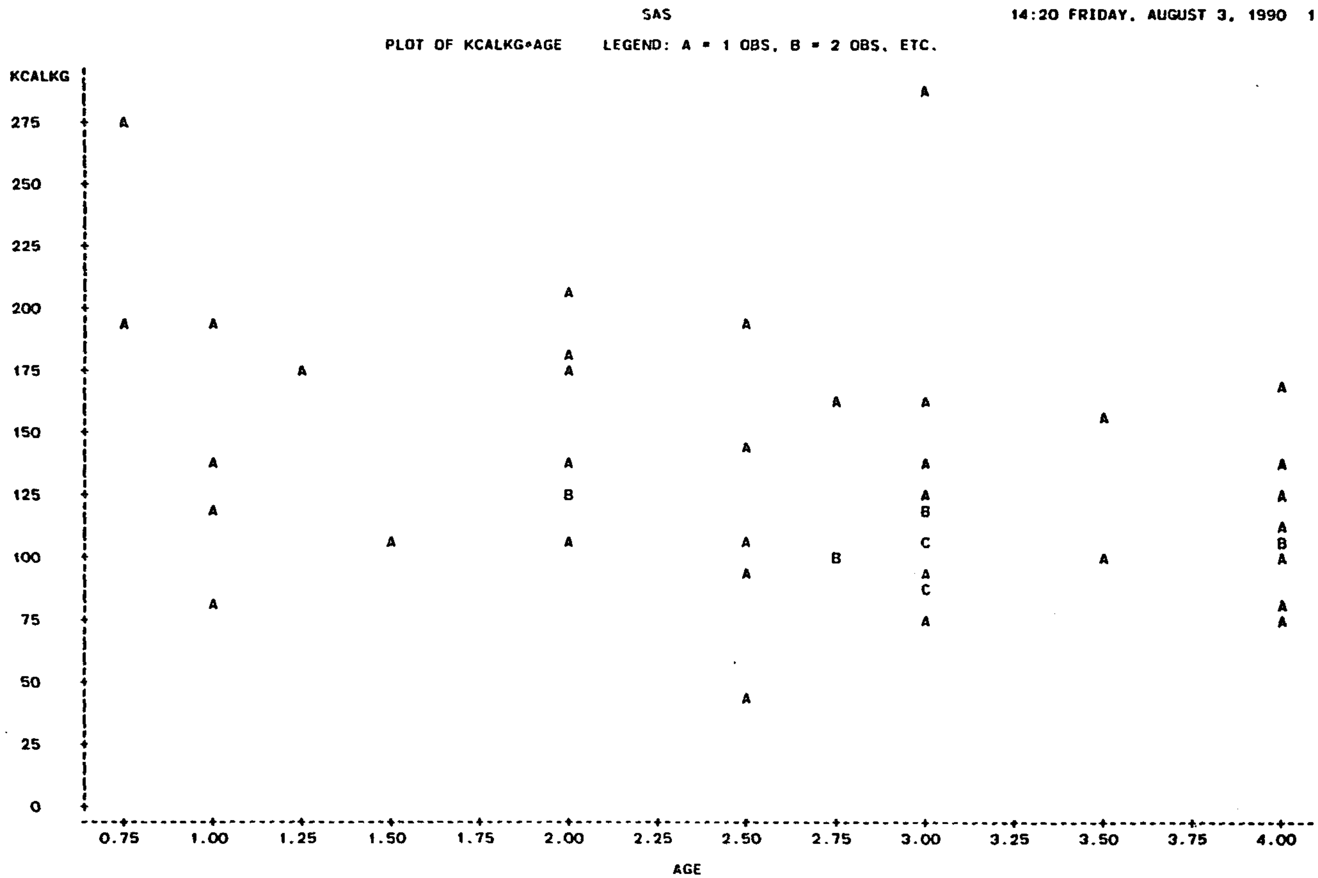
	Mature Breast Milk	Typical milk based formula		Typical Whey adapted formula	
	mg/dl	mg/dl	ratio	mg/dl	ratio
Histidine	31	43	139	43	139
Isoleucine	67	97	145	87	130
Leucine	120	158	132	197	164
Lysine	90	140	156	167	186
Methionine	19	42	221	37	195
Phenylalanine	48	78	162	63	131
Threonine	58	72	124	95	164
Tryptophan	30	27	90	28	93
Valine	87	108	124	97	111

Source: Raiha (45).

APPENDIX C

Energy Intake Per Kg Body Weight by Age

Figure 4. Energy Intake per Kg Body Weight by age



APPENDIX D

Nutrient Intake by Ethnicity and Gender

Table 15: Nutrient Intake by Ethnicity and Gender.

	Mexican		Caucasian	
	Girls n = 11	Boys n = 11	Girls n = 18	Boys n = 8
Energy (Kcal)	740 ± 228	732 ± 326	730 ± 150	686 ± 284
Protein (gm)	17.83 ± 5.41	17.85 ± 7.46	17.67 ± 3.27	17.49 ± 6.86
Fat (gm)	37.87 ± 11.77	37.98 ± 16.24	36.67 ± 7.10	36.37 ± 15.11
Carbohydrate (gm)	84.72 ± 28.63	82.14 ± 39.37	84.99 ± 22.52	74.95 ± 31.11

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