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PRODUCTION AND EVALUATION OF SOME FOOD FORMULAS AS COMPLEMENTARY FOOD FOR BABIES USING SOME FRUITS AND VEGETABLES

BY

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ABSTRACT

Twenty one food formulas included control were prepared for as complementary food babies (1-3 year age). Control was formulated mainly from papaya puree, potato, carrot, sugar and skim milk powder. In addition to other fruit ingredients such as apple, apricot, strawberry, banana, mango and guava which were added in combinations for the different formulas. These formulas were bottled in jars and thermal proccesed. The formulas were microbiologically examined to assure the safety of these products. The microbiological results indicated that the formulas were safe. So, the formulas were sensory evaluated by adult panelists and babies (20 boys + 20 girls). Seven formulas which obtained high scores in both adult panelists and babies were selected. These formulas were the control sample and formulas No. 1, 6, 12, 13, 16 and 18. These formulas were selected to complete the study. They were evaluated for physicochemical and rheological characteristics. Also, the cost of formulas was roughly estimated. Physiochemical characteristics indicated that the formulas contained good amount of carbohydrates beside some carotenoids, anthocyanine, ascorbic acid and minerals. So, the formulas were suitable for babies aged from 1-3 years as complementary food. Rheological characteristics of baby food formulas were also studied at the temperatures ranged from 0-100 °C. Bingham and Power law models were found to fit adequately over the entire temperature range. All baby food formulas exhibited yield stress, which decreased exponentially with the increase in temperature. All the formulas were found to behave as a pseudoplastic fluid. Arrhenius model gave a satisfactory description of the temperature dependence of apparent viscosity. The activation energy for apparent viscosity of all baby food formulas were found at range from 6.56 to 14.03 kJ/mol. From estimating the acceptability and costs it may be concluded that these products could be produced at home scale as well as on the commercial scale for babies gardens (kindergarten) and exportation.

INTRODUCTION

The weaning period is the most critical phase of infants life. During this period mother's milk is not generally adequate to cover the nutritional requirements and support body growth. With increasing the numbers of working mothers in the developing countries, the market of baby foods has been increased tremendously (Ahmed and Ramaswamy, 2006). Breast milk alone cannot support the nutrition and other needs of the growing infant (Elsom and weaver, 1999). There comes a time when complementary weaning foods must be introduced into the diet to fill the gap between what is provided by milk and what the infant requires to cover his nutritional requirements (Brown *et al.*, 1998). In the case of baby food products, mothers often try the product first and decide whether to give it to their children or not (Gambaro *et al.*, 2005).

In most developing countries commercial weaning foods of excellent quality either imported or locally produced are presently available, but due to sophisticate processing, expensive packing, extensive promotion and solid profit margins, the price of these commercial products are generally in the order of 10-15 times the cost of the common staple foods. While these products are generally highly appreciated and their use and value are well understood, they are priced beyond the purchasing power of the majority of population in the lower-income groups, Who spent already about 50-75% of their income in common foods (Wurdemann and Van de Meerendok, 1994).

Different baby food formulas consisting from dehydrated rice, soybean flour and different fruit purees were prepared by Segura *et al.* (1988) and acceptable to be given to children. Soliman *et al.* (2003) studied the characteristics of baby food formulas based on Anna apple pulp in addition to other ingredients such as some fruits, dry milk and sugar. Some of those formulas had high scores when evaluated by children as panelists.

Minerals are required for normal cellular function, and are critical for enzyme activation, bone formation, hemoglobin composition, gene expression, and amino acid, lipid and carbohydrate metabolism (IOM, 2004). The quality of fruit-based infant foods is of considerable important, since babies may be obtaining all their nutrients from a small number of foods, so over-processed infant foods may affect the nutritional status of consumer (Maite *et al.*, 2002).

Fruits and vegetables are interest good sources for antioxidants, vitamins and minerals. Fruits contain various carotenoids, which are a group of red, orange, and yellow pigments. Several of the carotenoids are vitamin A precursors. Carotenoids also, function as quenchers of singlet oxygen, as antioxidants, in gene activation, and in inflammation and immune processes as a modulator of lipoxygenases (Bendich, 1993). Carotenoids have been reported to have medical (Mathews-Roth, 1982) and industrial applications (Almela, *et al.*, 1991). Biochemical and epidemiological studies indicate that carotenoids may have protective effects in the prevention of cancer, carodiovascular disease, cataracts, and macule disease as well as neuralgia, inflammatory, and immune disorders (Bendich, 1993).

Many of tropical fruits appear to be good sources of vitamin C, β-carotene, Mg, K. etc. Papayas are a good source of vitamin C and A. Papaya ranks first among 13-17 fresh fruits for vitamin C content per 100g edible tissue

(Gebhardt and Thomas, 2002). Papaya purée is used in soft drink and ice cream. It is gaining popularity in mixed drinks (Hooper, 1995).

Papaya can tolerate a wide range of growing conditions. It is now distributed throughout the tropics between 32 North and 32 South latitude (Chan, 1993). Egypt cultivates papaya in many Governorates. Recently Egypt started to export some of the papaya (MALR, 2005).

Guava fruits are one of the most popular fruits in Egypt. Guava fruits are considered of excellent organoleptic qualities and good source of vitamin C (El-Farra, 2002).

Mango is one of the most important and widely cultivated fruit of the tropical and subtropical world. It is also called king of the tropical fruits. This is because of its succulence, exotic flavor and delicious taste. Mango puree is a popular formulating material for many types of mixed products (Hooper, 1995). Carrot was the richest source of carotene (Bao and Chang, 1994). Beside it is rich by vitamin C and many minerals (El-Mansy *et al.*, 2003). Banana is principal in the baby food, ice cream and bakery industries. It is principally used to lighten the color and to improve the texture in mixed fruit drinks (Hooper, 1995).

Apple and apple products are considered as splendent source in baby food industry. It is high in nutritive value due to its contents of carbohydrate, vitamins and a lot of minerals (Mattick and Moyer,1989).

Potato is one of the world's major agricultural crops, consumed daily by millions of people. Potato have long been recognized as healthy, economical and low in fat food product (Abu-Ghannam and Crowley, 2006).

Apricot is widely cultivated stone fruit in Egypt. Recently was cultivated in reclaimed land (El-Saidawy *et al.*, 1997).

Strawberries are an important source of vitamin C in the human diet (Nunes *et al.*, 1998). The recommended dietary allowence for vitamin C is 60 mg/day in adults, which can be met with an average of 100g of strawberries per day (Food and Nutrition Board, 1989).

Rheology of food products has a significant role in product development, quality control, sensory evaluation and design and evaluation of the process equipment. Measurements of rheological parameters have been considered to provide analytical tool to yield meaningful insight on the structural organization of food (Ahmed and Ramaswamy, 2004 and 2006).

Therefore, owing to all these advantages, the present work aims to formulate different babies food formulas consisting mainly from papaya puree and other some fruits and vegetables to use as a complementary for baby food formulas with lower cost. To evaluate the formulas from standpoint of organolyptically by some adults and babies. Physicochemical and rheological properties of the best formulas were evaluated. Finally, to estimate the cost of formulas.

MATERIALS AND METHODS

Materials:

Papaya (*Carica papaya* L.) was obtained from the farm of Horticulture department, Fac. of Agric. Moshtohor. Potato (*Solanum tuberosumm* L.), carrot (*Daucus carota* L.), Anna apple (*Malus sylvestris* L.), apricot (*Prunus armeniaca* L.), strawberry (*Fragaria xananassa* L.), banana (*Musa sapientum* L.), mango (*Mangifera indica* L.), guava (*Psidium guajava* L.) were purchased from certain farmers at Toukh area, Qaliuobia Governorate and immediately transported to the laboratory. Skim milk powder imported from Poland 4% moisture and 96% T.S. (37.5% protein, 0.85% fat, 8.7% ash and 48.95% carbohydrate) was obtained from Arab dairy company, Sendbees village, Qalyobia Governorate, Egypt. Sugar was purchased from local market.

Methods:

Preparation of raw materials:

Papaya, potato, carrot, apple, apricot, strawberry, banana, mango, and guava were washed with tap water, to remove dirt, adhering latex and other foreign matters, as well as to reduce the initial contamination with microorganisms, then papaya and banana fruits were hand peeled, papaya seeds was carefully removed and the fruits were cut into small parts. While, carrot was peeled using stainless steel peeler, the stones of apricot and mango were removed after cutting the fruits to two halfs and the green part of strawberry was removed by hand. After that, all fruits and vegetables were blanched by using a pressure cooker where the blanching time was adjusted to be proper for each material. Potato was peeled by hand after blanching. The blanched materials were transferred to Moulinex blender (Blender Mixer, type: 741) equipped with cutters and stirrer which crushed and homogenized each of above mentioned materials into a mixture of pulp, then the mixture was passed through fine strainer to separate the pulp from any skin or seeds and then it was packed in plastic bags, sealed and frozen (Gupta, 1998).

Preparation of formulated baby food formulas:

Twenty one baby food formulas included control were prepared as shown in Table (A). The control sample included papaya (45 parts), potatoes (10 parts), carrot (5 parts), sugar (5 parts) and skim milk powder (5 parts). Three other fruits (each of 10 parts) were added to the components of the control to complete the different formulas. The added fruits were selected from the following: Apple, apricot, strawberry, banana, mango and guava. So, the different combinations were ${}^{6}C_{3}$ which equal to 20 formulas. The ratio of papaya was applied as a result to preliminary experiments which indicated that 45 parts of papaya was the best ratio. The following Table (A) shows the different prepared formulas. After mixing the ingredients of the formulas, they were bottled in tight Jars, then thermally processed at 100° C for 40 min (Soliman, *et al.*, 2003)

Microbiological examination:

The following examinations were done for all formulas: Total viable bacterial count, mesophilic sporeformers bacteria, yeasts and moulds, coliform group were enumerated and the presence of (Salmonella spp. and *Staphylococcus aureus*) was detected according to the methods established by (APHA, 1992).

Table (A): Formulated baby food formulas.

Formulas	Ingredients parts										
	Papaya	**Potato**	**Carrot**	**Skim milk powder**	**Sugar**	**Apple**	**Apricot**	**Straw-berry**	**Banana**	**Mango**	**Guava**
Control	45	10	5	5	5	-	-	-	-	-	-
1	45	10	5	5	5	10	10	10	-	-	-
2	45	10	5	5	5	10	10	-	10	-	-
3	45	10	5	5	5	10	10	-	-	10	-
4	45	10	5	5	5	10	10	-	-	-	10
5	45	10	5	5	5	-	-	-	10	10	10
6	45	10	5	5	5	10	-	-	10	10	-
7	45	10	5	5	5	-	10	-	10	10	-
8	45	10	5	5	5	-	-	10	10	10	-
9	45	10	5	5	5	10	-	10	10		-
10	45	10	5	5	5	10	-	10	-	10	-
11	45	10	5	5	5	10	-	10	-	-	10
12	45	10	5	5	5	10	-	-	10	-	10
13	45	10	5	5	5	-	10	-	10	-	10
14	45	10	5	5	5	-	-	10	10	-	10
15	45	10	5	5	5	10	-	-	-	10	10
16	45	10	5	5	5	-	10	-	-	10	10
17	45	10	5	5	5	-	-	10	-	10	10
18	45	10	5	5	5	-	10	10	10	-	-
19	45	10	5	5	5	-	10	10	-	10	-
20	45	10	5	5	5	-	10	10	-	-	10

Sensory evaluation:

Sensory evaluation of the different formulas was carried out by two groups of panelists. The first group included 40 babies (20 boys and 20 girls), in the age of (1-3 years). The test was carried out as recommended by Kroll (1990) who depended on the face reaction of the baby (Figure 1). Beside if the baby asked for additional amount. Hedonic scale was used which included super good (9), really good (8), good (7), just a little good (6), may be good or bad (5), just a little bad (4), bad (3), really bad (2) and super bad (1) as shown in Fig. (1). The second group included 40 adults who were asked to evaluate texture (mouth feel), color, taste and flavor (odor) according to Pastor *et al.* (1996). Overall acceptability was calculated from the obtained scores of the evaluated attributes.

Physicochemical analysis:

Moisture content, total solids, ash, fat, protein, ascorbic acid and starch were determined according to AOAC (2000). The pH value was measured with a pH meter model Consort pH meter P107. Titratable acidity was determined by titration with NaOH 0.1 N solution using phenolphthalein as indicator according to AOAC (2000). Total and reducing sugars were determined by Shaffer and Hartman method as described in the AOAC (2000). Total pectin content and fractional pectin components were determined by the method of Robertson (1979). Crude fiber was determined by Weende method in which VELP Scientifica extraction unit was used. The method is based on the solubilization of non-cellulosic compounds by sulfuric acid and hydroxide solutions as described in AOAC (2000). Pulp content was determined according to El-Mansy *et al.* (2000a). Color index was determined by the method of Meydov *et al.* (1977). Carotenoids were determined according to Harvey and Catherine (1982). Total anthocyanins was measured according to the method of Skalaki and Sistrunk (1973). Three replications of all these determinations were carried out.

Super good	(9 point score)
Really good	(8 point score)
Good	(7 point score)
Just a little good	(6 point score)
May be good or bad	(5 point score)
Just a little bad	(4 point score)
Bad	(3 point score)
Really had	(2 point score)
Super bad	(1 point score)

Fig. (1): Typical face scale

Energy value (EV): Total calorie estimates (kcal) for formulas were calculated on the basis of a 100 g sample using Atwater values for fat (9 $kcal.g^{-1}$), protein (4.02 $kcal.g^{-1}$) and carbohydrate (3.87 $kcal.g^{-1}$) (Mansour and Khalil, 1997).

EV = (Carbohydrate x 3.87) + (protein x 4.02) + (fat contents x 9)

Minerals content were determined according to AOAC (2000) using Perkin-elmer, 2380 Atomic absorption spectroscopy apparatus in central laboratory of Veterinary Faculty, Moshtohor.

Rheological measurements:

Viscosity measurement was carried out by the Brookfield Digital Viscometer Model DV-II+ with 18 rotational speeds for comprehensive data gathering (0.3, 0.5, 0.6, 1.0, 1.5, 2.0, 2.5, 3, 4, 5, 6, 10, 12, 20, 30, 50, 60 and 100 rpm), the up and down curve of a shear rate were done. A temperature-controlled water bath was used to regulate the temperature of the samples. The Brookfield spindles small sample adapter were used. Data were analysed by using Brookfield Software Rheocalc version (1.1). Bingham plastic (BP) and Power Law (PL) math models provide a numerically and graphically analyze of the behavior of data sets.

Bingham Plastic model (BP):

The Bingham equation is

$\tau = \tau_o + \eta\gamma$ (1)

According to Bingham (1922) and mentioned by Pastor *et al.* (1996) and Ibarz *et al.* (1996 a,b).

Power law model (PL):

The power law equation is

$\tau = k\,\gamma^n$ (2)

As mentioned by Pastor *et al.* (1996).

Activation energy and the effect of temperature on viscosity:

Activation energy was calculated using Arrhenius-type equation as mentioned by Ibarz *et al.* (1996 a), El-Mansy *et al.* (2000 a,b):

$\eta = \eta_\infty \exp (E_a/RT)$ (3)

where: η is the viscosity, η_∞ is a constant (It is the viscosity at infinite temperature), E_a is the activation energy of flows (J/mol), **R** is the gas constant and **T** is the absolute temperature in °K.

Estimation of cost:

The cost of formulas was roughly determined according to the price of the materials used in preparing the formulas, gas, electricity, jars, water and 25% gain. The cost of the prepared formulas were compared with the marketing commercial baby foods at the same time.

Statistical analysis:

Data of chemical composition of ingredients and formulas were expressed as mean of three replicates ± standard error (SE). Data for the sensory evaluation of all baby food formulas were subjected to the analysis of variance followed by multiple comparison using LSD (Snedecor and Cochran, 1989).

RESULTS AND DISCUSSION

Chemical properties of ingredients:

The chemical properties of ingredients used for the preparation of the baby food formulas are presented in Table (1). The results demonstrated that the moisture content of ingredients varied from 76.06% to 91.11% in banana puree and strawberry juice, respectively. Potato puree had the highest level of ash being about 1.154% while, the lowest level of ash was found in apple puree being about

0.394%. Also, potato puree had the highest level of protein (1.55%). So, skim milk powder and potato puree were the main source of protein in formulated baby food formulas. Potato puree was the main source for starch. The pH value for papaya puree; the main component in formulated baby food, was 5.36. The pH value for other ingredients ranged from 3.59 to 6.14 for strawberry juice and carrot puree, respectively. Titratable acidity for all ingredients was less than 1% except for apricot juice which, was 1.792%. With regard to total sugars the data showed that the banana puree had the highest amount of total sugars,15.208%. Pectin ranged from 0.709 to 3.420% in carrot puree and apricot juice, respectively. The pectin can hold the water in baby stomach. So, pectin is very important for children especially when they have diarrhea. On the other hand guava puree had the highest level of fiber (2.091%) followed by banana puree (1.802%) and apricot juice (1.734%), while potato puree had the lowest level of fiber being (0.648%). Papaya puree contained amount of carotenoids less than carrot puree. So, adding of carrot puree will increase the percentage of carotenoids in all formulas. As known that the carotenoids help the baby as color to attract any foods. Strawberry juice had high percentage of anthocyanin more than other fruits or vegetables ingredients. Results appeared that ascorbic acid content was ranged from 9.386 to 91.896 mg/100g in carrot and papaya puree, respectively. The results of chemical composition for ingredients used for the preparation of baby food formulas were in agreement with those obtained by MaCance and Widdowson's (1992), Matuk *et al.* (1996), Abd-Elaziz *et al.* (2000), Tsen and King (2002), Alline *et al.* (2003), El-Mansy *et al.* (2003), Nourian *et al.* (2003), Ramulu and Rao (2003) Bahlol (2005) and Wall (2006).

Microbiological quality of formulas:

The overall bacteriological status of the formulas was observed to be satisfactory. The obtained results revealed that the total viable bacterial count was 36.5 and 88 CFU/g for formulas No. 5 and 8, respectively as indicated in Table (2). The low counts of the examined formulas indicated adequate thermal process, good quality of raw materials and as a result of the good different processing conditions under which the production of formulas was carried out. Mesophilic sporeformers bacterial count was 8.5 and 36 CFU/g for formulas No. 2 and 7 respectively. However, yeasts and moulds, coliform group, Salmonella and *Staphylococcus aureus* were found to be absent in all the formulas. The microbiological results were in agreement with many authors such as Wadud *et al.* (2004) and Soliman (2001). The microbiological results suggested that the formulas are suitable to be submitted for sensory evaluation by babies and adult panelists .

Sensory evaluation:

Analysis of variance for data of sensory evaluation for baby food formulas evaluated by babies indicated that there are no significant differences ($P > 0.05$) between the 21 prepared baby food formulas. The averages of the obtained scores were in the range from 6.70 to 7.83. These means that all the prepared baby food formulas were accepted by the babies without significant differences, Tables (3 and 5).

Table (1): Chemical composition of ingredients

Components	Papaya puree	Potato puree	Carrot puree	Apple puree	Apricot juice	Strawberry juice	Banana puree	Mango puree	Guava puree
Moisture %	87.02±0.438	79.63±0.574	88.21±0.729	86.21±0.681	84.23±0.526	91.11±0.191	76.06±0.716	82.67±0.884	84.85±0.925
Total solids %	12.98±0.438	20.37±0.574	11.79±0.729	13.79±0.681	15.77±0.526	9.89±0.191	23.94±0.716	17.33±0.884	15.15±0.925
Ash %	0.672±0.006	1.154±0.002	0.731±0.006	0.394±0.009	0.873±0.004	0.531±0.005	0.955±0.002	0.601±0.005	0.677±0.007
Fat %	0.471±0.001	0.338±0.001	0.483±0.003	0.271±0.002	0.162±0.001	0.276±0.003	0.512±0.002	0.408±0.007	0.192±0.005
Protein %	0.739±0.007	1.550±0.003	1.432±0.008	0.236±0.005	0.841±0.012	0.483±0.011	1.409±0.065	0.953±0.020	1.091±0.002
pH values	5.36±0.002	5.86±0.001	6.14±0.002	3.70±0.000	3.84±0.009	3.59±0.007	4.87±0.013	4.35±0.002	4.01±0.000
Titratable acidity %*	0.146±0.000	0.582±0.002	0.194±0.000	0.543±0.007	1.792±0.008	0.921±0.009	0.431±0.009	0.503±0.002	0.427±0.004
Starch%	0.577±0.016	14.388±0.401	0.037±0.000	0.182±0.001	0.368±0.001	0.007±0.000	3.00±0.072	0.318±0.002	0.008±0.000
Total sugars %	7.123±0.061	0.902±0.002	7.331±0.011	9.083±0.053	7.194±0.11	4.175±0.009	15.208±0.031	11.29±0.099	8.873±0.049
Reducing sugars %	2.984±0.031	0.292±0.002	2.101±0.006	5.932±0.091	3.234 ±0.08	2.855±0.092	9.324±0.079	2.440±0.006	3.279±0.077
Non reducing sugars %	4.139±0.022	0.610±0.004	5.230±0.107	3.151±0.067	3.960±0.016	1.320±0.002	5.884±0.010	8.850±0.027	5.594±0.009
Total pectic substances %	1.883±0.008	0.713±0.006	0.709±0.003	1.506±0.002	3.420±0.006	2.022±0.006	0.772±0.004	2.337±0.005	1.318±0.008
Water soluble pectin %	0.826±0.004	0.311±0.009	0.201±0.007	0.368±0.000	1.07±0.05	0.885±0.006	0.309±0.005	0.910±0.002	0.656±0.000
Ammonium oxalate soluble pectin %	0.631±0.016	0.203±0.006	0.369±0.011	0.827±0.001	1.62±0.04	0.503±0.009	0.322±0.000	0.736±0.005	0.419±0.001
Acid soluble pectin %	0.426±0.005	0.199±0.001	0.139±0.009	0.311±0.001	0.73±0.04	0.634±0.051	0.141±0.003	0.691±0.002	0.243±0.001
Fiber %	1.301±0.011	0.648±0.004	0.930±0.007	1.536±0.007	1.734±0.06	1.040±0.009	1.802±0.441	0.883±0.006	2.091±0.063
Carotenoids (mg/l)	29.826±0.210	3.819±0.011	107.36±2.105	3.832±0.016	21.080±0.417	2.316±0.092	2.721±0.044	18.700±0.791	5.869±0.005
Anthocyanine (O.D. at 535)	0.0152±0.000	-	2.453±0.013	2.282±0.001	0.171±0.004	15.39±0.399	-	0.016±0.000	-
Ascorbic acid (mg/100g)	91.896±1.601	11.184±0.007	9.386±0.127	14.500±0.501	11.862±0.113	47.291±0.767	15.355±0.829	38.272±1.001	76.836±2.908

Each value is the average of three replicates ± S.E.
Chemical composition on wet weight basis
*as anhydrous citric acid.

Table (2): Microbiological quality of baby food formulas (CFU/g).

Formulas No.	TVBC*	MSB*	Formulas No.	TVBC*	MSB*
Control	57	10.5	11	66.5	21
1	40.5	10.5	12	80.5	25
2	84.5	8.5	13	69	29
3	76	30	14	57	28
4	40	35	15	77	19
5	36.5	19.5	16	64.5	17
6	67	30	17	67	13
7	82	36	18	67.5	19
8	88	30	19	58.5	21
9	72	17	20	67	35
10	65.5	16			

* (TVBC) Total viable bacterial count (MSB) Mesophilic Sporeformers bacteria

Table (3) Sensory evaluation scores of baby foods given by babies*

Products	Overall acceptability (Mean ±S.E.)
Control Formula	7.50 ± 0.11
Formula (1)	7.80 ± 0.17
Formula (2)	7.20 ± 0.28
Formula (3)	7.13 ± 0.25
Formula (4)	6.70 ± 0.28
Formula (5)	7.30 ± 0.18
Formula (6)	7.50 ± 0.26
Formula (7)	7.08 ± 0.29
Formula (8)	7.25 ± 0.20
Formula (9)	6.85 ± 0.27
Formula (10)	7.30 ± 0.22
Formula (11)	7.33 ± 0.21
Formula (12)	7.58 ± 0.26
Formula (13)	7.48 ± 0.23
Formula (14)	7.03 ± 0.24
Formula (15)	7.30 ± 0.23
Formula (16)	7.83 ± 0.24
Formula (17)	7.28 ± 0.19
Formula (18)	7.45 ± 0.26
Formula (19)	7.25 ± 0.24
Formula (20)	7.50 ± 0.18

*Values represent of 40 babies (Mean ±S.E.)
*Anova (Table 5) indicated no significant differences between baby foods ($p > 0.05$).

On the other hand, analysis of variance for obtained scores by adults for overall acceptability indicated significant differences ($P > 0.05$) between the different formulas (Tables 4 and 5). So, LSD test was applied to carry out the multiple comparisons which indicated that the different formulas could be divided into four significant groups ($P > 0.05$) (LSD = 3.26), where there are no significant differences ($P > 0.05$) between the different formulas inside every group. The first group included formulas No. (16, 12, 15, 6 and 18) which had scores average in the range 90.05 –

93.1. The 2nd, 3rd and 4th groups included formulas Nos. (control, 2, 1 and 13), (17, 11, 14, 3 and 4) and (7, 8, 5, 19, 20, 9 and 10), respectively with groups scores averages of 84.75-87.88, 79.03-82.23 and 75.68-78.83, respectively.

Correlation coefficient (r) between scores for overall acceptability obtained by the babies and that obtained by the adults was calculated which was (0.62). It is not strong correlation. So, it is recommended to carry out the sensory evaluation of the food formulas by the babies themselves as mentioned before by Kroll (1990).

Seven baby food formulas were selected which obtained high scores in both baby and adult panelists. These formulas were No. 16, 12, 6, 18, 1, control and 13. These formulas had scores average of (84.75-93.10) in the case of adult panelists and scores average of (7.45-7.83) which equal to 82.77-87% in the case of baby panelists. The study was continued on the selected formulas that their physicochemical, rheological properties and costs of preparation were determined.

Physicochemical properties of formulated baby food formulas:

The food formulas were prepared to produce as complementary baby food using some fruits and vegetables. But the visibility of chemical composition is too important. Therefore some chemical analyses were carried out. Data in Table (6) indicated that moisture and total solids content in food formulas nearly varied. This is due to the adding kind of fruits and vegetables. It is clear that the total solids in control formula was the highest among other formulas which was 25.60 due to dried skim milk powder and sugar more than other formulas. Control formula had the highest level of ash content (1.06%) followed by formula No. 18 (0.93%), while formulas No. 1 and 6 had the lowest level of ash being 0.86%. Fat in all formulas was less than 0.5%. The protein content of formulas was ranged from 1.51% in formula No.13 to 1.84% in control formula. Titratable acidity and pH values are important as it affected on the taste and flavor. The pH values indicated that all formulas were non acid food, this may be due to the high percentage of papaya puree in all formulas. The obtained data indicated that the total sugars was the major component in total solids in all formulas and the main source of energy value. Data in the same table show that the highest percentage of total sugars was detected in the control formula (16.35%), while the lowest percentage was found in formula No. 1 (12.91%). The percentages of total pectic substances and fiber were acceptable and suitable for babies related to the important of those for excertion. The level of anthocyanine in formulas No. 1 and 18 was higher than other formulas attributed to the addition of strawberry juice. Amount of carotenoids was found in formula No. 16 more than other formulas related to apricot juice and mango puree. Also, data indicated that color index (measurements as O.D. at 420) for formulas No. 16 was higher than other formulas. Ascorbic acid in all formulas was ranged from 18.16-25.52 mg/100g for formulas No. 1 and control respectively. Formulas no. 12, 13 and control had the highest levels of ascorbic acid related to papaya puree and guava puree. Energy values for formulate baby food formulas were estimated from the percentage of total carbohydrate, protein and fat contents and were 73.42 and 88.89 k cal/100g formula in formulas No. 1 and control, respectively.

Table (4): Sensory evaluation scores of baby foods given by Adults

Products	Sensory attributes					
	Color (20)	Taste (20)	Odor (20)	Consistency (Texture) (20)	Mouth feel (20)	Overall acceptability (100)
Control Formula	19.00a ± 0.23	16.58gh ± 0.35	17.28bcd ± 0.28	17.78abc ± 0.27	17.35bcd ± 0.28	87.88bc ± 1.12
Formula (1)	17.10ef ± 0.41	17.03ab ± 0.31	16.93d ± 0.32	17.33bcd ± 0.30	17.55bcd ± 0.26	85.98c ± 1.24
Formula (2)	17.38cdef ± 0.33	17.03gh ± 0.35	17.20cd ± 0.29	17.18bcde ± 0.32	17.18cde ± 0.35	86.10c ± 1.32
Formula (3)	16.85efgh ± 0.26	15.93a ± 0.28	16.00efg ± 0.25	16.38efgh ± 0.32	15.33hi ± 0.34	80.55efg ± 0.95
Formula (4)	15.85hi ± 0.29	15.65a ± 0.30	15.45gh ± 0.29	16.25efgh ± 0.23	15.28hi ± 0.26	79.03efgh ± 0.93
Formula (5)	15.33jk ± 0.41	15.58efgh ± 0.47	15.35gh ± 0.33	16.25efgh ± 0.34	15.48ghi ± 0.36	78.10ghi ± 1.48
Formula (6)	18.00bcd ± 0.22	17.78h ± 0.30	18.03abc ± 0.29	18.40a ± 0.24	17.80abcd ± 0.28	90.30ab ± 0.96
Formula (7)	16.68fgh ± 0.25	15.50a ± 0.37	15.65gh ± 0.30	16.58defg ± 0.23	14.83i ± 0.47	78.83fghi ± 1.35
Formula (8)	15.53ijk ± 0.36	15.78cdef ± 0.37	15.85fgh ± 0.38	16.05fgh ± 0.38	15.05i ± 0.43	78.60ghi ± 1.21
Formula (9)	14.78jk ± 0.34	15.28a ± 0.36	15.70fgh ± 0.34	15.58h ± 0.47	14.70i ± 0.43	76.00hi ± 1.51
Formula (10)	14.78jk ± 0.35	14.75defg ± 0.37	15.15h ± 0.30	15.80gh ± 0.27	15.15i ± 0.31	75.68i ± 1.07
Formula (11)	15.63ij ± 0.39	16.05bc ± 0.32	16.50def ± 0.31	16.95cdef ± 0.31	16.23fgh ± 0.34	81.95def ± 1.25
Formula (12)	18.45ab ± 0.23	18.33defg ± 0.29	18.23a ± 0.33	18.43a ± 0.35	18.25ab ± 0.31	92.20a ± 1.21
Formula (13)	16.93efg ± 0.30	16.68cd ± 0.38	16.83de ± 0.30	17.33bcd ± 0.27	17.03def ± 0.30	84.75cd ± 1.21
Formula (14)	15.75i ± 0.33	15.83defg ± 0.33	15.88fgh ± 0.30	16.68defg ± 0.30	15.58ghi ± 0.40	80.60efg ± 1.30
Formula (15)	18.28ab ± 0.21	18.05bc ± 0.34	17.93abc ± 0.30	18.08ab ± 0.31	18.23ab ± 0.26	90.60ab ± 1.24
Formula (16)	18.43ab ± 0.23	18.63defg ± 0.22	18.63a ± 0.24	18.43a ± 0.32	18.70a ± 0.27	93.10a ± 1.02
Formula (17)	16.15ghi ± 0.31	16.43fgh ± 0.26	16.50def ± 0.23	16.03gh ± 0.47	16.28efg ± 0.35	82.23de ± 0.92
Formula (18)	17.70bcde ± 0.27	18.08gh ± 0.24	18.05ab ± 0.24	18.00ab ± 0.29	17.95abc ± 0.29	90.05ab ± 1.05
Formula (19)	14.68k ± 0.37	15.60fgh ± 0.36	15.68fgh ± 0.29	16.10fgh ± 0.26	15.30hi ± 0.37	77.60ghi ± 0.97
Formula (20)	14.78jk ± 0.38	15.40cde ± 0.35	15.53gh ± 0.35	15.90gh ± 0.30	14.98i ± 0.34	76.88hi ± 1.16
L.S.D at $p \leq 0.05$	0.87	0.93	0.83	0.88	0.94	3.26

*Values represent of 40 panellists (Mean ±S.E.)

* a, b,...: There is no significant difference ($p \geq 0.05$) between any two means have the same superscripts, within the same acceptaptability attribute.

Table (5): ANOVA Table for sensory evaluation of different baby food formulas given by babies and adults.

Sensory attributes	F	P	F Critical	Conclusion
Overall acceptability given by babies	1.4119	0.1078	1.5834	NS*
Adult attributes:				
Overall acceptability given by adults	23.4815	2.90E-67	1.5834	VS*
Color	19.3292	6.49E-56	1.5834	VS
Taste	11.4630	1.58E-32	1.5834	VS
Odor	13.1543	9.13E-38	1.5834	VS
Texture	8.9519	1.47E-24	1.5834	VS
Mouth feel	15.4805	8.73E-45	1.5834	VS

*NS (non significant) *VS (very significant)

Minerals content of baby food formulas:

The mineral composition of fruits can reflect the trace mineral of soil in a geographic region (Forster *et al.*, 2002 and Wall 2006) and varies with climate, maturity, cultivars, and agricultural practices. Some minerals content of the babies food formulas are shown in Table (7). The obtained data revealed that the highest potassium content are found in control formula and this may be due to the high percent of papaya puree, followed by formula No. 6. However the lowest potassium content was found in formula No. 18. Calcium is particularly essential for infant and young children (Whitney *et al.* 1990). The calcium content of all formulas ranged between 11.5 to 23.24 mg/100g. For, sodium, it is clear that formula No. 6 had the highest value while formula No. 1 had the lowest value. The trace elements (Magnesium, iron, manganese, copper and zinc), contents were ranged from 4.34 to 5.72, 0.0011 to 0.0873, 0.0604 to 0.0904, 0.0895 to 0.1527 and 0.225 to 0.290 mg/100g, respectively. The variation of the minerals content in all formulas, may be due to the different content of these elements in raw ingredients. From the results of minerals it could be concluded that the formulas are considered as a source for some minerals.

Rheological behavior of Baby food formulas:

In the food industry, rheological characteristics of concentrated fruit juices and baby food are a significant property in addition to chemical and physical properties. Moreover, rheological characteristics depend on both the chemical composition of fruits and processing conditions. However, a knowledge of the flow behavior of vegetable & fruit juices will be useful in quality control, calculating energy usage, process control and equipment selection (Kaya and Belibagli, 2002). Viscosity; a rheological property, is also considered as an important physical characteristic related to the quality of liquid food products. Rheological behavior of food depends on various factors like temperature, composition and total solids content.

Table (6): Physicochemical properties of baby food formulas

Components	Control Formula	Formula 1	Formula 6	Formula 12	Formula 13	Formula 16	Formula 18
Moisture %	74.40± 0.148	78.46± 0.052	77.00± 0.026	76.34± 0.309	76.56± 0.034	77.10± 0.023	77.23± 0.030
Total solids %	25.60± 0.148	21.55± 0.052	23.00± 0.026	23.66± 0.309	23.44± 0.034	22.90± 0.023	22.77± 0.030
Ash %	1.06± 0.017	0.86± 0.001	0.86± 0.002	0.87± 0.001	0.88± 0.002	0.87± 0.002	0.93± 0.001
Fat %	0.39± 0.002	0.34± 0.004	0.38± 0.009	0.36± 0.003	0.36± 0.001	0.36± 0.001	0.36± 0.001
Protein %	1.84± 0.023	1.65± 0.023	1.72± 0.028	1.64± 0.071	1.51± 0.055	1.56± 0.027	1.71± 0.067
pH values	5.79± 0.030	4.99± 0.009	5.51± 0.012	5.17± 0.015	5.02± 0.009	5.12± 0.009	5.04± 0.009
Titratable acidity %*	0.42± 0.003	0.47± 0.009	0.36± 0.003	0.39± 0.003	0.35± 0.006	0.42± 0.003	0.52± 0.003
Starch%	2.10± 0.031	1.59± 0.017	1.94± 0.017	1.78± 0.041	1.82± 0.033	1.57± 0.027	1.88± 0.036
Total sugars %	16.35± 0.173	12.91± 0.118	14.63± 0.202	14.99± 0.121	14.82± 0.139	14.31± 0.49	13.92± 0.104
Reducing sugars %	10.35± 0.038	8.16± 0.026	8.97± 0.107	8.99± 0.416	8.83± 0.023	8.94± 0.107	7.93± 0.217
Non reducing sugars %	6.00± 0.027	4.75± 0.088	5.66± 0.059	6.00± 0.071	5.99± 0.042	5.37± 0.037	5.99± 0.013
Total pectic substances %	1.71± 0.011	1.97± 0.009	1.52± 0.004	1.48± 0.007	1.53± 0.005	1.76± 0.007	1.73± 0.009
Water soluble pectin %	0.63± 0.007	0.88± 0.009	0.53± 0.003	0.51± 0.008	0.68±; 0.002	0.74± 0.006	0.77± 0.002
Ammonium oxalate soluble pectin %	0.51± 0.005	0.61± 0.005	0.68± 0.005	0.69± 0.005	0.56± 0.008	0.49± 0.006	0.71± 0.006
Acid soluble pectin %	0.57± 0.007	0.48± 0.007	0.31± 0.002	0.28± 0.007	0.29± 0.005	0.53± 0.004	0.25± 0.003
Fiber %	1.326± 0.003	1.476± 0.008	1.444± 0.006	1.529± 0.018	1.583± 0.016	1.483± 0.006	1.513± 0.007
Pulp content (V/V) %	60.48± 0.145	46.4± 0.217	67.71± 0.152	67.69± 0.187	53.33± 0.167	44.34± 0.052	51.27± 0.088
Colour index (O.D. at 420 nm)	0.382± 0.005	0.431± 0.003	0.397± 0.006	0.339± 0.001	0.422± 0.004	0.587± 0.004	0.525± 0.004
Carotenoids (mg/l)	19.18± 0.100	19.94± 0.054	19.43± 0.049	17.79± 0.069	19.87± 0.130	23.00± 0.073	20.53± 0.054
Anthocyanine (O.D. at 535)	0.210± 0.004	1.137± 0.008	0.463± 0.001	0.477± 0.005	0.189± 0.006	0.211± 0.003	0.999± 0.003
Ascorbic acid (mg/100g)	25.52± 1.09	18.16± 0.73	18.68± 0.46	22.08± 0.89	21.16± 1.13	20.82± 0.71	19.92± 1,02
Energy values k cal/100 g	88.89	73.42	80.34	80.48	79.60	77.80	77.95

Each value is the average of three replicates ± S.E.
Chemical composition on wet weight basis
*as anhydrous citric acid

Table (7): Minerals content of baby food formulas (mg/100g on wet weight basis):

Minerals	Formulas No.						
	Control	1	6	12	13	16	18
K	115.58	108.39	109.07	89.05	69.47	86.79	66.40
Ca	17.25	11.50	13.71	13.78	13.78	17.36	23.24
Na	13.77	11.19	15.14	12.94	13.51	12.65	12.75
Mg	5.36	4.34	5.72	4.91	5.21	4.96	5.12
Fe	0.0029	0.0070	0.0873	0.0047	0.0057	0.0098	0.0011
Mn	0.0604	0.0821	0.0904	0.0663	0.0718	0.0678	0.0718
Cu	0.1179	0.0915	0.1527	0.0981	0.1292	0.0895	0.1190
Zn	0.256	0.260	0.290	0.231	0.233	0.225	0.285

The shear stress - shear rate data obtained during experimentation were applied to some rheological models (Bingham, power law, IPC Paste, Herschel and Buckley, Casson's models). The Binghm (Eq., 1) and power law (Eq., 2) models were the best models described the flow behavior of the analysed baby food formulas. Bingham model was applied to determine the plastic viscosity (η) and yield stress (τ_o), while the power law model was applied to determine the consistency coefficient (k) and flow behavior index (n).

Baby food formulas exhibited yield stress, which decreased exponentially with temperature. The consistency coefficient k values decreased from 24812 to 3142 mPa.s^n when the temperature was increased from 0 °C to 100 °C, for control formula. At higher temperatures, due to rupture, the food structure becomes weak resulting in the lowering of yield stress (Steffe, 1992). The same trend was found in all baby food formulas. The flow behavior index (n) was less than unity and increased with temperature for the 7 baby food formulas. This indicated that the baby food formulas behaved as a shear-thinning (pseudoplastic) fluid. The numerical values of the rheological parameters of the all 7 baby food formulas showed that there was little difference in their flow behavior index. Because pseudoplasticity is related to the average site of the particle of the disperse phase, it can be assumed that all samples had particles of similar size, due to a similar finishing operation.

The plastic viscosity (η) was found to decrease with increased shear rate, which also proves its pseudoplastic or shear thinning nature. The yield stress values at selected temperatures were incorporated into the plastic viscosity value, and apparent viscosity-shear rate data fitted the Bingham adequately over the entire temperature range. The coefficients for the Bingham and Power law model are given in Table 8.

Decreasing in yield stress values with increasing temperature is related to the strength of the coherent network structure as the force per unit area required to breakdown the structure, followed by a rupture of network bond or linkages connecting the flow units (Qiu and Rao, 1988 and Alonso and Zapico, 1996). The decrease in yield stress may be related to the formation of a softer network of particles. It may be due to the expulsion of liquid from the matrix upon storage, it must act as a lubricant among particles thus reducing particle-particle interaction as well as the resistance to flow. The rheological properties, especially the yield stress, are important in the handling, storage, processing and transport of baby foods.

Table (8): Rheological parameters of baby food formulas

Baby food formulas	Temp. (°C)	Parameters for different models					
		Bingham			Power law		
		η	τ_o	Conf.%	K	n	Conf.%
Control formula	0	2169	26.9	99.1	24812	0.21	99.0
	20	1282	21.1	98.9	21810	0.22	99.6
	40	1202	19.5	99.0	18204	0.26	99.5
	60	1132	7.34	97.8	6219	0.47	98.7
	80	1019	5.60	99.2	5449	0.49	99.4
	100	989.7	2.80	97.4	3142	0.66	99.7
Formula 1	0	2618	10.2	97.9	10864	0.46	98.8
	20	1868	7.12	98.4	8212	0.48	99.3
	40	1633	7.61	98.3	7234	0.50	98.7
	60	851.4	6.73	98.7	6298	0.50	99.4
	80	817.6	5.33	98.0	4331	0.52	98.9
	100	669.3	3.18	98.6	2770	0.64	99.0
Formula 6	0	2546	22.4	98.2	22869	0.32	98.2
	20	2039	21.9	98.6	21738	0.32	98.7
	40	1452	20.1	98.1	19270	0.36	98.1
	60	1287	14.3	99.5	14299	0.39	98.0
	80	983.4	6.72	99.1	5335	0.44	99.2
	100	655.1	4.75	99.3	4810	0.46	99.3
Formula 12	0	2346	19.3	97.2	18574	0.40	96.5
	20	2067	16.5	97.0	14874	0.40	97.4
	40	1743	12.0	98.4	12148	0.46	97.1
	60	1452	11.5	97.9	9595	0.47	98.6
	80	1221	3.27	98,8	3281	0.65	98.2
	100	1044	3.72	99.2	3269	0.68	99.1
Formula 13	0	2580	12.4	98.1	8496	0.64	97.3
	20	2163	10.2	98.3	7200	0.70	98.4
	40	2095	6.37	98.6	5179	0.77	98.9
	60	1395	4.07	98.4	2733	0.95	99.1
	80	1370	2.19	98.1	1896	0.96	99.6
	100	1081	1.64	98.5	1266	0.97	99.1
Formula 16	0	1960	15.40	96.6	11751	0.60	97.5
	20	1628	13.98	97.8	8482	0.61	98.4
	40	1408	8.34	98.2	5810	0.65	99.1
	60	957.5	6.52	98.4	2030	0.70	99.5
	80	687.7	3.05	98.0	1212	0.90	99.0
	100	482.7	1.96	99.3	877	0.93	99.0
Formula 18	0	3223	19.6	97.8	15686	0.60	98.5
	20	2792	16.6	97.6	12844	0.61	98.9
	40	2475	10.7	98.1	8851	0.65	99.5
	60	1912	8.14	97.8	7155	0.70	99.2
	80	1408	4.84	99.2	1712	0.94	99.4
	100	1229	1.11	99.2	904.9	0.94	99.3

Where:

(η):Plastic Viscosity (mPa.s)

(τ_o): Yield Stress (N/m^2)

(k): Consistency index ($mPa.s^n$).

(n): Flow index (dimensionless).

Table (9): Arrhenius-type constants relating the effect of temperature and viscosity at 100 RPM on baby food formulas.

Baby food formulas	E_a (kJ/mol.)	η_∞ (mPa.s)	Determination coefficient (r^2)	Temperature range (°C)
Control Formula	7.615	4.553	0.988	0 -100
Formula 1	10.76	3.234	0.986	0 -100
Formula 6	13.69	2.264	0.986	0 -100
Formula 12	8.616	4.23	0.982	0 -100
Formula 13	6.564	4.975	0.986	0 -100
Formula 16	14.03	1.569	0.972	0 -100
Formula 18	9.041	4.206	0.967	0 -100

Finally the flow behavior of baby foods is very important with respect to the eating characteristics of the product; it must be thick enough to stay on a spoon but not so thick that a baby would have trouble during swallowing it. The rheological parameters of the tested formulas ranged as (1282 - 2792) and (7200 - 21810) for η and k, respectively. So, it could be recommended to prepare baby foods with η and k values in the mentioned ranges.

Effect of temperature on rheological characteristics:

Temperature has significant effect on rheological characteristics of baby foods. It is seen from Table 8 that the apparent viscosity (η) and consistency index (K) decreased significantly while the flow behavior index value (n) increased with an increase in baby food formulas temperature (Table 8). The Arrhenius model (Eq., 3) gave a satisfactory description of the temperature dependence of apparent viscosity at 100 rpm. The coefficients were computed using the least-square technique. In Table 9, flow activation energy (E_a) values were shown for each baby food formulas calculated using the Arrhenius equation, together with the respective fitting parameters and determination coefficients (r^2). Activation energy (E_a) data obtained in this work were very similar to that reported by Bahlol (2000), for strawberry juice and its products. The activation energy increased with decreasing pulp content, pseudoplastic behavior and temperature. Therefore, temperature had a greater effect on the formula with higher pulp content.

Cost of formulated baby food formulas:

Cost of the formulated baby food formulas and other baby food commercial products (Gerber and Riri) were roughly calculated as shown in Table (10). The costs of formulated baby food formulas were estimated without wages, rent, machinery and equipment, transportation, taxes, advertisement and maintenance. The price of formulated baby food formulas are suitable for the low national income in Egypt and more less than those of commercial products. From estimating the cost it may be concluded that these products could be produced for children garden (kindergarten), exporting and could be for home made.

Table (10): Cost of formulated baby food formulas and commercial samples.

Price (LE)	Formulas No:							Commercial samples	
	Control	1	6	12	13	16	18	Gerber	Riri
Kilogram of ingredients *	2.29	1.96	2.64	2.13	2.13	2.33	2.18	-	-
Electricity, gas and water	0.05	0.05	0.05	0.05	0.05	0.05	0.05	-	-
Jars	3.08	3.08	3.08	3.08	3.08	3.08	3.08	-	-
Collection of cost	5.42	5.09	5.77	5.26	5.26	5.46	5.31	-	-
25% gain of cost	1.36	1.27	1.44	1.32	1.32	1.36	1.33	-	-
Kg of formulas	6.78	6.36	7.21	6.58	6.58	6.82	6.64	44.23	120

* After preparing any fruit or vegetables (peeling and removing stone).
The drained weight of baby food in Gerber and Riri jar was 130 and 100g, respectively.

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إنتاج وتقييم خلطات غذائية للأطفال كأغذية تكميلية باستخدام بعض الفاكهة والخضر

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تم إنتاج ٢١ خلطة غذائية مكملة لغذاء الأطفال من سن ١ إلى ٣ سنوات باستخدام بعض منتجات الخضر والفاكهة حيث فى العينة الكنترول تم استخدام فاكهة الباباظ ذات القيمة الغذائية الجيدة والسعر الرخيص كمكون أساسي بنسبة ٤٥ % بالإضافة إلى "بوريه الجزر بنسبة٥% ، وبوريه البطاطس بنسبة ١٠%، سكر ٥% ، لبن فرز مجفف بنسبة ٥% " كمكونات ثابتة فى التركيب أما باقي الخلطات فتم إضافة بوريه أو عصير ثلاثة منتجات من كل من (الجوافة ، المشمش، التفاح، المانجو، الموز والفراولة) بنسبة إضافة ١٠% لكل منها وتم تعبئة الخلطات فى برطمانات زجاجية وتم إجراء المعاملة الحرارية لها على درجة حرارة ١٠٠ ° م لمدة ٤٠ دقيقة بعد ذلك قيمت هذه الخلطات ميكروبيولوجيا لدراسة أمانها قبل تقييمها حسيا ووجد أنها أمنة ميكروبيولوجيا. تم إجراء التقييم الحسى للخلطات المنتجة بواسطة ٤٠ طفلا " ٢٠من الذكور، ٢٠ من الإناث وكذلك أجرى التقييم الحسى للخلطات بواسطة ٤٠ محكم من الكبار وتم اختيار ٧ خلطات بناء على نتائج التقييم الحسى للأطفال والكبار وتم إجراء تحليل كيماوى طبيعى وريولوجى لهذه الخلطات المختارة وأوضحت دراسة خصائص التركيب الكيماوى لهذه الخلطات أنها مناسبة كغذاء مكمل للأطفال من سن ١-٣ سنوات وفى نفس الوقت اقتصادية من حيث التكلفة ولذلك يمكن إنتاجها على النطاق المنزلى وعلى النطاق الصناعى وكذا يمكن تصديرها للخارج. كما أوضحت نتائج التحليل الريولوجى أن جميع الخلطات المختارة تسلك السلوك "الغير نيوتينى "البلاستيكى الكاذب" مع إجهاد خضوع وتم دراسة تأثير درجة الحرارة على قوام نفس الخلطات ووجد أن للحرارة تأثير كبير على قوام هذه الأغذية وتم حساب طاقة التنشيط ومن خلال هذه الاختبارات وجد أن هذه الخلطات ذات قوام جيد ومناسبة كغذاء للأطفال فى هذا السن.