Studies in development of complementary food for infants

Dissertation II Report

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CERTIFICATE

This is to that Mona Saini (Registration No. 11718245) has personally completed M.Sc. dissertation II entitled **(Studies in development of complementary food for infants)** under my guidance and supervision. To the best of my knowledge, the present work is the result of her original investigation and study. No part of dissertation has ever been submitted for any other purpose at any University.

The project report is appropriate for the submission and the partial fulfilment of the conditions for the evaluation leading to the award of Master of Nutrition and Dietetics.

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Chapter 1: Introduction

According to the Academy of Pediatrics, after thoughtfulness of all the factors tangled, recommends that the ideal time for introducing solid foods into the infant's diet is 4-6 months of age (Sajilata et al.2002). The solid food which are given to infant at this age are generally called as complementary food (Singhal et.al 2002). Weaning period is time period of feeding infants along with breastfeed to meet nutritional requirements according to WHO (Vali et.al 2015).

Need of weaning food

Introduction of other foods in infants' diet becomes necessary after the age of 4-6 months because breast milk alone is not adequate to meet the rising requirements of the infants (Sihag et.al 2016). Prevalence of malnutrition , iron deficiency anemia, xerophthalmia due to vitamin a deficiency and other cause which increase undernutrition infant rate(Sihag et.al 2016). The main purpose to initiating complementary foods is to provide the flavour and variety to the infant's diet, to provide the absent nutrients, to impart the baby swallowing, chewing and eating skills, and to familiarise the baby to the taste and flavour of home food (Srivastava et.al 2015). Proper feeding practices are fundamental to survival, development, growth, health and nutrition of toddler (Katepa et.al 2015). To nutritional need of infant during weaning period is challenge for mother, which may ultimately effect toddler mental and physical growth(Dewey et.al 2016).

Moringa oleifera ,best known and most widely distributed, belongs to the family Moringaceae. The height of tree ranges from 5 to 10 m. Moringa oleifera, an important food commodity, has massive attention as the 'natural nutrition of the tropics'. The immature pods, fruit, leaves and flower of this tree are used as nutritive vegetable in many countries, particularly in India (Anwar *et al*., 2005). Moringa leaves have been reported to be a rich source of β -carotene, protein, ascorbic acid, potassium, calcium and act as a good source of natural antioxidants, thus enhance the shelf-life of fat containing foods owing to presence of various antioxidant compounds viz, ascorbic acid, flavonoids, phenolics and carotenoids (Dillard and German, 2000; Siddhuraju and Becker, 2003). .

Chickpea (*Cicer arietinum* L.) also called garbanzo bean or Bengal gram is a pulse of old world belonging to family Fabaceae and is consumed worldwide, especially in Afro-Asian countries(Jukanti *et al.* 2012 ; Rachwat *et al*. 2013). It is cultivated extensively throughout the world including East Africa, South and North America, Central and South Asia, Mediterranean basin and Australia with India being the leading manufacturer contributing about 66% of the global produce (Rachwat *et al,*. 2013; Segev *et al*., 2012).

Based on the variation in size, shape and color, chickpea is classified into two categories:kabuli type- having thin seed coat that varies in color from white to cream and desi type- having thicker, irregular shaped seed coat varying in color from light tan to black (Segev *et al*., 2012).Chickpea is considered as cheap and best source of healthy vegetarian diet containing high quality proteins, fats, dietary fiber, vitamins and both macro minerals like calcium, potassium, sodium and magnesium and micro minerals like copper, iron and zinc. Chickpea flour is known to have low glycemic index and low carbohydrate availability (Rachwat et al., 2013).Studies have shown that the energy provided by desi variety grains is 327 k cal/100g and that provided by kabuli variety grains is 365 k cal/100g (Maheri-Sis et al., 2008). It was also seen that chickpea protein digestibility varies between 48-89.01% (Rachwat *et al*., 2013).

The consumption of beans is often limited due to the presence of several anti-nutritional factors(ANF) like phytic acids, tannins, saponins, trypsin inhibitors etc.. The presence of these anti-nutritional factors reduces the bio availability of nutrients present in them and decreases the protein digestibility and starch digestibility. However, treatments like cooking, soaking, germination and roasting prove beneficial in reducing the ANF and hence increase the consumption of beans.In the present study an attempt has been made to develop a ready to eat complementary food using underutilized pulse viz. chickpea, Moringa oleifera and other valuable ingredients.

Chapter 2: Problem background

For the infants who are stunted causes permanent damage, including reduced cognition and educational performance in childhood, reduced efficiency and earnings in adulthood and if assist by extreme weight gain in later stages of childhood which lead to increase threat of chronic diseases (Aguayo et al., 2017).Because of small gastric capacity, infant consume small amount of food during complementary feeding. Hence complementary foods should be high in nutrients density and can be fed after short interval of period to support mental and physical growth and developments of infants (Dewey et al., 2016). It is challenging to meet the nutritional requirements of infants 6-23 months of age particularly in poor resource setting where it can lead to stunted growth and development during pre-schooling (Dewey et al., 2016).

Chapter 3 Review of Literature

3.1 RDA for infant

The full term infant is able to digest all the macro-molecules, viz. Proteins, fats and carbohydrates. As there is rapid growth during infancy, the nutritional requirements are made accordingly. In India, expert committee of ICMR recommends the dietary requirements of the infants. 1.2 g/kg body weight of protein is required for proper physical development. Micro-nutrients like calcium, iron, Vitamin A, Vitamin B complex etc are essential for carrying out various metabolic processes. All the nutrient requirements should be adequately met to avoid any nutritional deficiencies. **Table 1** represents RDA for infants.

3.2 Chickpea (Cicer arietinum L.)

Chickpea is one of the widly and oldest consumed annual grain legume which is cultivated throughout the world including Asia, Mediterranean basin, East Africa , Near East Australia and North and South America (Segev *at al.,* 2012). It is the third most largest grown food legume in the world followed by common bean (*Phaseolus vulgaris* L.) and pea (*Pisum sativum* L.) (Xu *et al,*. 2014). Based on the variations in shape, size and color, chickpea is divided into two categories: kabuli-type(thin seed coat with color ranging from white to cream) and desi-type(thick, irregular seed coat with color ranging from light tan to black) (Segev *et al.,* 2012). It is cheap and best source of carbohydrates, proteins, dietary fiber, vitamins and minerals. The consumption of chickpea is done only after cooking, roasting, baking and frying so as to reduce anti-nutritional factors present in them. In India, the flour of chickpea called ‘besan’ is used in snack preparation and in the other parts of the world, it is used in stews, soups and salads (Jukanti *et al*., 2012). It is also known to possess various health benefits.

Table 1: RDA for 6-12 month infant

The recommended dietary allowances for 6-12 months infant as suggested by ICMR is:

Component	Value
Energy(kcal/d)	80
Protein(g/d)	1.69
Visible fats(g/d)	19
Calcium(mg/d)	500
Iron(mg/d)	05
Vitamin A(µg/d)	350
B-carotene(µg/d)	2800
Thaimine (mg/d)	0.3
Vitamin B2(mg/d)	0.4
Ascorbic acid (mg/d)	25
Dietary folate (µg/d)	25
Cynocobalamin (µg/d)	0.2
Magnesium (mg/d)	45
Pyrodoxine (mg/d)	0.4
Niacin(mg/d)	650

Table 2: Nutritional composition of chickpea

Component	Varieties of chickpea (%)	
	Kabuli	Desi
Dry matter	92.08	91.17
Crude protein	24.63	22.76
Crude fibre	6.49	9.94
Total tannin	0.09	0.12
Total phenolic compounds	0.27	0.26
Non fibrous carbohydrate	49.13	46.81
Starch	39.12	38.48
Soluble sugars	8.43	7.53

(Rachwat et al., 2013)

Table 3: Nutritional composition of chickpea

Components	Chickpea (kabuli)	Chickpea (desi)
Vitamins(mg/100g)		
Folic acid	299.0	206.5
Vitamin C	1.34	1.65
Vitamin B1	0.49	0.29
Vitamin B2	0.26	0.21
Vitamin B3	1.22	1.72
Vitamin B5	1.02	1.09
Vitamin B6	0.38	0.30
Vitamin E	12.9	11.2

(Jukanti et al. 2012)

3.3.1 *Antinutritional factors in chickpea*

The occurrence of anti-nutritional factors limits the biological value and use of chickpea in food. The presence of anti-nutrients interferes with the consumption and limits the availability of other nutrients present in them. Phytic acids are known to decrease the bioavailability of minerals like calcium, zinc and iron in the body by forming the soluble complexes with them (Rachwat *et al*., 2013). The phytic acid content(4.9-6.1 mg/g) of chickpea is found to be less than red bean (11-17mg/g), field bean (10.1-13.7mg/g), and soybean (10-14.7mg/g) (Thavarajah *et al*., 2012).Tannins are known to inhibit enzyme activity, decrease the digestion and make chickpea astringent (Jukanti et al. 2012).Chickpea is known to contain higher saponin content (56g/kg) as compared with pulses such as green gram(16g/kg), lentils(3·7– 4·6g/kg), field bean (4·3g/kg) and broad bean (3·5g/kg) and is responsible for giving bitter taste to pulse (Jukanti *et al.*, 2012).

Table 4: Antinutritional composition of chickpea

Anti-nutrients		References
Tannins (mg/g)	4.85	Alajaji et al. 2006
Phytic acids (g/kg)	10.6	Wang et al. 2010
Trypsin inhibitors (mg/g dm)	8.29	Wang et al. 2010
Saponins (g/kg)	56	Jukanti et al. 2012

3.3.2 Health potential of chickpea

Chickpea is considered as a functional food with a potential of optimizing health and reducing several chronic diseases. The antioxidant properties of chickpea due to phenolic compounds are known to reduce the oxidative stress in humans and the presence of bioactive compounds like isoflavones is known to have oestrogenic, antifungal, antibacterial and antioxidant properties (Rachwat *et al*.,2014). The presence of essential fatty acid that is linoleic acid produce the hormone- like prostaglandis which lowers the blood pressure. On the medical side, chickpea is used as stimulant, appetizer, tonic and in the treatment of bronchitis. Ikpea increases the bowel health and relives constipation. Chickpea is also effective in the control of cholesterol, diabetes and blood pressure (Jukanti *et al*., 2012).Both rice bean and chickpea are known to contain anti-nutrients which limit their consumption in diet despite having high health potential. Several processing methods are adopted to reduce or eliminate the anti-nutrients present in the beans. These include soaking, germination, cooking and roasting. There is significant reduction in the amount of anti-nutrients when these processing techniques are conducted at variable time and temperature.

3.4 Moringa oleifera

Moringa oleifera belongs to the family of Moringaceae and it is an effective remedy for malnutrition. It is rich in nutrition due to the presence of essential phytochemicals present in leaves, seeds and pods. It provide 7 times more vitamin C as compare to oranges, 9 times more protein than yoghurt,10 times more vitamin A than carrots, 15 times more potassium than bananas ,17 times more calcium compared to milk and 25 times more iron than spinach (Rockwood and Anderson et al., 2013). Its easy cultivation makes it as good solution for malnutrition. In Countries such as Senegal and Benin they treat their children with moringa (Kasolo and Bimenya et al., 2010). Moringa is rich in phytosterols such as sitosterol, stigmasterol, kampesterol which act as precursors for hormones. These compounds increase the estrogen production, which stimulates the proliferation of the mammary gland ducts to produce milk. It is also use to treat malnutrition in younger children having age less than 3 (Titi and Estiasih et al., 2013)

3.4.1 Health potential of moringa oleifera

Moringa leaf extracts is a good source of antioxidants, anticancer agents and radical scavenging radicals. The compounds in leaves such as glucosinolates, niazimicin ,benzyl isothiocyanate are responsible for anticancer activity (Hermawan et al., 2012). Moringa oleifera is called as a panacea. It can cure more than 300 diseases. It is use as herbal medicine by Africans and

Indians. It cures both Type 1 and Type 2 diabetes. Type 2 diabetes is one associated with insulin resistance. The methanol fraction of leaf of moringa showed hepatoprotective and antiulcerogenic effects in rats (Pal et al., 1995). Aqueous leaf extracts of moringga showed antiulcer property (Pal et al., 1995). Roots have antibacterial activity (Rao et al., 1996).

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Table 5: Nutritional composition of moringa oleifera

Nutrients	Leaf powder (per 100gm)
Calories (cal)	205
Protein (g)	27.1
Fat (g)	2.3
carbohydrate (g)	38.2
Fibre (g)	19.2
Vitamin B1(mg)	2.64
Vitamin B2 (mg)	20.5
Vitamin B3(mg)	8.2
Vitamin C (mg)	17.3
Vitamin E (mg)	113
Calcium (mg)	2003
Magnesium (mg)	368
Phosphorus (mg)	204
Copper (mg)	0.57
Iron (mg)	28.2
Sulphur (mg)	670
Potassium (mg)	1324

(Gopalkrishnan et al., 2016)

Chapter 4: Proposed Research Objective

1. To Screen ingredients for the preparation of complementary food for infant.
2. To prepare ready to eat product for infant.
3. To study the shelf life of the developed product.

Chapter 5: Proposed Research Methodology

5.1 Detailed plan work

Objective 1: Screening of ingredients

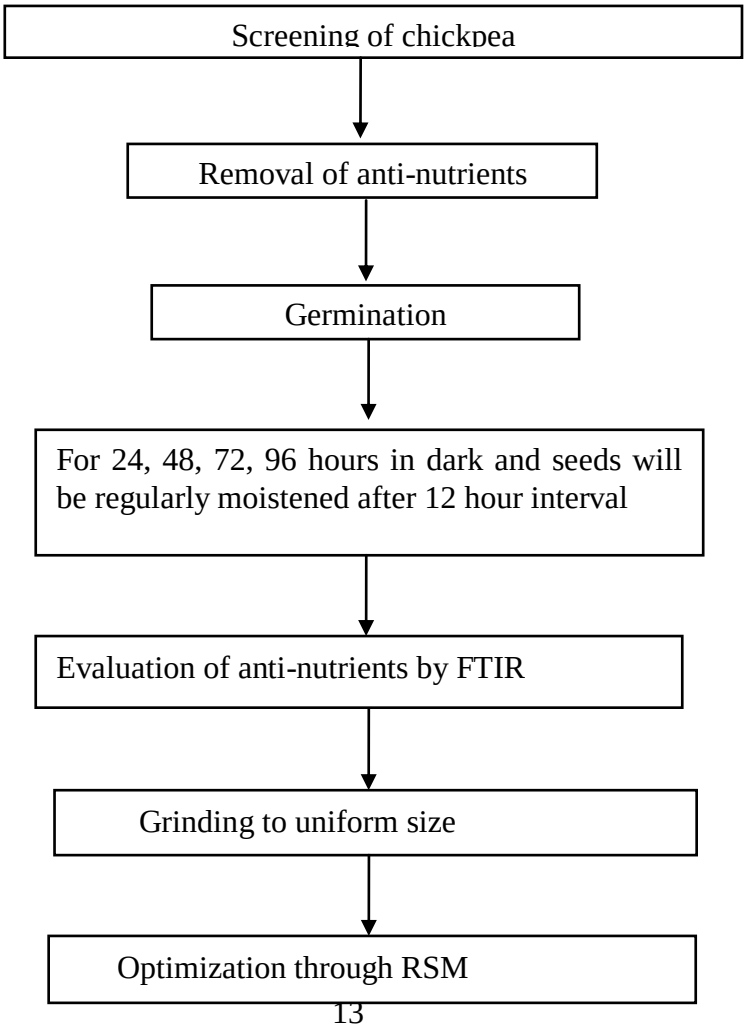
1.1 Chickpea

Germination

The soaked chickpea will be allowed to germinate in sterile petri dishes lined with filter paper for 24, 48, 72, 96 hours in dark and will be moistened at regular interval of 12 hours (Kalpanadevi et al. 2013).

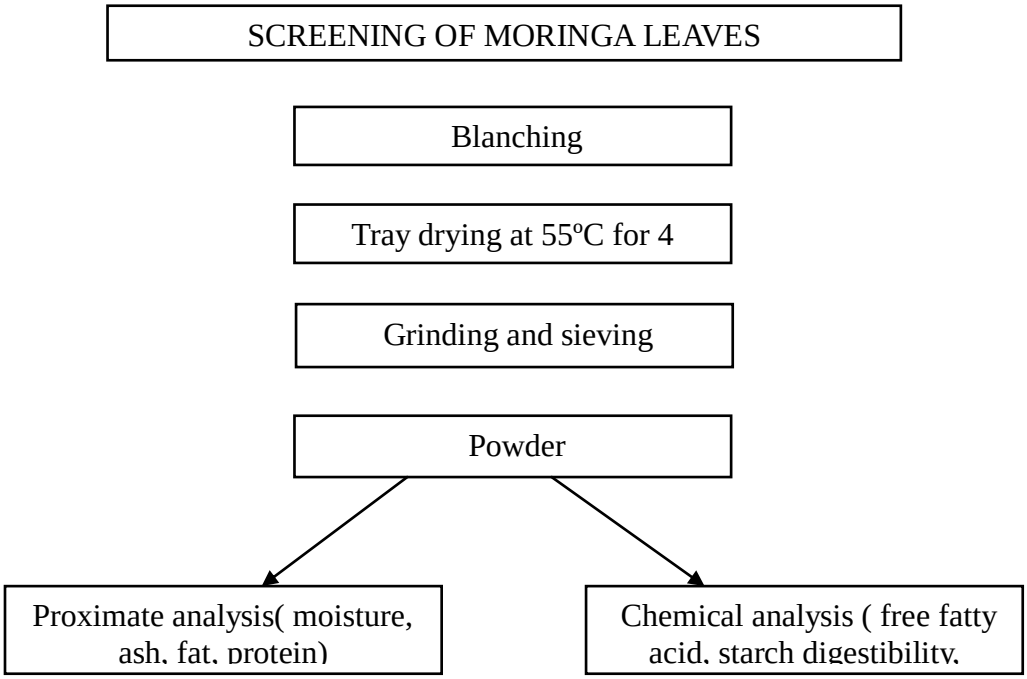
Detection of anti-nutrients by FTIR

a) Tannins (Ricci et al. 2015)
b) Phytic acids (Lewis et al. 2017)
c) Trypsin inhibitor (Zhang et al. 2008)
d) Saponins (Almutairi et al. 2014)



1.2 Moringa oleifera

a. Proximate analysis (Ranganna 2016)
    i. Crude moisture content
    ii. Crude ash content
    iii. Crude fat content
    iv. Crude protein content
b. Chemical analysis
    i. Free fatty acid test (Balogun et al. 2012)
    ii. Starch digestibility test (Du et al. 2014)
    iii. Protein digestibility test (Mundi et al. 2012)
    iv. Vitamin C (Baba et al. 2016)



Objective 2: To prepare ready to eat product for infant

A. Physical analysis

1) Solubility (Wani et al.2013)
2) Flowability (Emesu et al. 2013)
3) Wettability (Olawuni et al. 2013)
4) Bulk density (Wani et al. 2013)
5) Dispersibility (Jaya et al. 2004)
6) Foaming properities (Mundi et al. 2012)

B. Chemical analysis:

a) Moisture content (Olawuni et al. 2013)
b) Free fatty acid content (FFA) (Balogun et al. 2012)
c) Hydroxymethylfurfural content (HMF) (Capuano et al. 2009)
d) Thiobarbituric acid value (Ozvural et al. 2011)
e) Starch digestibility (Du et al. 2014)
f) Protein digestibility (Mundi et al. 2012)
g) Vitamin C content (Baba et al. 2016)

C. Sensory analysis:

A 9 point hedonic scale will be used to evaluate the experimental samples using 100 semi trained panelists. Healthy male and female of suitable age will be selected for the evaluation.

Color and appearance
Flavor and sweetness
Body and texture
Mouthfeel
Overall acceptability

Expression	Points to be assigned
Liked extremely	9
Liked very much	8
Liked moderately	7
Liked slightly	6
Neither liked nor disliked	5
Disliked slightly	4
Disliked moderately	3
Disliked very much	2
Disliked extremely	1

Sample code	Color and appearance	Flavor and sweetness	Body and texture	Mouthfeel	Overall acceptability	Remarks (if any)

Optimized product will be obtained using the above experimental setup.

3 Objective 3: To study the shelf life of the developed product.

The developed an optimized, ready to eat product for infant will be packed using different packaging material viz. LDPE, HDPE and Metalized polyester. Further, stored at three different temperature 10, 25 and 37 °C. The packaged products will be stored for 3 months and analysed for following parameters at regular intervals of 7 days.

D. Physical analysis

7) Solubility (Wani et al.2013)
8) Flowability (Emesu et al. 2013)
9) Wettability (Olawuni et al. 2013)
10) Bulk density (Wani et al. 2013)
11) Dispersibility (Jaya et al. 2004)
12) Foaming properities (Mundi et al. 2012)

E. Chemical analysis:

a) Moisture content (Olawuni et al. 2013)
b) Free fatty acid content (FFA) (Balogun et al. 2012)
c) Hydroxymethylfurfural content (HMF) (Capuano et al. 2009)
d) Thiobarbituric acid value (Ozvural et al. 2011)
4 Vitamin C content (Baba et al. 2016)

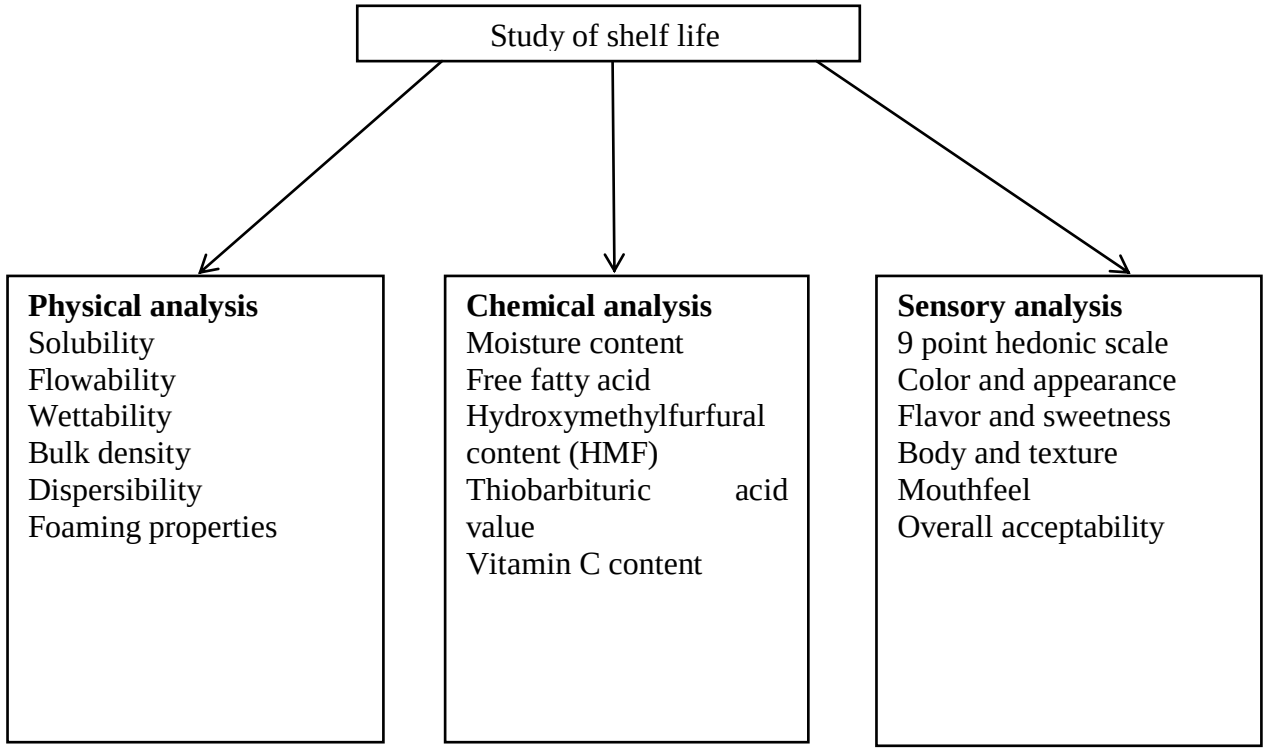
F. Sensory analysis:

A 9 point hedonic scale will be used to evaluate the experimental samples using 100 semi trained panelists. Healthy male and female of suitable age will be selected for the evaluation.

Color and appearance
Flavor and sweetness
Body and texture
Mouthfeel
Overall acceptability

Expression	Points to be assigned
Liked extremely	9
Liked very much	8
Liked moderately	7
Liked slightly	6
Neither liked nor disliked	5
Disliked slightly	4
Disliked moderately	3
Disliked very much	2
Disliked extremely	1

Sample code	Color and appearance	Flavor and sweetness	Body and texture	Mouthfeel	Overall acceptability	Remarks (if any)



Chapter 6: Expected research outcomes

1. Screening of ingredients will be carried out for the development of complementary food.
2. Fruit and vegetable based complementary food will be exhibit improved nutritional and organoleptic properties.
3. Process will be standardized for the preparation of fruits and vegetables based complementary food products.

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