Asian Jr. of Microbiol. Biotech. Env. Sc. Vol. 26, No. (3) : 2024 : 357-362

ISSN-0972-3005

DOI No.: http://doi.org/10.53550/AJMBES.2024.v26i03.009

ASSESSMENT OF CHANGES IN NUTRITIONAL QUALITIES AT DIFFERENT STAGES OF INFANT FOOD MIX PRODUCTION

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(Received 7 May, 2024; Accepted 23 July, 2024)

Key words*: Refractance window drying, Beta carotene, Infant food mix, Nutritional qualities*

Abstract– The goal of this study was to reduce nutrient loss in infant food mixes by using the method of refractance window drying. An analysis was conducted on nutritional characteristics that include beta carotene, potassium, and iron. The main ingredients of the four treatments (T0, T1, T2, and T3) were carrot, banana, apple. T0 contained all of these ingredients in similar amounts, however the other ingredients included different amounts of apple and carrot along with a fixed 50% banana. According to a sensory assessment, T0 was the most favoured. When exposed to refractance window drying, beta carotene lost the most nutrients (about 30%), but potassium and iron held steady. The best physico-chemical properties were shown by T2. It was discovered that the product could be consumed for up to 30 days. This research indicates that refractance window drying is effective for producing nutritious infant food, maintaining most of the nutritional quality.

INTRODUCTION

As infantfood requires unique preparation techniques, it plays a crucial role in a newborn's nutrition. An infant is defined as a person between the ages of six months and two years old under the Food Safety and Standards Regulations, 2019. Infants need foods that are soft, easily digested, and nutritionally balanced. For an infant's development and health, complementary feeding-which involves introducing solid meals while maintaining breastfeeding-must begin about six months of age (Maslin *et al.,* 2015). Approximately one-fifth of the 27 million childbirths that occur each year worldwide occur in India (UNICEF). The need for simple, nutrient-dense baby foods has been fuelled by the rise in working women and changing lifestyles. According to the Baby Food Global Market Report (2024), the market for baby food is expected to rise at a compound annual growth rate (CAGR) of 6.8%, from its anticipated $49.26 billion in 2023 to $52.62 billion in 2024. The rising popularity of natural and organic products, allergy-free choices, and eco-friendly packaging is blamed for this expansion.

The introduction of complementary meals helps babies develop appropriate eating habits and offers nutritional benefits. Parents are more and more looking for safely packaged goods that don't contain any additives or preservatives to protect the infant's health. For healthy growth, a well-balanced diet that includes grains, legumes, fruits, vegetables, and animal products are required. The study focuses on a baby food combination made via Refractance Window (RW) drying that includes banana, apple, carrot, ragi and cardamom. RW drying preserves nutrients, flavors, colours, and bioactive compounds better than other drying methods (Ortiz and Martínez, 2015; Durigon *et al.,* 2018). It uses hot water below boiling point as a heating medium, transferring heat to food through a polyester film. This method ensures nutrient retention and maintains quality. It is energy-efficient and cost-effective compared to freeze drying (Zotarelli *et al.,* 2015). The infant food mix is intended as a weaning food, helping infants transition from breast milk to solid foods, establishing lifelong taste and consumption patterns. The formulation can be fortified with minerals and vitamins to address specific nutritional needs, such as iron to combat anaemia (Jaiswal *et al.,* 2022).

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MATERIALS AND METHODS

Methods

1. Preparation of puree 2. Refractance window drying 3. Tray drying and powdering. Fig 1 Shows the flow chart followed for the study.

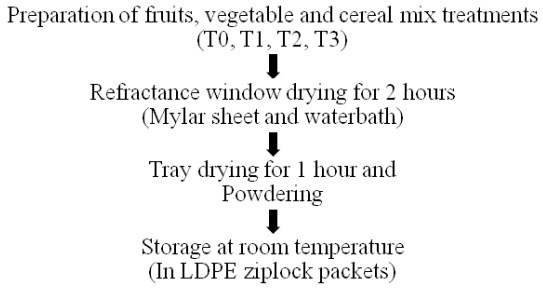

Fig. 1. Flow chart of the study

Preparation of puree

i. Apple puree was prepared by peeling, chopping apple into small pieces which were put into boiling water for 1 min after which taken out and blanched into ice cold water. Later sieved and put in a mixer blender where it was turned on at medium power for 1 min. The puree was collected and used according to formulation proportion.
ii. Banana puree was prepared by peeling and chopping banana, putting into a mixer blender where it was turned on at medium power for 1 min. The puree was collected and used according to formulation proportion.
iii. Carrot puree was prepared by peeling and chopping carrot into small pieces that were boiled for 15 mins at medium flame. Then transferred into mixer blender where it was turned on at medium power for 1 min. The puree was collected and used according to formulation proportion.
iv. Ragi mix was prepared by mixing ragi with water at a proportion of 1:8 respectively. Where for 50g of ragi 400 ml of water was used. Then heated under medium flame and stirred until water evaporated. The remaining was collected and used according to formulation proportion.
v. Cardamom powder was prepared by taking out cardamom pods from cardamom, powdered using mortar and pestle. This was then collected and used according to formulation proportion.

Four different treatments of infant food mix were formulated by incorporating the ingredients (banana puree, apple puree, carrot puree, ragi and cardamom) at various ratios which are shown in Table 1.

Drying using refractance window drying

After preparation of treatments T0, T1, T2, T3, each was poured onto the mylar sheet which then was placed over water bath maintained at 65°C. The heat from the water in the water bath was evenly distributed on the mylar sheet which helped to evaporate water. The mixture was let to remain on the water bath for 2 hours.

Tray drying

After 2 hours, the food mix turned into thin sheets which was placed in a tray dryer that was let to run at 65°C for 1 hour to further facilitate removal of moisture into crispy thin sheets easy for grinding in the further process.

Powdering and Storage

The thin sheets of each treatment were taken out, and ground into fine powder using a mixer grinder. These powders of each treatment were taken and stored in zip lock bags at room temperature.

Physico-chemical, sensory qualities and shelf life

Moisture content (%)

10 g of the whole sample was taken in the Petri/dish, dried in a hot air oven at 110°C, then cooled in a desiccator and weighed. The process of heating and cooling was repeated until a constant weight was achieved. The moisture content was calculated using the formula (1)

$$\text{Moisture content (\%)} = \frac{\textit{Mass of material with petri dish before drying} - \textit{Mass of material with petri dish after drying}}{\textit{Mass of material with petri dish before drying} - \textit{Mass of empty petri dish}} \times 100 \quad .. (1)$$

Table 1. Formulation of infant food mix

Treatments	Ingredients (%)
T0	Banana Puree (30%), Apple Puree (30%), Carrot Puree (30%), Ragi (9%), Cardamom (1%)
T1	Banana Puree (50%), Apple Puree (20%), Carrot Puree (30%), Ragi (9%), Cardamom (1%)
T2	Banana Puree (50%), Apple Puree (10%), Carrot Puree (20%), Ragi (19%), Cardamom (1%)
T3	Banana Puree (50%), Apple Puree (20%), Carrot Puree (10%), Ragi (19%), Cardamom (1%)

Acidity (pH)

The determination of the pH of the food was done using a digital pH meter equipped with a combined glass rod.

Bulk density

To determine the loose bulk density, 10 g of sample was measured into a calibrated 50 ml measuring cylinder with repeated mild tapping, until a constant volume was observed. The bulk density of the sample was recorded using formula (2)

$$\text{Bulk density (g/ml)} = \frac{\textit{Wt. of cylinder with sample} - \textit{Empty Wt. of cylinder}}{\textit{Empty Wt. of cylinder}} \quad .. (2)$$

Water absorption capacity (%)

Ten (10) ml of distilled water was added to 1 g of the sample in a beaker. The suspension was agitated using glass rod and stirred for 5 min. The suspension obtained was thereafter centrifuged at 2,058 rpm for 30 min and the supernatant was measured into a 10 ml graduated cylinder. The absorbed water by the flour was considered as the change between the initial volume of the water and the volume of the supernatant. The water density was taken as 1.0 g/ml. The water absorption capacity was calculated using formula (3)

$$\text{WAC (\%)} = \frac{\textit{Wet weight} - \textit{Dry weight}}{\textit{Dry weight}} \times 100 \quad .. (3)$$

Sensory Evaluation

Sensory evaluation was done with semi-trained panellists from department and from 30 parents having infants using five-point Likert scale. Final product T0, T1, T2, T3 was mixed with warm milk at the rate of 12 (1gm sample for 2ml milk). Evaluation was done for appearance, flavour, texture, taste, odour, overall liking and likelihood of buying.

Changes in nutritional qualities

Change in nutritional quality parameters which includes beta carotene, iron and potassium was performed using Rangana, 2007 method for three different stages that are before refractance window drying, post refractance window drying and final product (after tray drying and powdering)

Shelf life

The shelf-life was determined with total plate count method. According to prevention of food adulteration rules 1956, the infant food is acceptable until the total plate count (TPC) is not more than 10,000 cfu/g.

RESULTS AND DISCUSSION

Physico Chemical Properties

The physicochemical properties that include moisture content, acidity (pH), bulk density and water absorption capacity, of developed infant food mix were determined and analysed statistically according to its four treatments and are mentioned in Table 3.

Moisture Content (%)

The moisture content (%) in the infant food mix was measured after processing. The highest value was found in T2 (4.73%) and lowest in T0 (3.67%). Treatments with higher amounts of banana and ragi had higher moisture content due to ability to retain water, especially in gelatinized ragi. Apple and Carrot do not retain moisture and dry easily, contributed less (Anitha *et al.*, 2021). ANOVA showed a significant difference in moisture content between treatments.

Acidity (pH)

The highest pH was found in treatment T2 (6.56) and the lowest in T0 (6.23). Treatments with higher amounts of banana and ragi had higher pH values.

Table 3. Physicochemical properties

Treatment	Moisture content (%)	Acidity (pH)	Bulk density (g/ml)	Water absorption capacity (%)
T0	3.67	6.23	1.25	155.17
T1	4.33	6.4	1.36	162.27
T2	4.73	6.56	1.35	164.63
T3	4.16	6.43	1.38	162.87
P-Value	0.0016	0.2114	0.0636	4.48955×10^{-6}
Significant or Non-Significant	S	NS	NS	S

More apple content resulted in lower pH, while higher ragi and carrot content resulted in higher pH. Thus, apple significantly impacts overall product acidity (Morales *et al.*, 2008). ANOVA in Table 3 concluded that the difference in pH among treatments was not significant.

Bulk Density (g/ml)

Bulk density was measured to assess density and its quality. Highest value was found in T3 (1.38 g/ml) and the lowest in T0 (1.25 g/ml). Higher ragi proportions led to increased bulk density (Vadivoo *et al.*, 2016; Chavan *et al.*, 2019). ANOVA in Table 3 showed no significant change in bulk density among treatments.

Water Absorption Capacity (WAC %)

Highest value was found in T2 (164.63%) and the lowest in T0 (155.17%). Treatments with higher proportions of ragi had higher water absorption capacity because ragi absorbs more water, followed by banana, carrot, and apple (Anitha *et al.*, 2021). ANOVA in Table 3 showed a significant difference in water absorption capacity among treatments.

Sensory Analysis

The infant food mix was prepared according to the formulation in Table 1. After sensory analysis, the most liked treatment was T0. The least liked treatment was T1. It is assumed that the amount of apple, banana and carrot was in similar proportion leading to the good taste and likeness in T0. As the amount of banana puree and carrot puree was increased, the overall liking of the product was reduced leading to liking of T1 being lowest. The results are shown in Table 2.

Changes in nutritional qualities

Beta Carotene

The beta carotene content at first stage had been maximum in T0 (15.41 mg/100g) and the least in T3 (10.25 mg/100g). Statistically, there was significant reduction in quantity of beta carotene at post RWD, having maximum in T0 (10.56 mg/100g) and minimum in T3 (5.68 mg/100g). In the final product after tray drying and grinding, maximum content in T0 (9.71 mg/100g) and minimum in T3 (4.22 mg/100g). T0 contained maximum presence of beta carotene while T3 contained the least. Between first and second stage the changes were visible, as beta carotene degradation can begin at temperatures as low as 50-60 °C (Nguyen *et al.*, 1999).

Potassium Content

The quantity of potassium in the first stage was highest in T2 (905 mg/100g) and least in T0 (804 mg/100g). At the second stage, highest in T2 (903 mg/100g) and least in T0 (801 mg/100g). At the third stage, highest in T2 (902 mg/100g) and least in T0 (800 mg/100g). Potassium content was maximum in T3 and minimum in T0, also that very minimal

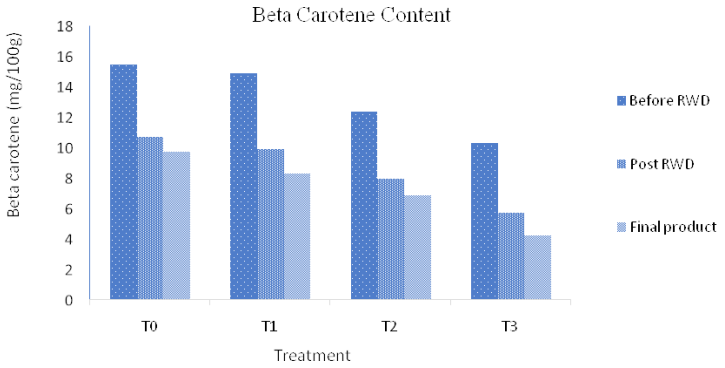

Fig. 2. Beta Carotene content

Table 2. Sensory evaluation

Sample	Good Appearance	Good Flavour	Good Texture	Good Taste	Good Odour	Overall liking	Likelihood of buying
T0	4	5	3	5	4	3	3
T1	3	3	2	3	2	2	2
T2	3	3	5	3	4	3	3
T3	3	4	3	4	3	4	3

Table 4. Total plate count (TPC)

Sample	TPC after 30 days (cfu/gm)	TPC after 45 days (cfu/gm)	TPC after 60 days (cfu/gm)
T0	7.62×10^3	1.04×10^4	4.50×10^5

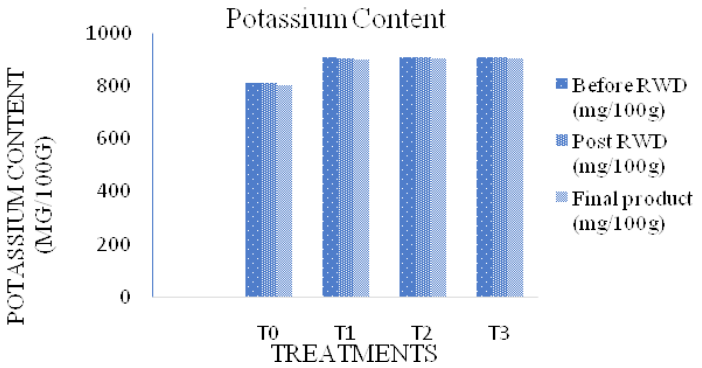

Fig. 3. Potassium Content

reduction in quantity occurred between the three stages for all the treatments. T3 had the maximum amount of potassium due to T0 maximum proportion of banana puree of 50% and least in T3 which was 30%. According to Food Safety and Standards (Foods for Infant Nutrition) Regulations (2019), the presence of potassium content in infant food allowed is between minimum of 300 mg/100 g and maximum 900 mg/ 100g. The minimal change in potassium content after each stage for all treatments was due to potassium being one of the minerals which is quite stable in heat (Miglio *et al.,* 2008).

Iron content

The quantity of iron was highest in T0 (3.70 mg/ 100g) and least in T2 (1.89 mg/100g). At the second stage, highest in T0 (3.68 mg/100g) and least in T2 (1.87 mg/100g). In third stage, was highest in T0 (3.62 mg/100g) and least in T2 (1.84 mg/100g). Iron content was maximum in T0 and minimum in T2, very minimal reduction in quantity occurred between three stages for all treatments. T0 had the maximum amount of iron due to higher proportion of apple and carrot 30% each and least in T2 due to having 10% and 20% apple and carrot respectively. According to Food Safety and Standards (Foods for Infant Nutrition) Regulations (2019), the presence of iron content in infant food allowed is between minimum of 3 mg per 100 g and maximum 7 mg per 100g.

Shelf life

The shelf-life was determined with total plate count method. According to prevention of food adulteration rules 1956, the infant food is acceptable until the total plate count (TPC) is not more than 10,000 cfu/gram. T0 being best liked sample in sensory evaluation was tested at interval of 15 days, beginning from 30 days from production and storage, followed by 45 days and 60 days. The results of the total plate count are shown in Table 4. The product was stored in an airtight zip lock bag at ambient temperature. Through observation it can be understood that, since product didn't contain any

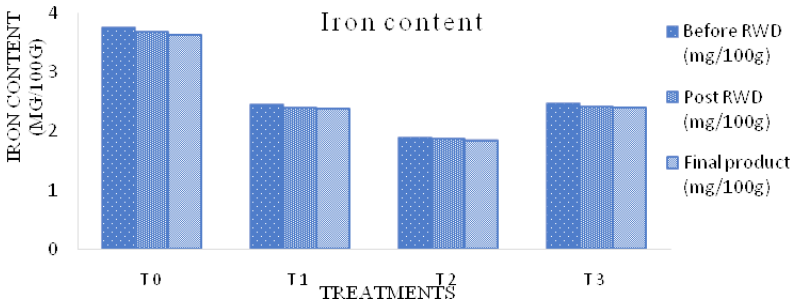

Fig. 3. Iron Content

preservatives, the product is safe to be consumed up until little more than 30 days.

CONCLUSION

Four different treatments of infant food mix were developed and tested where T2 exhibited most of the physico chemical properties. However, T0 was likes the most in sensory evaluation. Beta carotene content reduced significantly in first two stages of approximately 30% in all treatments. Iron and potassium content remained same without change.

ACKNOWLEDGEMENT

All the staff of Department of Processing and Food Engineering are gratefully acknowledged for all their contributions in this research.

Conflict of Interest

The authors declare that there is no conflict of interest in this study and no financial funding was received.

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