ISSN : 2350-0743

International Journal of Recent Advances in Multidisciplinary Research

Vol. 11, Issue 04, pp.9702-9706, April, 2024

RESEARCH ARTICLE

NUTRIENT-DENSE READY TO COOK CEREAL MIXES FOR CHILDREN BETWEEN 12-23 MONTHS - DEVELOPMENT AND EVALUATION

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ARTICLE INFO

Article History

Received 19th January, 2024
Received in revised form
03rd February, 2024
Accepted 06th March, 2024
Published online 30th April, 2024

Keywords:

Complementary feeding, dietary diversity, nutrient-dense mixes, Shelf life, Ready to cook mixes.

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ABSTRACT

Introduction: To combat malnutrition and its related consequences during the early stages of life, appropriate complementary feeding is essential. Moreover, developing complementary foods that address the gaps between the daily energy and nutrient requirements of infants and young children and the amount obtained from breastfeeding should be designed. ***Materials and Methods:*** The objective of this study was to develop nutrient-dense ready-to-cook cereal mixes for 12-23 months children.A market survey wasconducted to gain information regarding locally available foods. Five nutrient-dense ready-to-cook cereal mixes were prepared using different food groups like cereals, millets, pulses, fruits, vegetables, nuts and oilseeds. Recipes were evaluated for nutrient composition, adequacy, dietary diversity as well as shelf life. Forty semi-trained panelists using ten-point composite rating scale and a seven-point hedonic scale conducted organoleptic evaluation. ***Results:*** Nutrient composition analysis revealed that RTCs met more than 80% requirement for iron, fiber and calcium and almost 100% for energy, protein, fat and carbohydrates for breastfed children however, for non-breastfed children except fat and calcium all other nutrient requirements were adequately met.The overall acceptability of RTCs ranged from 5.7 to 6.83.Shelf life studies showed that there was no rancidity during 3 months of storage. A manual and videos on complementary feeding, as well as instructions on how to use RTC mixes, were developed. ***Conclusion:*** Thus, the nutrient-denseready-to-cook cereal mixes developed can be useful to bridge the gaps between energy and nutrient requirements.

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Citation: Dr. Vijayata Sengar and Ardra Santosh. 2024. *"Nutrient-dense ready to cook cereal mixes for children between 12-23 months - development and evaluation", International Journal of Recent Advances in Multidisciplinary Research,* 11, (04), 9702-9706.

INTRODUCTION

India showed a reverse trend for all indicators of malnutrition amongst children under 5 years except wasting which has gone down to 25.1% from 26.4% between NFHS 4 and 5. Underweight, stunting and overweight increased from 39.3%, 38.5% and 1.9% to 39.7%, 39.0% and 3.9% respectively between NFHS 4 and 5. Anemia prevalence amongst these children increased by 9% between NFHS 4 and 5 (1,2). During the early years of life, complementary food is very important for a child's growth. Complementary feeding is defined as the process starting when breast milk alone is no longer sufficient to meet the nutritional requirements of infants, and therefore other foods and liquids are needed, along with breast milk (3). Poor feeding practices are characterized by poor timing of complementary foods introduction (too early or too late); infrequent feeding; and poor feeding methods, hygiene, and child-care practices. In addition, poor dietary quality of the foods served, characterized as too little variety; inappropriate consistency (food is too thin or too thick); too few essential vitamins and minerals, especially vitamin A, iron, zinc, and calcium; too few essential fatty acids; and too few calories among non-breastfed infants (4,5). Thus, the present study was planned with the broad objective of developing nutrient-dense ready-to-cook mixes and assessing its nutrient composition along with organoleptic attributes and shelf life for children between 12 months to 23 months.

MATERIALS AND METHODS

Procurement of ingredients: To learn more about the foods available in the area, a market survey was done. All ingredients were procured from local markets which were seasonally available. Understanding the importance of dietary diversity, a wide range of foods were selected from these locally available foods which could help in meeting the micronutrient requirements apart from macronutrients. Nutrient requirements were calculated based on Recommended Dietary Allowances for Indians ICMR NIN, 2020 (6). For children between 12-23

months in developing nations who consume "average" amounts of breast milk, the energy requirements from complementary foods are roughly 750 kcal (7). Simultaneously, calculations were also done for non-breastfed children taking into consideration the average breastmilk intake of 550 ml for children between 12-23 months as per RDA 2020, ICMR-NIN (6).

Selection and formulation of mixes: The recipes were formulated manually by including at least five food groups to ensure dietary diversity.The criteria used for selection of various food groups for preparing RTC mixes were as follows:

- Each RTC mix should have at least 5 food groups to meet dietary diversity.
- Each RTC mix should meet RDA (ICMR 2020) requirements (6).

Using the above criteria, various combinations were worked out to prepare RTCs from the mentioned food groups.Total 5 recipes were prepared in which cereal, pulses, millets, roots and tubers, fruits, vegetables, green leafy vegetables, nuts and oilseeds and natural source for sweetness were selected.

- For RTC1 sweet potato, Bengal gram dal, sago, coconut, sesame, grapes, lotus stem, fenugreek leaves, flaxseed and jaggery were used.
- For RTC2 Jowar, tapioca, sesame, mint leaves, coconut, apple, jaggery and dates were used.
- For RTC3 buckwheat, horse gram, rice, sago, spinach, mint leaves, pineapple, plum, almond, flaxseed, coconut and jaggery were used.
- For RTC4 ragi, banana, walnut, sesame, moringa, arrowroot, strawberry, jaggery, sweet potato, dates and pumpkin were used.
- For RTC5 amaranth seeds, sesame, guava, jaggery, sago, arrowroot, green gram whole, coconut, cashew and fenugreek leaves were used.

Development of ready to cook cereal mix powders

- Millets like jowar, buckwheat and ragi were sprouted and then dry roasted to remove the moisture. The shoots were removed and then the ingredients were finely powdered. Sweet potato was blanched and thinly sliced and dehydrated. After dehydration the slices were powdered finely. Sago and rice were dry roasted and powdered. Dried Lotus stem was purchased from the market and then powdered finely. Arrowroot powder and tapioca powder was purchased from the store.
- Pulses like horse gram and green gram whole were sprouted and then dry roasted to remove the moisture. The shoots were removed after roasting and then finely powdered. Bengal gram dal was dry roasted and then powdered.
- Coconut, sesame, flaxseed, almond, walnut and cashews were dry roasted and finely powdered.
- Green leafy vegetables, vegetable and fruits like Fenugreek leaves, spinach, mint leaves, pumpkin, apple and plum were dehydrated and then powdered. Dried dates were purchased and then powdered finely. Moringa powder,pineapple powder, grapes powder, strawberry powder and guava powder were purchased from the market.
- Jaggery powder was purchased from the store.
- The powdered ingredients were mixed and once again finely powdered as per respective RTCs. To preparethe porridge, appropriate amount of water was boiled. The boiled water was added slowly to the powder until a proper consistency was obtained and was cooked properly for around 15-20 minutes. The same procedure was followed for all the recipes.

Nutrient analysis

To evaluate the nutritional quality of the developed RTCs nutrient analysis was performed in NABL accredited laboratory for determination of moisture, ash, protein, fats, carbohydrates, calcium, iron and dietary fibre using standard methods (Table 1).

Rancidity tests: To check rancidity, tests like peroxide value (A.O.A.C. 17th edn, 2000, Official Method 965.33) and acid value (ISO 660:1996) was conducted at 1st month, 2nd month and 3rd month (Table 1).

Table 1. Methods used for Nutrient composition Analysis

Parameters	Method
Energy	By Calculation
Carbohydrate	By difference
Moisture	IS 4333 (Part II): 2002 Methods of Analysis of food grains Part II Moisture
Fat	Fat extraction AOAC 981.11 (2000)
Protein	Kjeldahl Method AOAC 979.09 (2005)
Dietary fiber	AOAC, 962.09 (2005)
Total Ash	AOAC 923.03 (2000)
Calcium	Titrimetric method AOAC 976.09 (2000)
Iron	AOAC 944.02 (2000)
Rancidity	Peroxide value AOAC 965.33 and Acid Value ISO660:1996

Reference (8,9)

Sensory evaluation: A panel of 40 semi-trained panellists were selected for sensory evaluation after obtaining their consent. The panellists were selected by conducting a threshold test. The 40 semi-trained panellist were asked to rate attributes of the Ready-to-cook complementary mixes on the Composite and Hedonic rating scale. Panellists were asked to carry out the sensory evaluation on a google form in light of the ongoing pandemic. Other precautionary measures were also taken while conducting the test. Disposable cutlery and cups were used.

Composite Rating Scale: The 10-point scoring test was conducted so that specific characteristics of the product could be rated separately. It helps to point out which specific attribute is not acceptable or is at fault. All the developed Ready-to-cook complementary mixes were evaluated for the following attributes:

- Colour & Appearance
- Aroma
- Texture
- Taste
- After-taste

- Mouth feel
- Overall acceptability.

Hedonic Rating Scale: This is a test that a 7-point rating scale ranging from "Like very much" to "Dislike very much" with "neither like nor dislike" as the middle score that helped in identifying the most or the least liked product from the various recipes. Institutional Ethics Committee approval was obtained (IECHR/FCSc/MSc/2021/110)

RESULTS

Mean nutrient content of RTCs based on lab values (Breastfed child): Mean of all the nutrients were derived to know an average intake of nutrient per day of five developed RTCs for a breastfed child. Table 2 shows estimated values obtained after conducting nutrient analysis. The mean values for estimated energy, protein, carbohydrate, fat, iron, calcium and fibre were 825Kcal, 10gm, 153gm, 19gm, 7mg, 300mg and 12gm respectively. There wasn't much difference in the amount of nutrients in the 5 RTCs.

Mean Nutritive value of RTC1-5 as % RDA (Breastfed child): Mean of all the nutrients were calculated as % RDA to know what percent of daily requirements are fulfilled by the developed RTCs for breastfed child as shown in Table 4. The mean value of RTC1-5 as percent RDA for energy, protein, carbohydrate, fat, iron, calcium and fibre are 110%, 161%, 171%, 104%, 84%, 86% and 83% respectively. The amount of protein and carbohydrates are high above 150%. The high amounts of protein may be due to the nuts and oilseeds used in the mixes for meeting fat and energy requirements. Also, the carbohydrates are in more amount as energy requirement is high.

Mean Nutritive value of RTC1-5 as % RDA (Non-Breastfed child)

Mean of all the nutrients were calculated as % RDA to know what percent of daily requirements were fulfilled by the developed RTCs for non-breastfed child (Table 5).

The mean value of RTC1-5 as percent RDA for energy, protein, carbohydrate, fat, iron, calcium and fibre for non-breastfed child were 99%, 111%, 157%, 68%, 113%, 80% and 110% respectively. Only the amount of carbohydrate is high above 150%. Protein, iron and fibre were around 110%.

Table 2. Mean nutrient content of RTCs for breastfed children (lab values)

Nutrient	RTC1	RTC2	RTC3	RTC4	RTC5	Mean	SD
Energy (Kcal)	810.67	825.35	817.71	804.80	864.75	824.66	23.69
Protein (gm)	9.32	10.56	10.72	10.70	10.72	10.40	0.61
Carbs (gm)	154.69	148.64	157.81	154.16	150.01	153.06	3.72
Fat (gm)	17.17	20.94	15.95	16.14	24.64	18.97	3.75
Iron (mg)	5.49	7.19	6.76	9.16	5.16	6.75	1.59
Calcium (mg)	290.55	296.40	290.55	306.15	312.00	299.13	9.61
Fibre (gm)	13.51	12.16	11.56	11.44	13.44	12.42	1.00
serving size/d	195	195	195	195	195	195	

Table 3. Mean nutrient content of RTCs for non- breastfed child (lab values)

Nutrient	rtc1	rtc2	rtc3	rtc4	rtc5	Mean	SD
Energy (Kcal)	1080.89	1100.46	1090.28	1073.06	1152.99	1099.54	31.59
Protein (gm)	12.42	14.08	14.29	14.26	14.29	13.87	0.81
Carbs (gm)	206.25	198.18	210.41	205.54	200.01	204.08	4.95
Fat (gm)	22.89	27.92	21.26	21.52	32.85	25.29	5
Iron (mg)	7.32	9.58	9.01	12.21	6.88	9	2.12
Calcium (mg)	387.4	395.2	387.4	408.2	416	398.84	12.81
Fibre (gm)	18.01	16.21	15.41	15.25	17.92	16.56	1.332
serving size/d	260	260	260	260	260	260	

Table 4. Nutritive value of RTC1-5 as % RDA (Breastfed child)

Nutrient	rtc1	rtc2	rtc3	rtc4	rtc5	MEAN	SD
Energy (Kcal)	107.73	109.68	108.67	106.95	114.92	109.59	3.15
Protein (gm)	144.50	163.72	166.20	165.89	166.20	161.30	28.05
Carbs (gm)	173.23	166.45	176.72	172.63	167.99	171.40	8.70
Fat (gm)	93.83	114.43	87.16	88.20	134.64	103.65	38.34
Iron (mg)	68.63	89.88	84.50	114.50	64.50	84.40	21.58
Calcium (mg)	83.97	85.66	83.97	88.48	90.17	86.45	13.43
Fibre (gm)	90.07	81.07	77.07	76.27	89.60	82.81	5.18

Mean nutrient content of RTCs based on lab values (Non-Breastfed child): The mean values for estimated energy, protein, carbohydrate, fat, iron, calcium and fibre were 1110Kcal, 14gm, 204gm, 25gm, 9mg, 399mg and 17gm respectively for non-breastfed children. There was not much difference for nutrients in the five RTCs (Table 3).

Only the amount of fat was 68% of the requirement, rest for all the nutrients were fulfilled by the mixes for non-breastfed child. In the age group of 12-23 months the rates of breastfeeding decreases. So, the RTCs developed here if consumed will ensure to meet the RDA requirements. Up to 23 months as per recommendation breastfeeding should be continued.

Sensory Evaluation: To understand the acceptability of developed RTCs, organoleptic evaluation was conducted by 40 selected semi-trained panellists.

Table 5. Nutritive value of RTC1-5 as % RDA for non-breastfed child

NUTRIENT	rtc1	rtc2	rtc3	rtc4	rtc5	MEAN	SD
Energy (Kcal)	97.38	99.14	98.22	96.67	103.87	99.06	2.85
Protein (gm)	99.41	112.64	114.35	114.13	114.35	110.98	6.50
Carbs (gm)	158.66	152.45	161.86	158.11	153.86	156.99	3.81
Fat (gm)	61.87	75.46	57.48	58.16	88.79	68.35	13.53
Iron (mg)	91.50	119.83	112.67	152.67	86.00	112.53	26.51
Calcium (mg)	77.48	79.04	77.48	81.64	83.20	79.77	2.56
Fibre (gm)	120.09	108.09	102.76	101.69	119.47	110.42	8.88

Table 6. Mean values for Organoleptic evaluation of RTC1-5 (Composite Rating)

RTC	Colour and appearance	Aroma	Texture	Taste	After-taste	Mouthfeel	Overall acceptability	Mean
RTC1	7.05 ± 1.76	6.45 ± 1.98	7.05 ± 2.12	6.67 ± 1.97	6.3 ± 2.25	6.43 ± 2.35	6.65 ± 1.95	6.66
RTC2	6.95 ± 1.93	6.43 ± 1.95	6.58 ± 2.20	6.43 ± 2.04	6.35 ± 2.10	6.53 ± 2.09	6.6 ± 2.06	6.55
RTC3	6.33 ± 2.31	5.98 ± 2.24	6.28 ± 2.30	6.13 ± 2.26	6.38 ± 2.28	6.1 ± 2.41	6.3 ± 2.26	6.21
RTC4	6.45 ± 2.22	5.55 ± 2.27	6.08 ± 2.39	5.58 ± 2.68	5.28 ± 2.64	5.53 ± 2.79	5.45 ± 2.71	5.7
RTC5	7.15 ± 2.06	6.9 ± 2.20	6.7 ± 2.20	6.8 ± 2.15	6.6 ± 2.06	6.7 ± 1.95	6.95 ± 2.14	6.83

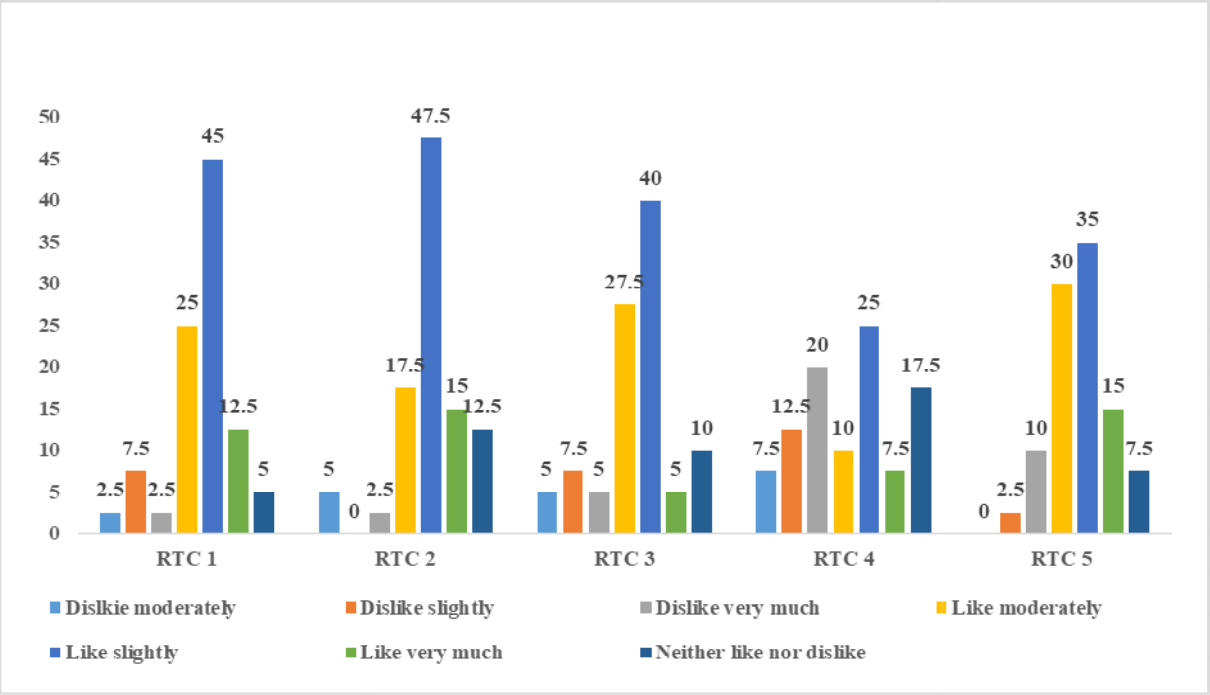

Figure 1. Hedonic rating for RTC mixes

The mean scores as percomposite rating for RTC1-5 were 6.66, 6.55, 6.21, 5.7 and 6.83 as shown in table 6. It was observed that RTC5 was the most accepted RTC, followed by RTC1, RTC2, RTC3 and RTC4 with mean scores of 6.66, 6.55, 6.21 and 5.7. Hedonic rating results as shown in Figure 1 revealed that the most liked RTC was RTC 2 followed by RTC 1 and 5. Around20% of the panellists did not like RTC 4 which was the highest number. From the results of sensory evaluation, it can be observed that the acceptability of baby foods (RTCs) evaluated by semi-trained panellists of the department was scored 6.9 as highest for RTC5 for overall acceptability. It was reported by the panellists that they were not used to bland tastes and usually expect baby foods to be sweet. Therefore, this could be one reason for slightly low scores. This brought up a very important point that, such mixes (RTCs) if given to children from the very beginning and foods high in salt, sugar or fat are avoided, then they may get used to it and develop healthy eating habits right from beginning. High consumption of HFSS foods have been reported in this age group which can also be taken into consideration.

Rancidity Tests: Rancidity tests were performed to know at what point of time rancidity is observed as nuts and oilseeds were added in developing RTCs during the intervals of 1 month, 2.5 months and 3months. There was increase in acid value with passage of time as there were ingredients like cereals, pulses and nuts and oilseeds. The acid values were in acceptable limits. The acceptable limits for acid value are 11-23 mg NaOH/gm as per a research paper. There were no standard guidelines for acid values for cereal mixes or cereals (Table 7).

Table 7. Acid value of RTCs

RTC	ACID VALUE (mg NaOH/gm)	ACID VALUE (mg)	ACID VALUE (mg)
	1st month	2.5 month	3rd month
1	5.43	6.29	7.06
2	4.16	6.81	7.11
3	1.88	3.43	3.78
4	6.86	7.67	9.10
5	2.46	3.80	3.91

Table 8 shows the values of peroxide value. The peroxide test was conducted at 2.5 months to know if the RTCs had rancidity or not. The values were low as per the acceptable limits of peroxide value as per FSSAI guideline. The limits for peroxide values were less than 10 mEq/1000gm.

Table 8. Peroxide value of RTCs

RTC	PEROXIDE mEq/1000g
1	2.03
2	1.99
3	2.94
4	3.99
5	1.62

Both, acid value and peroxide value indicated that no rancidity occurred in the developed RTCs. Dislike for specific food and such taste were also observed during the sensory evaluation conducted for nutrient dense RTCs in semi-trained adult population. This shows that such faulty practices maybe the outcome of early life dietary practices. High threshold for salt and sugary foods are developed in later stages of life. So, even when the child refuses to eat certain foods, the child should be practised to consume such foods as their taste buds would adapt that taste and won't find it difficult to accept these tastes in later stages of life. According to the findings of a study that used cohort data to estimate the explanatory effects of three CF behaviours on diet quality in early childhood, delaying the introduction of sweets and fruit juice, continuing to offer initially refused foods, and introducing flavor/texture variety before 1 year may all lead to higher diet quality 2 years later, with potential effect modification by child sex or infant breastfeeding status. Delay in introducing sweets and fruit juice was linked to decreased intake of foods included in the Youth Healthy Eating Index (YHEI) snack component, including sweets, regardless of sex or infant breastfeeding status. Breastfed children who were given sweets and fruit juice later in life had a better ratio of lean-to-fatty protein sources in their early infancy diet. Children who consume sweets throughout CF may be exposed to fewer taste profiles and hence retain greater intrinsic preferences for sweet and energy-dense foods, whereas children who are not exposed to certain flavors, such as salty or fat-rich dishes, may have less exposure (10).

CONCLUSION

It can be concluded that nutritious cereal mix for children can be prepared using simple methods like sprouting, dehydrating, preparing ARF and roasting from locally available food meeting RDA requirements and important indicators like minimum dietary diversity and minimum meal frequency which are very important for child's growth and development.

Conflict of Interest: None.

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