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Short Communication

Physicochemical, proximate and sensory evaluation of pearl millet and pigeon pea based nutrient dense mix

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ABSTRACT

Severe acute malnutrition serves a high risk of mortality among children aged 6-59 months. At a community level anganwadi centers play a vital role in identifying malnutrition among children and enabling resources for growth and development. The aim of this study was to develop a nutrient dense mix using pearl millet and pigeon pea and evaluate its sensory, physicochemical and proximate properties. The nutrient dense mix was formulated using pearl millet and pigeon pea in several variations and the best accepted variation was selected through sensory evaluation and analyzed for its physiochemical and proximate composition. Variation 3 of the nutrient dense mix prepared by balancing pearl millet with rice had the highest acceptability in all sensory parameters. It had favorable physicochemical properties including water solubility index (20.1%), swelling power (3.7%) and low moisture content (3.7%). The proximate analysis revealed high energy (347.10±0.85 kcals), protein (14.28±0.04 g), fat (19.53±0.03) and calcium content (154.63±2.2 mg). The percentage adequacy of the nutrients from the nutrient dense mix showed that 31.27% of energy as per the estimated average requirements was met for 1-3 year olds and 25.5% for 4-6 year olds. The high sensory acceptability, low cost and good micro and macronutrient profile encourages further exploration for the product in curbing malnutrition.

Keywords: Severe acute malnutrition, Pearl millet, Pigeon pea, Poshti, Nutrient mix, Malnutrition

INTRODUCTION

Malnutrition is a major public health issue in India housing more than one third of the worlds malnourished children with 34.7% children under 5 years wasted and 17.3% stunted [NFHS-5(2019-20)].[1] Severe malnutrition also known as severe acute malnutrition (SAM) serves a high risk of mortality among children aged 6 to 59 months. It is diagnosed when weight for height Z score is <-3 standard deviations below the mean, or a mid-upper arm circumference is less than 11.5 cm or the child presents nutritional edema.[2]

At a community level anganwadi centers play a significant role in guiding mothers and identifying malnutrition among poorer sections of society along with enabling resources for the proper growth and development of children including rehabilitation of SAM children. Currently anganwadi centers in Karnataka provide a standard nutritional powder mix (Poshti) for children under the age of 5 as a dense source of protein and other essential nutrients to ensure better nutritional status of children under 5 years of age.

Utilization of locally available cereals and pulses is essential to ensure accessibility of therapeutic foods to lower sections of society that encompass a higher percentage of SAM children. Locally available grains like pearl millet (*Pennisetum glaucum*) cultivable in harsh conditions and easily cultivable in Indian soil exhibits potential to serve as a highly nutritious grain for preparation of nutritional supplements for SAM children. With growing research highlighting the need for variety of cereals and legumes to adequately fulfil nutritional requirements of children. Pigeon pea (*Cajanus cajan)* cultivation has gained increasing economic interest and utilization in recent years. The high protein content of pigeon pea (21%) can be utilized to increase the protein content of the food product.[3] Groundnuts (*Arachis hypogaea*) are commonly included in therapeutic formula mixes due to their high energy, protein, fiber and omega 3 fatty acids content. In the wake of heightened food insecurity in developing countries, there is increasing research on utilization of plant by products, wastes and seeds. Watermelon seeds (*Citrullus lanatus* seeds) is one such nutritious foods rich in protein, water soluble vitamins and other minerals like zinc, calcium and iron which are helpful to support immunity, provide energy, contribute to muscle building, growth, bone formation and fight against anemia which is more prevalent in SAM children.[4]

The objective of this study was to develop a nutrient dense mix using pearl millet and pigeon pea and evaluate its sensory, physicochemical and proximate properties.

METHODS

Pearl millet, whole pigeon pea, rice, Bengal gram dal, groundnuts, soybean, watermelon seeds, milk powder, groundnut oil and sugar were all procured from the local market in Bengaluru, Karnataka, India. All analytical grade chemicals and reagents were used for this study. Poshti nutrient mix was obtained from anganwadi center in Bengaluru, Karnataka India and used as control nutrient dense mix (NDM). Each ingredient was individually processed to a suitable state for the preparation of the nutrient dense mix.

Processing of pigeon pea

Whole pigeon pea was processed by sorting manually for physical impurities. It was washed and cleaned with water and blanched at 85°C for 20 minutes. The legume was de-hulled manually by rubbing and surface dried followed by drying in the hot air oven at 50°C for 16 hours. The dried pigeon pea was milled using a milling machine to obtain a fine flour.[5]

Processing of soybean

Soybean was sorted manually for physical impurities and washed with water. It was blanched in water at 85°C for 10 minutes and soaked for 24 hours in 3 times volume water by changing the water every 6 hours. The water was drained and the legumes were de hulled manually by rubbing and spread in trays for surface drying. They were further dried in the hot air oven for 48 hours at 50°C. The dried soybean was milled in a milling machine to obtain a fine flour.[6]

Processing of groundnut

The groundnuts were sorted and washed for physical impurities and spread in trays for surface drying. Groundnuts were further dried in the hot air oven at 60°C for 3 hours. They were lightly roasted and de hulled. The roasted groundnuts were used to prepare the NDM.[7]

Processing of pearl millet, rice, Bengal gram dal and watermelon seeds

All the raw ingredients were sorted and washed to remove physical impurities. They were spread on trays for surface drying followed by drying in the hot air oven at 60°C for 3 hours. The dried ingredients were further utilized for preparation of NDM.[7]

Formulation of NDM

The variations for NDM were formulated using carefully selected ingredients from locally grown cereals, millets and pulses including pearl millet grown in Karnataka, pigeon pea grown in arid regions and underutilized watermelon seeds. The ingredients utilized for preparation were pearl millet, rice, pigeon pea, Bengal gram dal, groundnut, soybean, watermelon seeds, milk powder, groundnut oil and sugar. The proportions of pearl millet, rice, pigeon pea and Bengal gram dal were different in different variations of the NDM. Groundnut oil and sugar were included to add to the nutritional composition and energy density of the product.

Table 1 depicts the proportion of ingredients added in each variation V1, V2 and V3 of the NDM.

Table 1: Formulation of NDM.

Ingredients (%)	NDM (V1)	NDM (V2)	NDM (V3)
Pearl millet	30	20	15
Rice	0	10	15
Pigeon pea	10	5	5
Bengal gram dal	0	5	5
Groundnut	4	4	4
Soybean	4	4	4
Watermelon seeds	10	10	10
Groundnut oil	14	14	14
Sugar	20	20	20
Total %	100	100	100

Note: NDM (V1)- nutrient dense mix (variation 1); NDM (V2)- nutrient dense mix (variation 2); and NDM (V3)- nutrient dense mix (variation 3).

Sensory evaluation

Sensory evaluation was conducted by 30 panelists using the 9-point hedonic scale. Sensory attributes evaluated were appearance, color consistency, texture, taste, flavor, aftertaste and overall acceptability. All panelists were semi trained panelists including students and faculty from the Department of Nutrition and Dietetics, Mount Carmel College Autonomous, Bengaluru, Karnataka, India. Water at room temperature was also provided to rinse the mouth between evaluations.

Proximate analysis

The estimation of energy, protein, fat, carbohydrates, crude fiber, ash and mineral composition including calcium, iron and zinc were conducted using standards methods of AOAC.[8]

Physicochemical analysis

The physicochemical parameters of the prepared NDM were analyzed. Standard procedures for estimation of moisture using hot air oven was carried out.[9] Loose and packed bulk density was estimated using the method described in literature.[10] Particle density of the sample was measured.[11] The oil absorption, water absorption and water solubility index, pH, swelling power and the foam capacity and stability were analyzed by methods explained by Imtiaz et al.[12]

Statistical analysis

The statistical analysis was carried out using Statistical Package for Social Sciences (SPSS) 15.0 for windows. One-way ANOVA test was used to calculated mean, standard deviation and p value. Bivariate correlation was analyzed using Pearson's correlation formula.

RESULTS

Sensory evaluation

Sensory evaluation was carried out using a 9-point hedonic scale. Thirty panelists were selected for the sensory evaluation of the control NDM and its variations (V1, V2 and V3). Table 2 depicts that the highest score for appearance was given to the NDM V3 (7.42±0.02) as compared to other variation and the difference was significant ($p<0.002$) in the appearance scores. With respect to colour of the products NDM V3 (7.44±0.03) had higher scores followed by NDM V2 (7.23±0.01). NDM V1 (7.04±0.01) received the lowest scores for colour which may be attributed to its higher content of millets. NDM V3 (7.56±0.02) also had the highest scores for consistency as compared the other variation and control NDM (7.24±0.04) had least scores. Texture scores were given highest to NDM V3 (7.76±0.02) followed by NDM V2 (7.34±0.02) and least to control NDM (7.31±0.03). The flavor of the products was moderately liked in the NDM V3 (7.84±0.01) variation while NDM V2 (7.32±0.02) received a lower score. Among the products evaluated, the taste of NDM V3 was given higher sensory scores compared to NDM V2 (7.42±0.02) which received lower scores among other variations. Aftertaste was seen lowest in NDM V3 (7.87±0.01) and more aftertaste was seen in NDM V2 (7.25±0.02). All the differences in the parameters were statistically significant ($p<0.05$). Hence the variation NDM V3 was the most acceptable variation overall (7.67±0.02) compared to control NDM (7.31±0.03).

Physicochemical analysis

Physicochemical properties of food products are essential to determine the shelf life, preparation methods and hints the nutritional values of the products. Table 3 shows that the moisture percentage of control NDM (6.03±0.15) was higher than moisture percentage of variation NDM V3 (3.7±0.01) with statistically significant difference ($p<0.001$). The loose and packed bulk density measure of the product shows that the loose bulk density of NDM V3 was higher (0.55±0.01) compared to control NDM (0.5±0.010) while the packed bulk density of control NDM (0.7±0.1) was higher than NDM V3 (0.64±0.02) with statistically significant difference ($p<0.013$).

Assessment of particle density revealed to be higher in control NDM (0.81±0.01) as compared to NDM V3 (0.63±0.01) with a significant difference ($p<0.001$). Water absorption index is an important hydration property of products, it was seen that control NDM (2.6±0.01) has lower water absorption index than NDM V3 (3.2±0.15) and these differences are significant ($p<0.001$). Water solubility index of NDM V3 (20.1±02) was higher than control NDM (6.2±0.1) with a significant difference of $p<0.001$.

The oil absorption capacity of control NDM (1.14±0.05) was higher than NDM V3 (0.70±0.01) and significant difference ($p<0.001$) was found in the two products. Swelling power of control NDM (2.26±0.001) was lower than NDM V3 (3.7±0.32).

A significant difference ($p<00.002$) was seen in the swelling power of control NDM and NDM V3. This may be attributed to increased concentration of millets and pulses in NDM V3. The pH of the products was found to be significantly different ($p<0.003$) while control NDM (7.2±0.05) had a lower pH and was more acidic than NDM V3 (7.5±0.05).

Proximate analysis

Macronutrient analysis of NDM

The macronutrient contents of control NDM and variation NDM V3 were analyzed using different analytical methods and depicted in Table 4. Macronutrients play a vital role in providing essential sources of energy and muscle building during recovery from illness. As seen in Table 4, the energy content in the control NDM (312.46±0.55) was lesser than NDM V3 (347.10±0.85) which could be associated with addition of high energy ingredients in NDM V3 including oil and sugar. It is observed that the protein content of NDM V3 (114.28±0.04) was higher compared to control NDM (13.59±0.08) this could be linked to increased inclusion of millets and seeds in the NDM. The fat content was significantly higher in the NDM V3 (19.53±0.03) due to inclusion of oil in the product as compared to fat content in control NDM (3.50±0.05). Crude fiber plays an essential role in maintaining gut health and it was observed to be higher in control NDM (7.78±0.01) as compared to NDM V3 (4.22±0.02) due to higher proportions of millets in the control. The carbohydrate content in NDM V3 (50.90±0.01) was lesser than control NDM (56.5±0.08) attributing to its higher content of cereals and pulses. Ash content of product is linked to its mineral contents. Ash content of control NDM (1.80±0.02) was higher than NDM V3 (0.81±0.01). All the difference in the nutrient compositions were significant ($p<0.001$).

Micronutrient analysis of NDM

Calcium, iron and zinc are essential in maintaining many key functions like formation of bone structure and neuromuscular activity. The calcium, iron and zinc levels in control NDM and NDM V3 were analyzed using different analytical procedures. It was observed in Table 4 that that calcium content of the NDM V3 (154±2.2) was higher than the control NDM (132.34±0.4) which could be owing to the addition of milk powder in the NDM V3 and this difference was statistically significant ($p<0.001$). The iron content of control NDM (3.24±0.02) was higher in comparison to NDM V3 (2.66±0.04), this could be linked to higher proportions of pulses and millets in the control compared to the variation. It was observed that the zinc contents of the control NDM (3.01±0.004) was higher than NDM V3 (2.20±0.01) with a statistically significant difference ($p<0.001$). This difference could be attributed to high content of zinc rich pulses and millets in the control.

Nutritional adequacy of NDM

The nutritional composition of the control NDM and NDM V3 was compared to the RDA requirements of 1-3 year olds and 4-6 year olds. This data gave an insight to percentage adequacy of the products in meeting the daily requirements of the children.

From table 5 it was seen that control NDM meets one third (28.14%) of the energy requirements in 1-3 year olds and slightly lesser requirements were met for 4-6 year olds (22.97%). The NDM V3 meets higher requirements of 1-3 year olds (31.17%) and 4-6 year olds (25.5%). The increased energy from the NDM V3 can be beneficial in meeting energy requirements of SAM children with lesser quantity of the product. The protein for 1-3 year olds obtained from the control NDM (108.72%) and from NDM V3 (114.24%) was more than the RDA requirements for this age group. While it was approximately meeting the RDA for 4-6 years for both control NDM (84.93%) and NDM V3 (89.25%). The fiber content of the control NDM meets 52.46% of the requirements for 1-3 years while NDM V3 meets only 28.13%. RDA fiber requirements of 4-6 years were also partially met with control NDM (38.9%) and NDM V3 (21.1%). Table 5 also shows the micronutrients provided from the NDM V3 and their percentage adequacy to the RDA of the two age groups. This shows that the calcium in the control NDM meets 27.06% of the RDA for 1-3 years and meets 24.06% for 4-6 years. A similar percentage of RDA was met by NDM V3 for 1-3 years (30.92%) and 4-6 years (28.05%). With respect to the iron content in both products the iron from control NDM was higher and meets a higher percentage of the RDA for 1-3 years (40%) and 4-6 years (29.45%). While NDM V3 meets a lesser percentage of RDA for 1-3 years (32.5%) and 4-6 years (24.18%). The zinc content of NDM V3 was also higher on similar grounds and meets the RDA for 1-3 years (91.21%) while it only meets 66.88% of the RDA for 4-6 year olds. The NDM V3 meets a similar percentage of RDA for 1-3 years (66.6%) and 4-6 years (48.88%).

Table 2: Sensory evaluation of NDM.

Sensory parameters	NDM	NDM (V1)	NDM (V2)	NDM (V3)	P value
Appearance	7.06±0.15	7.32±0.02	7.14±0.01	7.42±0.02	0.002*
Color	7.05±0.03	7.04±0.01	7.23±0.01	7.44±0.03	<0.001*
Consistency	7.24±0.04	7.31±0.01	7.34±0.02	7.56±0.02	<0.001*
Texture	7.31±0.03	7.34±0.02	7.36±0.01	7.76±0.02	<0.001*
Flavor	7.45±0.03	7.50±0.01	7.32±0.02	7.84±0.01	<0.001*
Taste	7.75±0.04	7.79±0.01	7.42±0.02	7.8±0.02	<0.001*
Aftertaste	7.41±0.01	7.52±0.02	7.25±0.02	7.87±0.01	<0.001*
Overall acceptability	7.31±0.03	7.42±0.02	7.32±0.02	7.67±0.02	<0.001*

Note: *-Significant at 5% ($p<0.05$); NS- not significant; NDM- nutrient dense mix (control); NDM (V1)- nutrient dense mix (variation 1); NDM (V2)- nutrient dense mix (variation 2); NDM (V3)- nutrient dense mix (variation 3). Data expressed as mean±standard deviation.

Table 3: Physicochemical properties of NDM.

Physiochemical properties	NDM	NDM(V3)	P value
Moisture (%)	6.03±0.15	3.7±0.01	<0.001*
Loose bulk density (g/cc)	0.5±0.01	0.55±0.01	0.004*
Packed bulk density (g/cc)	0.7±0.1	0.64±0.02	0.013*
Particle density (g/cc)	0.81±0.01	0.63±0.01	<0.001*
Water absorption index (g)	2.6±0.01	3.2±0.15	0.002*
Water solubility index (%)	6.2±0.1	20.1±0.2	<0.001*

Continued.

Physiochemical properties	NDM	NDM(V3)	P value
Oil absorption capacity (%)	1.14±0.05	0.70±0.01	<0.001*
Swelling power	2.26±0.01	3.7±0.32	0.002*
Foam capacity (%)	0.76±0.04	0.79±0.05	0.463^{NS}
Foam stability (ml/60min)	0.05±0.01	0.1±0.03	0.52^{NS}
pH	7.2±0.05	7.5±0.05	0.003*

Note: *-Significant at 5% (p<0.05); NS- not significant; NDM- nutrient dense mix (control); NDM (V1)- nutrient dense mix (variation 1); NDM (V2)- nutrient dense mix (variation 2); NDM (V3)- nutrient dense mix (variation 3). Data expressed as mean±standard deviation.

Table 4: Macronutrient composition of NDM.

Nutrient per 100g	NDM	NDM(V3)	P value
Energy (kcals)	312.46±0.55	347.10±0.85	<0.001*
Protein (g)	13.59±0.08	14.28±0.04	<0.001*
Fat (g)	3.50±0.05	19.53±0.03	<0.001*
Crude fiber (%)	7.78±0.01	4.22±0.02	<0.001*
Carbohydrates (g)	56.5±0.08	50.90±0.01	<0.001*
Ash (%)	1.80±0.02	0.81±0.01	<0.001*
Calcium (mg/100g)	132.34±0.64	154.63±2.2	<0.001*
Iron (mg/100g)	3.24±0.02	2.66±0.04	<0.001*
Zinc (mg/100g)	3.01±0.004	2.20±0.1	<0.001*

Note: *-Significant at 5% (p<0.05); NS- not significant; NDM- nutrient dense mix (control); NDM (V1)- nutrient dense mix (variation 1); NDM (V2)- nutrient dense mix (variation 2); NDM (V3)- nutrient dense mix (variation 3). Data expressed as mean±standard deviation.

Table 5: Nutritional adequacy of NDM.

Nutrient	RDA		NDM (per 100 g)	% RDA met (%)	NDM (V3) (per 100 g)	% RDA met (%)	P value
Energy (kcal) (EAR)	1-3 years	1110	312.46±0.55	28.14	347.10±0.85	31.27	<0.001*
	4-6 years	1360		22.97		25.5	<0.001*
Protein (g)	1-3 years	12.5	13.59±0.08	108.72	14.28±0.04	114.24	<0.001*
	4-6 years	16		84.93		89.25	<0.001*
Crude fiber (g)	1-3 years	15	7.78±0.01	52.46	4.22±0.02	28.13	<0.001*
	4-6 years	20		38.9		21.1	<0.001*
Calcium (mg)	1-3 years	500	132.34±0.64	27.06	154.63±2.2	30.92	<0.001*
	4-6 years	550		24.06		28.05	<0.001*
Iron (mg)	1-3 years	8	3.24±0.02	40	2.66±0.04	32.5	<0.001*
	4-6 years	11		29.45		24.18	<0.001*
Zinc (mg)	1-3 years	3.3	3.01±0.004	91.21	2.20±0.1	66.6	<0.001*
	4-6 years	4.5		66..88		48.88	<0.001*

Note: *-Significant at 5% (p<0.05); NS- not significant; NDM- nutrient dense mix (control); NDM (V1)- nutrient dense mix (variation 1); NDM (V2)- nutrient dense mix (variation 2); NDM (V3)- nutrient dense mix (variation 3). Data expressed as mean±standard deviation.

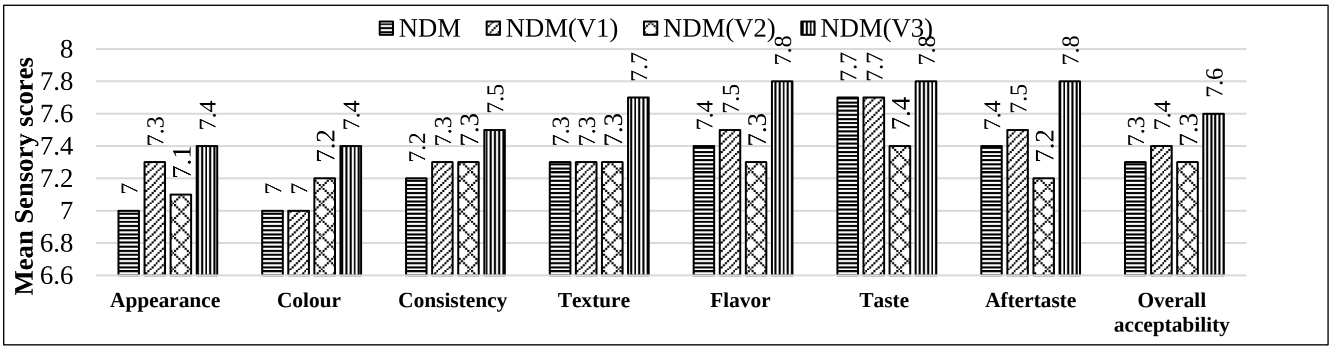

Figure 1: Sensory scores of NDM control and variation.

Note: NDM- nutrient dense mix (control); NDM (V1)- nutrient dense mix (variation 1); NDM (V2)- nutrient dense mix (variation 2); NDM (V3)- nutrient dense mix (variation 3).

DISCUSSION

In other similar studies, a health drink developed using pearl millet indicated that variations containing 50% pearl millet and 30% ragi flour received the highest score for appearance followed by 60% pearl millet flour compared to other higher proportions of pearl millet in other variations. The study concludes that inclusion of a higher percentage of millets may affect the sensory parameters like appearance of product.[13]

Weaning foods were prepared using pearl millet, cowpea, wheat and groundnuts, the study observed that addition of groundnuts in the weaning foods increased their overall acceptability.[14] The overall acceptability increased from 7.38±0.78 to 8.97±0.75 on addition of groundnuts. Products developed including pigeon pea soup, millet soup (containing pearl millet, red lentil and chickpea), little millet and rice and 10% pigeon pea and finger millet dessert showed that products developed using pigeon pea had a greater acceptability like pigeon pea soup (4.4±0.8) and little millet with rice and 10% pigeon pea (4.3±0.9).[15]

Product developed with groundnut-millet flour blend show decreasing bulk density with increasing groundnut content added to the flour blend. This is attributed to the reduction in packaging and transport cost due to smaller size of packaging. A reduction in bulk density is also linked to nutritional implications as more can be consumed resulting in higher energy and nutrient density.[16] A study on the functional properties of weaning foods prepared using millet, maize, beans and soybean shows that water absorption capacity, water absorption index and oil absorption capacity is higher in the formulation containing millet (65%) and bean (30%). These functional qualities are linked to addition of legume flour which is high in protein.[17] Swelling powers and pasting properties of different flours of rice, taro and pigeon pea and higher protein content of the flours is linked to starch granules being trapped in a stiff protein matrix and restricted swelling. High carbohydrate and low protein in rice flour results in its high swelling ability compared to other flours.[18]

Similar studies about development of RUTF using millets, maize flour, soybean flour, bean flour show that increasing proportions of bean and legume flours significantly increases the energy contents. Energy content increases from 277.87 kcals in 95% millet to 408 kcals and 403 kcals in 30% bean and 50% maize and soybean flour respectively.[17] Infant weaning foods prepared using mung bean, wheat flour, full fat milk powder and sucrose show that on increasing the proportions of mung bean flour and decreasing wheat flour the protein content increases from 19.25 g to 23.97 g.

Therefore, increased proportions of legumes is attributed to increased protein levels in the weaning foods.[12] There is an increase in ash content in weaning foods prepared from lightly roasted teff, finger millet and peanut compared to ones prepared using raw ingredients. The ash content increases from 1.88 g to 2.31 g in roasted weaning foods and a 2.90% increase is observed in fermented weaning foods attributed to decrease in fat and carbohydrate content. There is also a 4.39% increase in crude fiber content on roasting the ingredients compared to raw weaning food preparations.[19]

Research shows that locally prepared rice- lentil based RUTF show increased calcium content in (301.3 mg) comparison to the standard plumpy nut RUTF (279.7 mg) due to its higher contents of grains and legumes. Similar increase is seen in iron content from 11.2 mg to12.1 mg and zinc from 12.9 mg to 13.8 mg in rice-lentil based RUTF.[20]

In a study on the development of pigeon pea and maize complimentary foods, the calcium content of complimentary foods increases by fermentation for 48 hours in 60:40 (maize: pigeon pea) blend from 174 mg to 344 mg and the iron content increased from 6.72 mg to 14.05 mg on 4 hours of fermentation. Therefore, it is seen that processing of ingredients using methods like fermentation helps increase the mineral bioavailability.[21] Inclusion of organic acids is observed to increase mineral bioavailability in pearl millet porridge by inclusion of boab fruit pulp. The zinc content increases from 1.84 mg in pearl millet porridge with inclusion of boab fruit pulp in 20% ratio to 2.02 mg.[22]

Consumption of RUTF crackers is observed to increase energy and protein intake in test subjects of 1 to 3 and 4 to 6 years old in comparison to the RDA in Indonesian children. This intervention helps meet energy intake (95.49%) in the intervention group of 4-6 years on consumption of the crackers.

Consumption of the crackers is observed to increase the weight of the children under 5 years at an average of 0.39 kg.[23] In comparison to the percentage adequacy of nutrients in plumply nut RUTF to the RDA of 1-3 year olds in Italy, it is observed that 100g of the RUTF meets 64% of the calcium needs, 4074% of iron and 341% of zinc requirements.

The limitation of this finding is that most children fail to consume the required amount of recommended RUTF leading to slower recovery of SAM children.[24]

CONCLUSION

In conclusion, the NDM prepared using local pearl millet, pigeon pea and underutilized plant wastes like watermelon seeds have high sensory acceptability and favorable physicochemical properties. It has a potential to be used as a nutritionally dense food for children under 5 years of age. Additionally, utilization of arid crops, and nutrient dense pulses ensure a good micro and macronutrient profile at a low cost. The high potential of the product paves way for further exploration in curbing malnutrition.

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