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EFFECT OF THE DIETRAY ZINC SUPPLEMENTATION IN THE READY-TO-USE THERAPEUTIC FOOD (RUTF) ON THE HEALTH STATUS AND DERMATITIS OUTCOMES IN SEVERELY ACUTE MALNOURISHED CHILDREN: A RANDOMIZED CONTROL TRIAL

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Abstract

Introduction

Severe Acute Malnutrition (SAM) and Protein Energy malnutrition (PEM) in under- five children are a serious concerns accounting for a huge number of child mortality and disease burden each year. Despite great efforts Pakistan still face a chronic and severe under- five malnutrition that need to addressed through sustainable solutions.

Objectives: *The current Randomized control Trial was based on the following objectives.*

1. To determine the efficacy of dietary enrichment of zinc in the RUTF among children with PCM.

2. To investigate the effects of dietary zinc source supplementation on the weight gain, states of dermatitis and oedema among children with SAM during the recovery.

Methodology: *This study was conducted at the stabilization Units of Khyber Teaching Hospital, Peshawar. Based on written and informed consent a sample of 100 SAM children were divided equally into a control group where they receive the standard protocols and an experimental group which receive the standard protocol along a RUTF khtichri with the value addition of sunflower and pumpkin seed flours (being prepared under standard laboratory procedures). The effects were observed on the weight gain, oedema, and dermatitis.*

Results: *Results of the current indicated that 96% of the children belonged to rural background with both parents largely being illiterate, living in an extended family system (68%) and a larger family sizes. The household conditions exhibited a number of probable factors leading to unhygienic environments. The feeding profiles of the children showed that 22% were exclusively breast fed while 68% received a diluted formula or cow's milk with added sugars. About 40% children were partially vaccinated and 96% children were not given timely complementary feedings. Overall, 76% children were born with normal weight but suffered severe concurrent diarrhea. The anthropometric data indicated severe acute malnutrition with mean Z Score of 4.28± 4.09 which declined to 2.6 ± 2.63 in the control* *and 1.91 ± 2.11 in the experimental group which was significantly different from both pre-test and post-test of the control group. The dermatitis in both the groups improved but the results were more promising for the experimental group (64% no dermatitis) at discharge. The similar trend was also observed in the oedema where 78% severe generalized edematous children improved but in a more promising manner in the experimental group.*

Conclusion: *the study concludes that the safe addition of value addition of the local, nutrient rich food source to the complementary feeds of the SAM and PCM children help overcome child malnutrition in a more sustainable manner.*

INTRODUCTION

Child undernutrition is referred to as deficiencies or imbalance in the energy and other nutrients' intakes. South Asia is considered as the most vulnerable for its higher prevalence of under-5 severe under nutrition as two thirds of children are affected live in Asia [1]. Pakistan was among the top three countries struggling with high burden of under-5 severe undernutrition being 10% between 2010-2014 [2]. The role of micronutrients has been recognized to have a vital role in human health along the macronutrients. After the Sommer's pioneer work on the impact of vitamin A supplementation on respiratory infections in young children the role of micronutrients on children' survival in both clinical and subclinical deficiencies have led to a host of experimentations [3, 4]. Vitamin A and zinc have greater public health potential effects as compared to another micronutrient. The assessment of zinc is more difficult in humans due to its diverse biological effects in malnourished children that range from its profound effect on growth to its significant role in immunity [5-7].

In the human body zinc is a component of more than 200 metalloenzymes, including carbonic anhydrase, alkaline phosphatase, carboxypeptidase A and B that perform a range of vital life functions. The deficiency of zinc, however, does not exert its effects through the deficient functions of these enzymes alone. Zinc also plays an important biological function of being part of maintaining bio-membranes, its role in DNA's replication, transcription, and translation, maintenance of adequate immune function, brain development, and metabolism of fatty acids [8-13]. Zinc is considered extremely important for normal fetal growth and its deficiency in pregnancy has been associated with increased malformations and premature births [14-18]. Maternal zinc deficiency has also been associated with Intrauterine growth retardation (IUGR) and low birth weights [19, 20]. Maternal zinc levels in the breast milk also decrease progressively with the duration of lactation and has been shown to be directly related to maternal zinc intake, however, its content is still higher than the commercial formulae and has been postulated that poorly fortified formulae may cause hypozincemia and poor growth [21-24].

The relationship of zinc hemostasis with growth in malnourished children is well documented and its serious effects are associated with protein energy malnutrition [25, 26]. The metabolism of serum albumin and pre-albumin are closely dependent on zinc status and are considered useful parameters in monitoring children's health at community level [27, 28]. Its deficiency has been associated with some special sub-types of malnutrition and long-standing PEM [28, 30]. Its supplementation among malnourished children has shown dramatic increase in linear growth, weight gain, and sexual maturation [31].

Zinc deficient diets have implications in delayed recovery from PEM, probably due to its close relationship with anorexia and reduced protein turn over. It has also been demonstrated that zinc deficiency led to reduced rate of weight gain during nutrition rehabilitation in zinc deficient children and its supplementation led to decreased energy cost of tissue depletion [32-34]. Diarrhea itself may a manifestation of zinc deficiency and its subsequent profound losses and balance in diarrheal illnesses can be a major determinant of the diarrhea-malnutrition cycle [35, 36].

In Pakistan the magnitude of zinc deficiency is still not clear but its major at risk are pregnant mothers, PEM, and children with frequent infections specifically diarrhea [37]. In the Nutrition Rehabilitation Units, the medically stable children with SAM (also referred to as “uncomplicated” SAM) are treated in outpatient/community settings with ready-to-use therapeutic food (RUTF) while sick children with SAM or “complicated” SAM, defined as severe wasting and/or nutritional edema with appetite loss, severe edema, or the presence of medical complications, require inpatient treatment [38.39]. Treatment first involves stabilization and management of urgent medical conditions. During this stabilization phase, children are fed therapeutic milk F-75 orally or enterally (130 mL/kg/d = ∼100 kcal/kg/d). Following stabilization, children are gradually transitioned to high-calorie therapeutic foods, either F-100 and/or RUTF, for their rehabilitation phase (∼135–220 kcal/kg/d). Once children are well established with intake of their rehabilitation phase foods, they are discharged home and continue rehabilitation with RUTF [40]. The traditional kitchri and yoghurt diet that is frequently given in the nutrition rehabilitation of PD 17, the estimated daily zinc intake has been reported to be mere 0.02µg/100 Kcal consumed which is much lower in addition that oral supplements may not be possible in these children due to the associated diarrheal episodes. The current study was an effort to enrich this traditional kitchri with some indigenously grown, cost effective zinc sources that may be nutritionally adequate and sustainable to follow after these children are discharged from the hospital.

1. METHGODOLOGY

2.1: Location of the Study

This study was conducted at Nutrition Rehabilitation Units/Stabilization Centers of the Khyber Teaching Hospital, (the fully equipped Medical Teaching Institute), Peshawar, Pakistan. Data was collected from the Stabilization Centre of Pediatric Ward. The study spanned from June 2022 to August 2022 and then October 2022 to January 2023. The study was conducted under the supervision of qualified nutritionists who provide nutritional care to the patients. Once admitted, the children were provided routine medications (where needed), child’s progress was monitored, and provided referrals to inpatients when children fail appetite tests or developed complications. All services including screening, admission cost, RUTF, medications, and inpatient facilities were provided free of cost to the children.

2.2: Study Design

The study was a randomized, double-blind, placebo-controlled trial. Based on written consents of the mothers the children were be randomly divided into two groups to received either a zinc supplement and the predefined protocol or a zinc source enriched RUTF, supplements and protocols for 12 weeks. The primary outcome measure was the change weight, Z score of the WHO growth charts, state of dermatitis being assessed by the Scoring Atopic Dermatitis Index (SCORAD) and oedema as per the UNICEF criteria.

2.3: Sample Selection

A consent based convenient random sample of 100 SAM children age 6-59 months with PCM related medical complications such as wasting, dermatitis, oedema was recruited from the Stabilization Sections ward A and B at the Khyber Teaching Hospital Peshawar.

2.4: Data Collection

Based on the protocol for the Community-based management of SAM children a self- constructed questionnaire was designed to record age, sex, feeding history, medical history, last diet intake, and demographic history and socio-economic conditions.

2.4.1: Test Variables of the study

i. Body weight: Weight was measured by using the UNICEF infant, spring-type scale.

ii. MUAC: MUAC was measured with the help of UNICEF MUAC, 11.5 Red, PAC-50. The MUAC tape was placed on the left upper arm of a child with the arm hanging down the side of the body in a relaxed position.

iii. Fever: Fever was measured by taking the temperature rectally as recommended by the American Academy of Pediatrics.

iv. Oedema: Normal thumb pressure was applied on both feet for three seconds and edema was confirmed by shallow print on both feet.

v. Diarrhea, nausea, and vomiting: These parameters were assessed by the physicians based on their observations and apparent signs and symptoms of the children.

2.4.2: Ethical Approval and Participants' Consent

This study was carried out in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Board of the College of Home Economics, University of Peshawar (H.ECO/22). Permission from the Executive Director of KTH Peshawar was also acquired. Written consents from the mothers of the children were procured and the purpose of the study was fully explained to them in the local language. All patients' records were fully anonymized before data collection by coding each child and no one had access to information that could identify individual participants during or after data collection

2.4.3: Assessment Health status of children

The following methods were used to assess the nutritional status of the patients:

2.4.3.1: Anthropometric Assessment

Anthropometric assessment of children included the physical measurement of height / length, weight and z scores. (Weight for height/length) of the patient.

A). Weight

Weight was measured by using the pediatric scale. On the basis of child & age and ability to stand, the height of the child is measured. Recumbent length was measured if a child was less than two years old.

B). Weight for Height Z-Score

The WHO growth charts were used to assess the health and nutritional status of the children. The WHO Z-Score criteria was adopted to classify the children.

- If a child had -3 SD Z-score then he or she was taken as severely malnourished.
- If the child had - 2 SD, then it would be moderately malnourished.
- A child with -1 SD was considered as normal child.
-

2.4.3.2 Medical History

A medical history is a record of a patient's condition, present and past, detail of illnesses and any surgery, pain, discomfort or other medical issues the patient may be experiencing were recorded.

2.5 Nutritional Management

The WHO protocols were followed used within the SC of pediatric ward as:

2.5.1 WHO Protocols for Malnourished Child

2.5.1.1 Management of Hypoglycemia

Treatment for hypoglycemia was started with mixture of Sugar and water given orally or through NG tubes and the F - 75 was initiated at feed on two hourly for 24 hours.

2.5.1.2 Management of Hypothermia

The children were kept warm by covering in blanket, hot water bottle, and mothers' laps to ensure temperature rises to ≥35.5 -37°C.

2.5.1.3 Management of Dehydration

Children were given with ReSoMal (5ml/kg body weight) every 30 minutes for 2 hours orally or through NG tube. During treatment rapid respiration and pulse rates were recorded and until the child began to pass urine.

2.5.1.5 Correction of Micronutrient Deficiencies

Zinc oxide paste was applied on the skin 3-4 times a day for dermatitis. Vitamin A and one tablet of folic acid was given to the patient on first day of admission and half tablet was given daily for a month. Children with mild edema were given Vitamin A on day 1 (for age 12 months; 100,000 IU, for age 6-12 months 1, 00,000 IU, and for age 0-5 months 50,000 IU). Children with severe eye infections were given a mega dose of 2, 00,000 UI on first day then on third day and on fourteen days. Iron supplements were given after the child started weight gain

2.5.1.6 Management of Dermatitis

Dermatitis was present among all children of the study. The assessment of the dermatitis was done on the Scoring Atopic Dermatitis Index (SCORAD) throughout the course of study. The criteria adopted was grading the dermatitis as

+ Mild discoloration or a few rough patches of skin,
++ Moderate multiple patches on arms and/ or legs.
+++ Severe flaking skin, raw skin, fissures (lesions in the skin).

2.5.1.7: Management of Edema

Children admitted to RC had three grades of edema. + mild both feet, ++ Moderate both feet, plus lower legs, hands, arms and face, +++ Severe Generalized oedema (all over the body)

2.5.1.8: Management of Anemia

Children with Hb less than 4g/dl were transfused blood. while those Hb above than 4g/dl were given folic acid in order to prevent severe anemia.

2.5.1.9: Cautious Feeding

At admission the three days were considered as Stabilization phase. In those days the patient were given therapeutic milk i.e., F-75 tor stabilization according to patient's weight. During the stabilization phase, diarrhea gradually diminished and edematous children lost some weight. The amount offered and let over of feed, vomiting, frequency of watery stools was monitored. In case of breast-fed child, it was continued every 2 hours.

2.5.1.10: Catch Up Growth

After stabilization the child was considered in a recovery phase when weight gain of 10g/kg/d started. In this phase F-100 was given containing 100 kcal/100mL and 2.9g protein/10OmL. It was given after 2, 3 and 4 hours. Weight of the child was measured every morning. The criteria for growth catch were estimated as:

≤5g/day: poor weight gain,
5-10g/day: moderate weight gain,
10g/day: good weight gain

2.5.1.11: Sensory Stimulation and Emotional Support

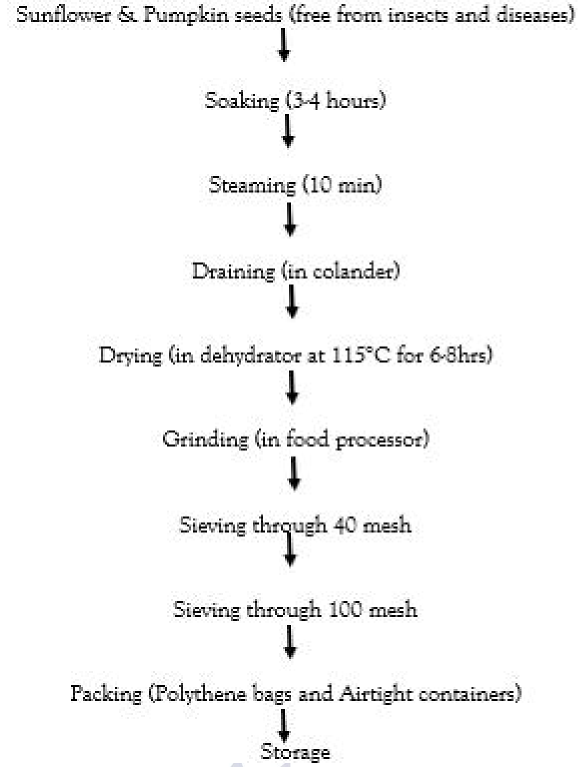
Children were provided with care and love, cheerful environment, physical activity when the child was well, and maternal involvement hugging, comforting, feeding, play was stimulated.

2.6: Preparation of the Test flours and complementary Feeding (Zinc Enriched Kitchri)

After three days of stabilization children were started with complementary feedings (RUTF) along the rest of the protocols. In order to ensure Zinc supplementation, the indigenous mixed cereal rice (kitchri) was prepared with the addition of 15% and 10% w/w of one lentil and either a sunflower seed flour or a pumpkin seed flour. The feed was freshly prepared daily. About 1-2 spoons of yoghurt was mixed in the kitchri or was given before or after the feed for diarrhea and for prevention of dehydration. Alternatively mashed banana and yoghurt were also given.

2.6.1: Preparation of the Seed Kernel Flours

A good quality sunflower and pumpkin seeds were procured from a local market. The seeds were checked for any insects of disease and then were soaked in lukewarm water for 3-4 hours. In order to remove the potential antinutrients and mycotoxins sunflower and pumpkin seeds were steamed in a boiling water in a double boiler for 10 minutes. After this step the seeds were drained and were shifted to dehydrator/lab oven for drying till constant weight. Once dried the seeds were grinded in a lab food grinder to a fine texture. In order to remove the husks, the flours were sieved twice through two size mesh lab Sievers to obtain a husk free fine textured flour. The flours were packed in polythene bags and then air tight jars and were stored in cool and dry place for further use.



2.6.2: Composition of the conventional & supplemented RUTF (Kitchri): The complementary feeds were freshly prepared each day in the kitchen of the SC. The composition of the kitchri were as:

Table 1: Composition of the Control and Test Kitchri (W/W)

Feeds	Food Items	Weights (gms)
Control	Rice+ Split Mung +Oil	80+20+07
T1	Rice+ Red Lentil+ Split Mung+ Oil	80+10+10+07
T2	Rice+ Split Mung+ Sunflower Seed Flour+ Oil	65+10+15+5
T3	Rice+ Split Mung+ Pumpkin Seed Flour +Oil	70+15+15+5
T4	Rice + Red Lentil + Sunflower Seed Flour + Oil	70+15+10+5
T5	Rice + Red Lentil + Pumpkin Seed Flour + Oil	70+10+15+5
T6	Rice + Red Lentil+ Split Mung+ Pumpkin Seed Flour + Oil	65+10+10+10+5

2.6.2: Proximate & Mineral Composition

The proximate composition of the control and value added kitchris for five macro nutrients and three minerals were performed as per the standard procedures of AOAC in the laboratory.

2. RESULTS & DISCUSSION

3.1: Nutrient Composition of The Supplemented RUTF kitchris

Results of the nutrient composition of the major ingredients of the test feed showed (Table 1) that the addition of both the split mung beans and split red lentils are a valuable source of proteins (23.4± 0.1 and 23.9 ± 0.23 g/100gm respectively), zinc (32.3 ± 1.0 & 36.3± 0.06 mg/kg^{-1} respectively), iron (74.0± 0.1 & 73.9±1.02 mg/kg^{-1} respectively) while the contribution of copper was not significant from these sources. The addition of both sunflower seed and pumpkinseed flours had shown to be a positive potential enrichment source. The higher total as content (3.61± 0.01 & 5.7±0.04), Proteins (22.98± 0.02 & 22.8±20.1), a comparatively low fiber (3.1±0.1 & 2.53±0.26) will be of additional benefit to these children due to the facts reported that higher fiber content of cereals may be a frequent source of diarrhea/stools and retention of water [41]. while these seed flours are not only significantly higher in proteins, fat (an additional benefit to the total energy of these feeds) but are also low in fiber (the double sieving had an advantage). The zinc content (mg Kg^{-1}) of the sunflower seed flour was found to be 56.42 ± 0.61 and that of pumpkin seed flour was 61.06± 0.21 making them not a zinc rich source but also an economical source of biofortification. As compared to cereals the iron and copper content of these seeds were significantly higher and the parboiling of the seeds further were of further advantage of removal of potential antinutrients and opportunist mycotoxins from these seeds. These findings are in strong agreement with the findings of other studies [41- 43] which reported that the addition of indigenous economical sources to the commonly consumed food items are beneficial biofortification sources in addition that both of these seeds are a rich source of many other nutrients especially the omega 3 fatty acids which further help elevate the health outcomes and being rich in oils and Vitamin A would enable these families to overcome the burden of malnutrition for other children of their households for at-home-functional-foods.

Table 1: Nutritional Composition of the Complementary Feeds Components

Food Items	Ash (%)	Crude Protein (%)	Crude fiber (%)	Zn (mg kg^{-1})	Fe (mg kg^{-1})	Cu (mg kg^{-1})
Rice	0.93±0.01	7.52±0.75	0.39±0.05	32.56±0.00	40.21±0.04	2.80±0.14
Mung beans	3.63±0.13	23.4* ± 0.1	3.95*±0.1	32.3 ± 1.0	74.2*±0.1	2.90±0.1
Red Lentils	3.1±0.15	23.9±0.23	10.8*±1.03	36.3±0.06	73.9±1.02	1.3±0.19
Sunflower seed flour	3.61 ± 0.01	29.8** ± 0.02	3.1±0.1	56.42* ± 0.61	106.7 ± 3.35	19.74 ± 0.23
Pumpkin seed flour	5.7**±0.04	29.8**±2.01	2.53±0.26	68.06**± .021	105.9** ±0.02	4.51±0.12

3.2: Socio-Demographic Characteristics of the Sample

The socio-demographic characteristics of the sample (Table 2) indicated that 96% of the children belonged to rural background, illiterate parents (96% fathers & 98% mothers) with fathers being employed in laboureres/low paid daily wages occupations (80%) and mothers being housewives (92%). Majority of the children were living in an extended family systems (68%) with larger family sizes in a nuclear unit i.e., 6-9 children (48%) and total family size of 10-14 members was common in 28% households. The next of kin showed that 04 children before the patient child was 22% while 14% had 07 siblings. About 57% families had two rooms in their households with one washroom facility (78%), and verdant (katcha0 kitchen in 96% households and a striking feature of wood burning as the major fuel source was common in 96% households. The water source at many households was hand pumps (68%) and it was stored in domestic utensils. This whole socio-ecologic scenario at the households of these children represents a deep-rooted poverty- and unhygienic model for the aetiology of SAM in these children and was reported in many such studies [2]

Table 3: Socio-Demographic Characteristics of the Sample

S#	PARATMETERS	FREQUENCY	PERCENTAGE
1.	**Address**		
	Rural	96	96
	Urban	4	4
2.	**Father education**		
	Illiterate	96	96
	Matriculate	4	4
3.	**Mother education**		
	Illiterate	98	98
	Elementary	2	2
4.	**Father Occupation**		
	Shopkeeper	16	16
	Labor	80	80
	Jobless	4	4
5.	**Mother Occupation**		
	House wife	92	92
	Any other	6	6
	Late	2	2
6.	**Type of family**		
	Extended family	68	68
	Nuclear family	32	32
7.	**Total no of family members**		
	3-5	14	14
	6-9	48	48
	10-14	28	28
	<15	10	10
8.	**Number of siblings**		
	1	6	6
	2	8	8
	3	18	18
	4	22	22
	5	16	16
	6	12	12
	7	14	14
	8	4	4
9.	**Type of house**		
	Personally Owned	72	72
	Rented	28	28

10.	**No of rooms in a house**		
	1	14	14
	2	57	57
	3	16	16
	4	10	10
	5	9	9
11.	**No of washrooms**		
	1	78	78
	2	22	22
12.	**Type of kitchen**		
	Transitional kitchen	2	2
	semi constructed	2	2
	Verdant (kacha)	96	96
13.	**Type of fuel used in kitchen**		
	Gas	4	4
	Wood	96	96
14.	**Water Sources**		
	Wells/Bore	4	4
	Hand Pump	68	68
	Tube Well	28	28
15.	**Water Storage**		
	Storage Utensils	98	98
	Tank	2	2

3.3: Feeding, Weaning, Vaccination, and age at Complementary feeds Profiles of the sample

The data regarding the gender wise distribution (Graph 1) showed 44% male and 46% female patients in the study. Only 22% of the children were breast fed for 6-12 months while 60% children were in formula that obviously was diluted as evident that 62% of the formula were given with added sugars about 28% children received milk from multiple sources. Despite the fact that breastfeeding is promoted at all level still a large majority of these SAM did not receive their mothers' milk and if any.

The birth weight and weaning record (Figure 2) indicated that 76% of the children were born of normal weight and 12% with low birth weight. About 72% of the children suffered chronic recurrent diarrhea and 96% of the children did not receive any proper complementary feeding.

The vaccination profile of the children showed that 28% of the children were not vaccinated for the essential vaccination while 40% received partial vaccination. Only 16 % of the children had completed their vaccine course. This situation is quite alarming as the vaccination program is free for all Pakistani children and this percent of children being not given or partially given is negligence on part of parents which might be of gross consequences in the future.

The age of the complementary feeds (Figure 4) showed that 48 % of the children received a type of solids at the age of 6-10 months while 32% at the age of 10-15 months.

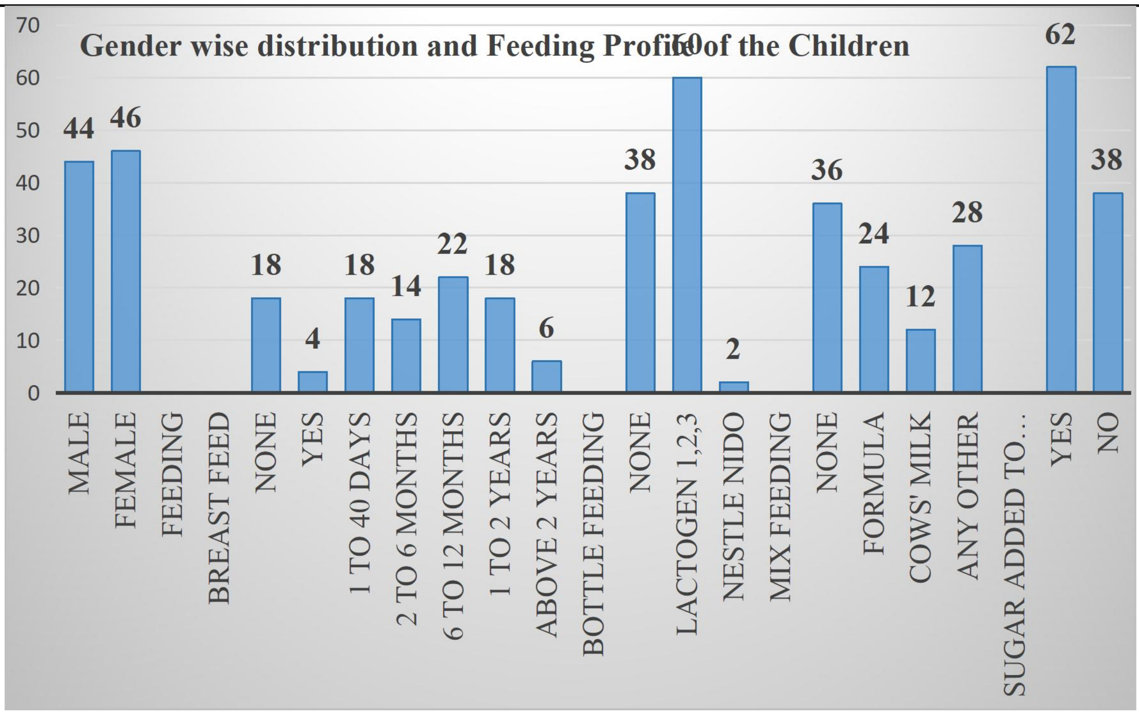


Figure 1: Gender and feeding profile of the Sample

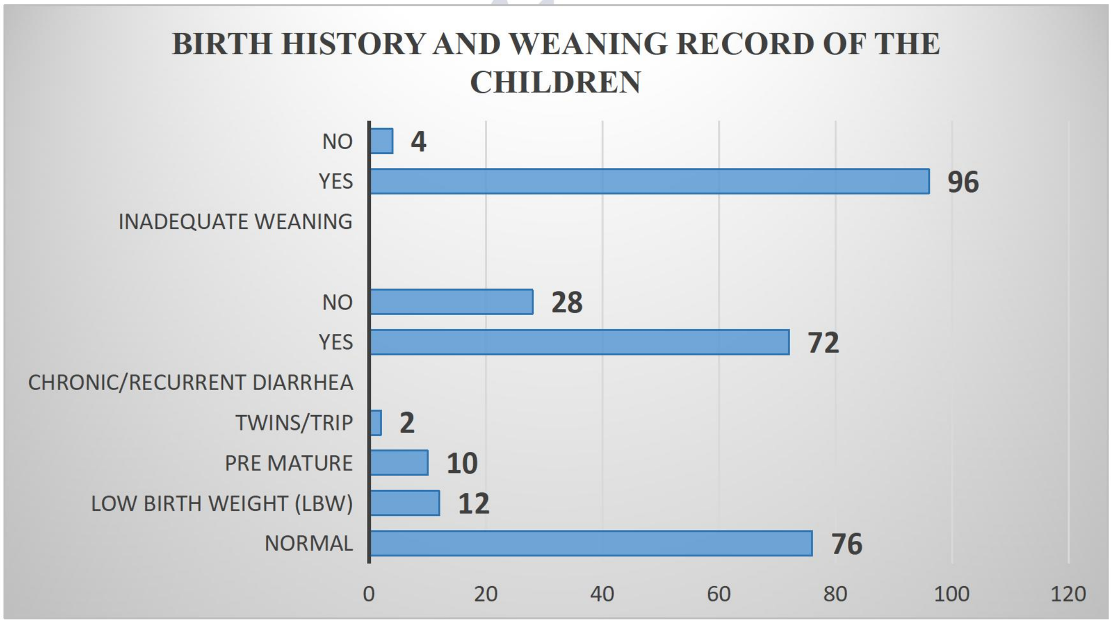


Figure 2: Birth weight and Weaning Record of the sample

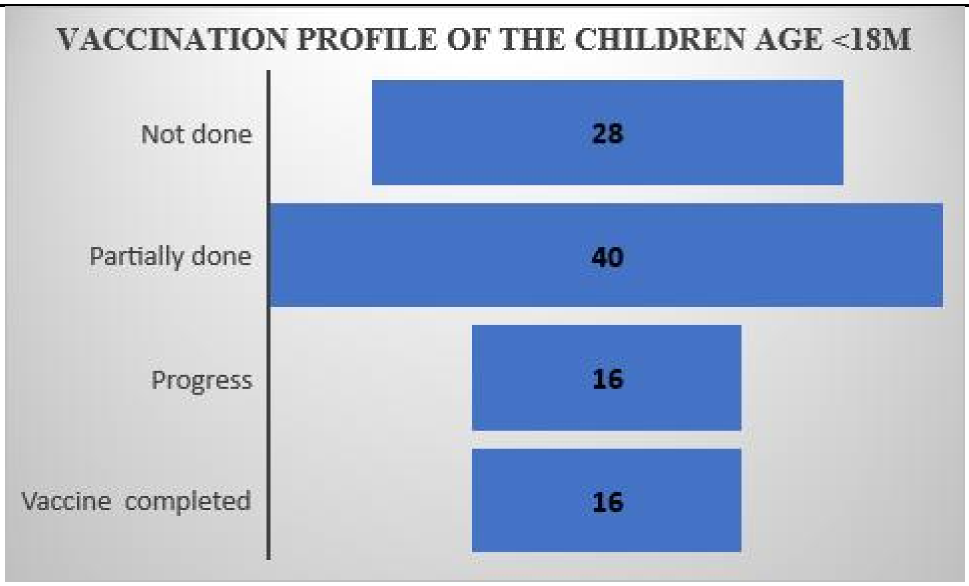


Figure 3: Vaccination profile of the children

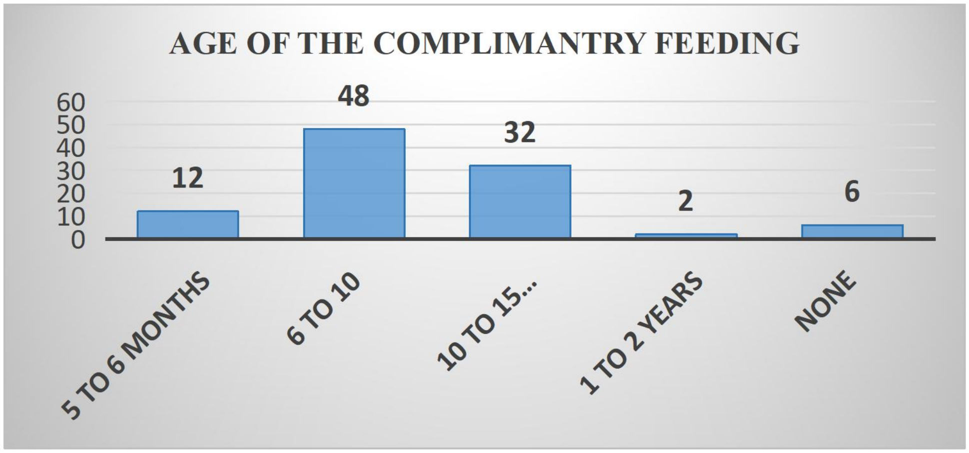


Figure 4: Age at Complementary Feeding of the children

3.4: Effect of Zinc Supplemented RUTF on the Anthropometric Profiles of the Sample

The data regarding the anthropometric measurements (Table 4) of both the control and experimental groups before the initiation (at admission) of the trial showed mean age to be 24.72 ± 11.09 months with mean lengths of 68.50 ± 6.30 Cm, weights 6.80 ± 1.22 Kg and Z scores of 4.28 ± 4.99 indicating the children to be severely malnourished as per the WHO criteria for SAM. In the post-test a significant improvement occurred both in the weights (7.91^{*} ± 2.67) and Z Scores (2.6^{*} ± 2.63) of the control group from pre-test. However, the overall results of the experimental group were more promising in terms of both weight gain (8.53 ± 3.07) and Z scores (1.91 ± 2.11) which significantly improved not only from the pre-test (P= 0.035 & 0.002 respectively) but also from the control group (P= 0.004 & 0.019 respectively). These differences in the mean values are indicative that a combination of any value addition to the complementary feedings at the stabilization centers and at home are a sustainable and economical way of preventing the recurrence of PCM in these children.

Table 4: Anthropometric Profile of the Sample

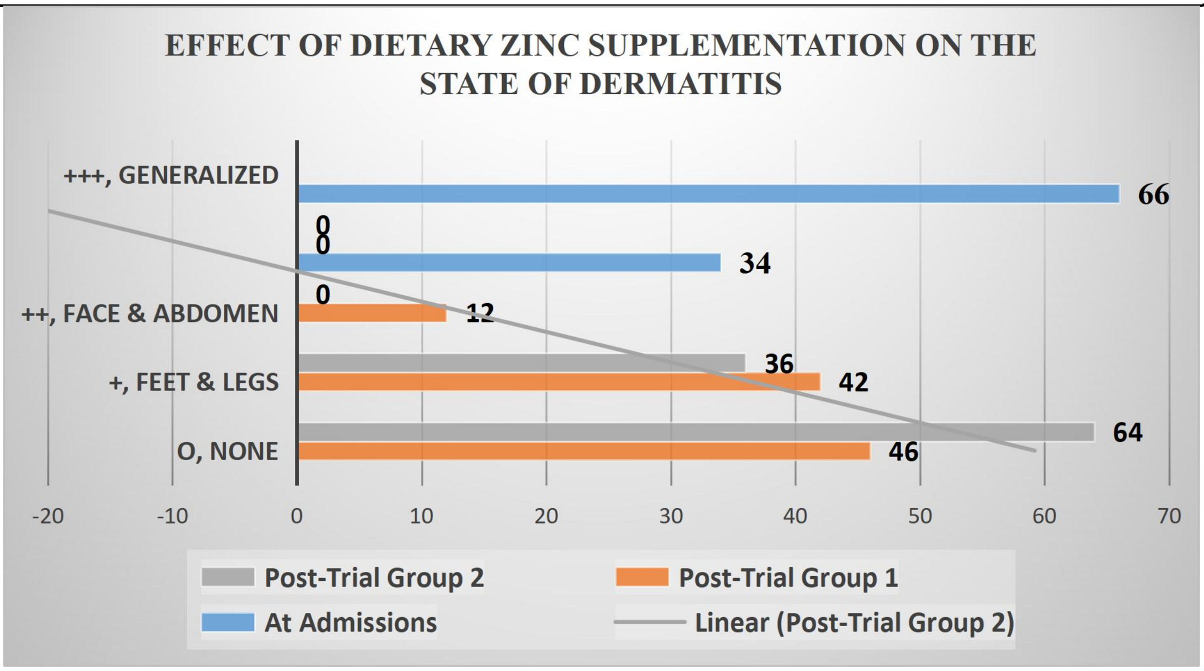
Parameters	Inter quartile Range	Pre- Trial	Post- Trial control	Post- Trial Experimental	P-Value Pre- Test	P-Value from Control
		Mean ± SD	Mean ± SD	Mean ± SD		
Age of child (months)	11.00 - 59.00	24.72 ± 11.09	24.93 ± 1.6	24.90 ± 1.6	NS	NS
Height/ length (Cm)	54.00 - 79.00	68.50 ± 6.30	68.50 ± 6.74	68.54 ± 2.64	0.117	0.171
Weight (Kg)	4.00 - 10.90	6.80 ± 1.22	7.91* ± 2.67	8.53 ± 3.07	0.035	0.004
Z-score (SD of the median on growth chart)	2.8.00 - 7.00	4.28 ± 4.99	2.6* ± 2.63	1.91 ± 2.11	0.002	0.019

3.5: Effect of Zinc Supplemented RUTF on the Dermatitis Profiles of the Sample

The effect of dietary zinc supplementation in the complementary in the indigenous kitchri on the state of dermatitis (table 5 & Figure 5) showed that at the time of admission #4% of children had grade- 2 dermatitis (face & abdomen) while 66% children were suffering from generalized severe dermatitis. After receiving the standard protocols both the groups showed a progressive improvement in the alleviation of dermatitis. However, at the time of discharge the experimental group showed more promising results. In this group 64% of children had no dermatitis while 36% had mild (grade-1) symptoms on feet & legs. In contrast in the control group only 46% were free from any signs of dermatitis while 42 % had mild symptoms and 12% had moderate degree of dermatitis. These findings confirm that the safe addition of zinc rich foods to the complementary feeds had significant positive effects on the state of dermatitis in the experimental group. The graph is also a clear indication of a parallel decline from generalized severe dermatitis to no dermatitis at the termination (discharge of children from hospital) of the study showing a drastic improvement. This strategy for improving/diversifying the diets of the children at risk of PCM through new innovation by utilizing local food ingredients that contain high amounts of zinc for supplementation so that the zinc needs can be met is a much-needed strategy since zinc rich animal- based foods are expensive and these families usually suffer severe food insecurity. The findings of the current studies are in agreement with many such studies which promoted the utilization of local zinc sources for PCM children [44-46]

Table 5: Effect of Dietary Zinc Supplementation on the State of Dermatitis in the sample

Dermatitis Status	At Admissions		Group 1/ Control		Group 2/ Experimental	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
0 (None)	0	0	23	46	32	64
+ Feet & Legs	0	0	21	42	18	36
++ Face & Abdomen	17	34	6	12	0	0
+++ Generalized	33	66	0	0	0	0



Graph 5: Effect of dietary zinc supplementation on the Dermatitis in the sample

3.6: Effect of Zinc Supplemented RUTF on the Oedema Profiles of the Sample

The effect of food based a source of zinc in the complementary feed on the oedema state among the children (Table 6, Figure 6) showed that at the time of admission 78% children had generalized severe oedema while 22% had moderate oedema. After the test period both groups showed marked improvement. In the control group had 30% no oedema, 50% mild oedema and 20% moderate oedema at the time of discharge. The results of the experimental group showed that 36% children with no oedema, 54% mild oedema, and 10% moderate edematous state. These results confirm the availability of nutrients more specifically the proteins which were found to be quite good in proportion in these seeds' flours of the current study. In addition, the low fiber of these seed kernels, the presence of essential fatty acids and other bioactive compounds in both the sunflower seeds and pumpkin seeds' flours exerted beneficial effects on these children in addition to the WHO protocols for these children. The results of the current study however are contrary to the findings of another such study which showed that short term supplementation exert no significant effects on under nourished children. These differences may be attributed to the type of supplements used and duration of the study period [47].

Table 6: Effect of Dietary Zinc Supplementation on the State of Oedema in the Sample

Oedema Status	At Admissions		Post-Trial Group 1/ Control		Post-Trial Group 2/ Experimental	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
O, None	0	0	10	30	18	36
+, Feet & Legs	0	0	25	50	27	54
++, Face & Abdomen	22	22	10	20	5	10
+++, Generalized	78	78	0	0	0	0

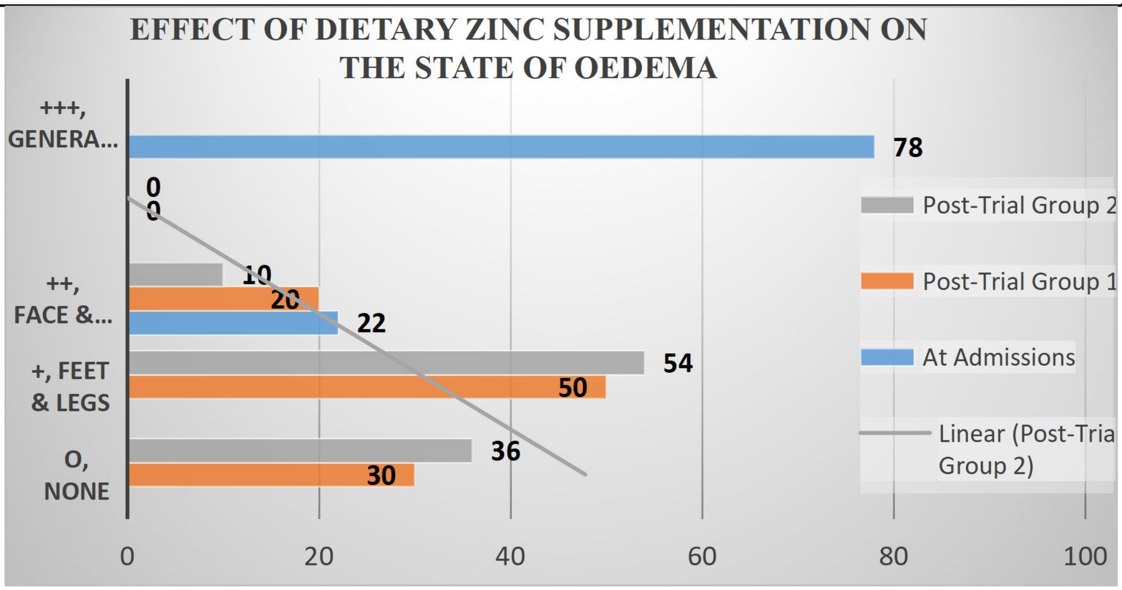


Figure 6: Effect of dietary Zinc supplementation on the state of Oedema in the Sample

3. Conclusion

The current study can be concluded on the findings that the safe addition of nutrient rich food sources into the indigenous complementary feedings of the SAM children are a potential biofortification area in resource limited countries like Pakistan that further need to be explored. Additionally, these indigenous and economical sources of value addition are a sustainable solution that can help these children to avoid relapse and the utility of these agrarian based nutrient dense foods may help other members of the family amid the severe food insecurity. The mass illiteracy in the current sample also necessitates parental education in general and nutrition education in specific for a stable, life-long solution to the problem of PCM children.

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REFERENCES

1. World Health Organization. Management of severe acute malnutrition in infants and children (2018)
2. Aurangzeb B, Whitten KE, Harrison B, Mitchell M, Kepreotes H, Sidler M, Lemberg DA, Day AS. Prevalence of malnutrition and risk of under-nutrition in hospitalized children. Clin Nutr. 2012 ;31(1):35-40.
3. Sommer, A., Katz, J. and Tarwotjo, 1. increased risk of respiratory disease and diarrhoea in children with preexisting mild vitamin A deficiency. Am. J. Clin. Nutr., I 984;40: 1090-5.
4. Bhaskaram, P. Mieronutrient deficiencies in children - the problem and extent. Indian J. Pediatr., 1995;62: 145-56.
5. Hambige, KM. and Krebs, N. Asseatment of zinc status in man. Indian J. Pediatr., 1 995;62: 169-80.
6. Allen, LII. Nutritional influences and linear growth: A general review Eur.J. Clin. Nutr.,1994;48: Suppl: 575-589
7. Beitel, W.R. Single nutrients and immunity. AmJ. Clin. Nutr, 1982;35: Suppl:41 7-68
8. Hambidge, KM. The role of zinc and othertraeemetala in pediatric nutrition and health. Pediatr. Clin. North Am., 1977;24:95-106.
9. Cheaters, J.K. Metabolism and biochemistry ofzine. In. Prasad, AS. ed. Clinical biochemical and nutritional aspects of trace elements. New York, Alan R List, 1982: 221-38.

10. Bettger, W.J. and O'Dell, B.L. A critical physiological role of zinc in the structure and function of bio-membranes. Life Sci., 1981 ;28:1425-3 8.
11. Wu, F. Y.H. and Wu, C.W. zinc in DNA replication and transcription. Ann. Rev. Nutr., 1987;7:251-72.
12. Fraker, P.3., Genshwin, ME., Good, R.A. et al. Interrelationships between zinc and immune function. Federation Proc., 1986;45: 1474-9.
13. Sandatead, H.H. zinc: essentiality for brain development and function. Nutr. Rev., 1985;43:129- 138.
14. Clejan, S., Gastro-Magans, M., Collip, P et al. Effects of zinc deficiency and castration on fatty acid composition and desaturstion in rats. Lipids, 1982;17:129-35.
15. Simmer, K. and Thompson, R.PH. Zinc and the fetus, JR. Soc. Health, 1986;106: 166-8.
16. Solomons, NW., Helitzer-Allen, DL. and Villar, J. Zinc needs during pregnancy. Clin. Nutr., 1986;5:63-71.
17. Ferriera, R.M.C., Maraquiegni, I.M. and Elizaga, LV. Terstoginicity of zinc deficiency in the rat Study of the fetal skeleton. Teratology, 1989;39: 181-94.
18. Fcrriera, R.M.C., Gonzalez, J.I.R., Marquiegni, LM. et al. Changes in fetal tibial growth plate secondary to maternal zinc deficiency in the rat. A histological and histochemical sttrffy. Teratology, 1991 ;4: 1-11.
19. Sikoraki, R., Juskiewicz, T. and Paszkowski, T Zinc status in women with premature rupture of membranes at term. Obatet. Gynccol., 1990;76:675-7.
20. Simmer, K. and Thompson, R.PH. Maternal zinc and intrsuterine growth retardation, Clin. Sci.,1985;68:395-9.
21. Neggers, YH., Cutter, G.R., Acton, R.T. et at, A positive association between maternal serum zinc concentration and birth weight. Am. S. Clin. Nutr., 1990;51:678-84.
22. Bates, 0.3. and Tsuchiya, H. Zinc in breast milk during prolonged lactation: comparison between the UK and the Gambia. Eur J. Clin. Nutr., 1990;44:61-9.
23. Kreba, N.F. Hambidge, K.M., Jacobs, MA. ct al. The effects of a dietary zinc supplement during lactation on longitudinal changes in matemal zinc status and milk-zinc concentrations. Am. J. Olin.Nutr., 1985;4t :560-70.
24. Higashi. A., Matauda, I., Mssumoto, T. et al. Serum zinc and copper concentration in LBW infants during firat three months of life. Correlation to birth weight and different feedings. Tohoku 3. Exp. Med., 1985; 146:253-63.
25. Maatuda, I. Higaahi, A., Weds, T. Effects of zinc and copper contents of formulas on growth and on the concentrations of zinc and copper in serum and hair. J. Pediatr. Gastroenterol.Nutr., 1984; 3:421-5.
26. Bates,J. and McOlain, C.J. Tue effects ofaevcre zinc deficiency on serum levels of albumin, transferrin and prealbumin in man. Am. J. Clin. Nutr, 1981 ;34:1655-60.
27. Beatchart, B., Biedcr, HP, Gautschi, K. et at. Serum proteins and zinc as parameters to monitor the health of children in s rural Tanzanian community. Acts Trop. 1987; 44:191-211.
28. Bradfield R.B,,Yee, T. and Baertl, M. Hair zinc levels of And can Indian children during protein calorie malnutrition. Am. S Olin. Nuts., 1969;22: 1349-53.
29. Gibson, R.S., Heywood, A., Yaman, C. ct al. Growth in children from the Wosera subdistrict, Papua New Guinea, in relation to energy and protein intakes and zinc status. Am. S. Olin. Nutr., 1991;53:782-9.
30. Ronaghy, HA., Reinhold, J.G., Mahloudji, M. et al. Zinc supplementation of malnourished school boys in Iran: Increased growth and other effects. Am. 3. Olin. Nuts., 1974;27:112-21.
31. Ilambidge, KM. Zinc deficiency in the weaning - how important? Acta - Paediatr. Scand., Suppl 1986;323:52-8.
32. Giugliano, R. and Millwsrd, D. S. The effects of severe zinc deficiency on protein turnover in muscle and thymus. Br. S. Nutr., 1983:57: 139.55.

33. Golden, BE. and Golden, M.H.N. Plasma zinc, rate of weight gain and the energy cost of tissue depositions in children recovering from severe malnutrition on a cow's milk or soya protein-based diet Am. S. Olin. Nuts., 1981 ;34:892-9.
34. Golden, MEN. and Golden, B. E. Effect of zinc supplementation on the dietary intake, rate of weight gain and energy cost of tissue deposition in children recovering from severe malnutrition. Am. J. Clin.Nutr., 1981;34:900-8.
35. Krieger, I., Evans, G.W. and Zelkowitz, PS. Zinc dependency as s cause of chronic diarrhoea in variant acrodermatitis enteropathica. Pediatrics, 1982;69:773-7.
36. Behrens, RH., Tonkins,' A.M. and Roy, SR. Zinc supplementation during diarrhoea, a fortification against mslnutrition? Lances, 1990;336:442-3.
37. Bhutta AZ. The role of zinc in health and disease: Relevance to child health in developing countries. Journal of Pakistan Medical Association, 1997, 47(2), 68-73.
38. World Health Organization. Management of Severe Malnutrition: A Manual for Physicians and Other Senior Health orkers. 1999. https://www.who.int/publications/i/item/9241545119.
39. World Health Organization. Guideline: updates on the management of severe acute malnutrition in infants and children. 2013. https://www.who.int/publications/i/item/9789241506328
40. Ashworth A, Khanum S, Jackson A. Guidelines for the Inpatient Treatment of Severely Malnourishedchildren2003. https://www.unscn.org/web/archives_resources/files/WHO_guidelines_for_the_inpatient_tr_223.pdf.
41. Syam, A, Zainal, Wahiduddin, Cangara, MH., Kurniati, Y. and Hasfiah, NA. Nutrient content and toxicity of pumpkin seed flour. Food Research, 2023; 7 (6) : 69 – 76. https://doi.org/10.26656/fr.2017.7(6).069
42. Aminuddin Syam, Novi Puspita Sari, A. Razak Thaha, Suriah, Nurhaedar Jafar, Abdul Salam, Anwar Mallongi, The effect of pumpkin seed flour (Cucurbita moschata Durch) on zinc serum levels in malnourished Wistar rats; Enfermería Clínica, 30, Supp 4, 2020, 337-340
43. Aishwarya S and Anisha V. Nutritional Composition of Sunflower Seeds Flour and Nutritive Value of Products Prepared by Incorporating Sunflower Seeds Flour; Int. J. of Pharm. Res. & All. Sci. 2014;3(3):45-49
44. Brown KH, Peerson JM, Rivera J, Allen LH. Effect of supplemental zinc on the growth and serum zinc concentrations of prepubertal children: A meta-analysis of randomized controlled trials. Am J Clin Nutr 2002;75(6):1062-71. https://doi.org/10.1093/ajcn/75.6.1062 PMid:12036814
45. Kattelmann KK, Ho M, Specker BL. Effect of timing of introduction of complementary foods on iron and zinc status of formula fed infants at 12, 24, and 36 months of age. J Am Diet Assoc 2001;101(4):443-7. https://doi.org/10.1016/ s0002-8223(01)00114-6 PMid:11320951
46. Mulyaningsih TR. The concentration of Fe and Zn in agricutural, livestocks, and fishery food products using K0-AANI methods. J. Sains Teknol Nuklir Indones 2009;10(2):71-80. https://doi.org/10.21059/buletinpeternak.v11i1.1800.
47. Rahman MM, Tofail F, Wahed MA, Fuchs GJ, Baqui AH, Alvarez JO. Short-term supplementation with zinc and Vitamin A has no significant effect on the growth of undernourished Bangladeshi children. Am J Clin Nutr 2002;75(1):87-91. https://doi.org/10.1093/ajcn/75.1.87