

**Nutrition education of mothers and zinc supplementation among children in the rural
community, Cameroon**

ABSTRACT

Aims: Malnutrition among children, especially stunting is a public health problem in Cameroon. This study assesses the impact of zinc supplementation of children and nutrition education of mothers on the nutritional status of the children in the Bangang rural community.

Study design: This was a descriptive and prospective study.

Place and Duration of Study: The study took place in the Bangang community in the Region of West Cameroon, during the period from March to December 2015.

Methodology: The children aged 6 to 48 months and mothers aged 20 to 34 years were selected after the baseline survey and enrolled. Dietary surveys were used to evaluate the frequency of foods consumed by 150 children. Zinc supplementation group of children (ZSG, n= 25) received 10 mg of zinc sulfate tablets per day for 14 days and control group (CG, n=25) was formed by children whose mothers received nutrition counseling. The nutrition education sessions organized into 4 modules were conducted quarterly for 9 months on a sample of 100 mothers. After interventions, impact of zinc supplementation and maternal education was assessed by determining height for age and weight for age indices, and biochemistry parameters.

Results: The results showed that zincemia of ZSG varied significantly ($P = .0001$) and not significantly ($P = .23$) for CG. After nutrition education, dietary diversity was improved; reduction of chronic malnutrition (10.9%) and increasing number of children with good nutritional status (6.6%) were observed. Increased for phosphoremia (3.6 ± 2.4 to 5.7 ± 1.8 mg/dl; $P = .001$) and albuminemia (34.8 ± 15.5 to 46.9 ± 8.9 g/l; $P = .002$) were significant which was not the case of calcemia, zincemia, magneemia and serum iron.

Conclusion: This study showed positive impact of zinc supplementation and maternal education on the nutritional status of children.

Keywords: Zinc supplementation, Nutrition education, Children, Bangang, Malnutrition

1. INTRODUCTION

Malnutrition is a major global public health problem particularly in communities of developing countries [1]. Indeed, malnutrition refers a pathological state resulting from relative or absolute deficiency or excess of one or more essential nutrients [2]. Although, malnutrition can affect any age group but children are at a higher risk. It is associated with an increased morbidity and mortality [3].

Undernutrition is an underlying cause of almost half (45%) of deaths in children under five worldwide, promotes an increased susceptibility to infection and predisposes to poor physical and cognitive

38 development [4]. Globally, 144 million (21.3%) children under-five years of age suffering from stunting,
39 47 million (6.9%) suffering from wasting and 38.3 million (5.8%) are overweight [5]. Africa and Asia
40 bear the greatest share of all forms of malnutrition. In Africa, according to several Organizations, 40%
41 children under-five were stunted, 27% wasted and 24% overweight [5]. The stunting and wasting rates
42 are above global estimates, albeit inter-country variations. Although childhood stunting is ubiquitous
43 round the world, it is particularly prevalent in low and middle income countries [6]. Stunting is
44 associated with cognitive and behavioral problems, delayed mental development, poor school
45 performance, and reduced intellectual capacity [7].

46 A national multiple indicator cluster survey indicated that in Cameroon, 31.7% of children under five
47 are stunted, 14.8% are underweight and 5.2% are wasted [8]. In rural community, high prevalence of
48 malnutrition was observed among children, particularly stunting, poor knowledge on feeding practices,
49 low education and socio economic level of mothers [9, 10].

50 Inadequate food intake and zinc deficiency are followed by multiple consequences among children.
51 Zinc deficiency in children is associated with growth retardation and contributes to a large amount to
52 childhood morbidity and premature mortality [6].

53 These situations are so important that, the WHO adopted a resolution on maternal, infant and young
54 child nutrition including a global target to reduce by 40% the number of stunted under-five children by
55 2025 and by 2030, end all forms of malnutrition [11, 12]. To participate in this wide program and
56 improve nutritional status of the children, this study was conducted and assessed the impact of zinc
57 supplementation of children and nutrition education of children' mothers in the Bangang rural
58 community.

59 MATERIAL AND METHODS

60 2.1 Study area

61 The study was conducted in the Bangang rural community, where previous field work was carried out.
62 This community is located in the Region of West Cameroon, Department of Bamboutos. It has a
63 tropical rainy grass field and savannah forest vegetation, humid climate with a population of 250 000
64 inhabitants.

65 2.2 Study design

66 A cohort of 150 children (100 for nutritional education and 50 for zinc supplementation) and 100
67 mothers (75 for nutritional education and 25 for nutritional consultation in zinc supplementation) was
68 recruited in the Bangang community. The ages of the children ranged from 6 to 48 months with a
69 mean of 16 ± 6 months.

70 2.3 Procedures

71 A questionnaire was developed, tested, adjusted and validated prior the field survey. During the study,
72 the knowledge of mothers on children nutrition, the eating habits of children, the estimated
73 consumption of energy, nutrients of children and food availability on the market during harvesting and
74 sowing seasons were evaluated. Subsequently, the impact of the interventions was evaluated by
75 comparing the anthropometric parameters (height-age and weight-age indices) and biochemical

76 parameter (serum albumin level, calcium, zinc, iron, magnesium and phosphorus) before and after
77 these interventions.

78 **2.4 Dietary surveys**

79 Food history was made during the months of March, June, September and December, representing
80 small and great sowing and harvesting periods. The reason of choosing different months in harvesting
81 and sowing seasons was to evaluate food access and availability in each season. The eating habits of
82 children whose parents agreed to participate in the study were reported. In fact, mothers of those
83 children listed all meals including drinks consumed by children each day for a week.

84 **2.4.1 Food intake**

85 The food diary was used to compare the food consumption between healthy children ($2 < z\text{-score}$
86 below < -2) and malnourished children ($z\text{-score}$ below -2), and to determine the amount of food
87 consumed by children every day for a week. The amount of food consumed by each child was
88 weighed using measurement tools (standard bowls and cups) and the balance (Kern EMB 2000 -2;
89 Germany) to reach 2,000 g and 0,001 g accuracy. The food composition table [13, 14] was used to
90 evaluate the composition and nutrient content of food consumed by children.

91 **2.4.2 Bangang market**

92 The market investigation took place at Bangang market (The big market day is held 1 time per week)
93 during the same periods as the food history. This survey was to identify all major traded food and
94 determine their frequencies.

95 **2.5 Nutritional status of children**

96 **2.5.1 Anthropometric parameters**

97 The weight and height were measured before and after interventions. We used electronic balance
98 (AEG PW4923, Germany) with a range of 0-150 kg with accuracy of 0.1 g for children 24 to 48
99 months, and the scale baby weighs (EBSA Kinlee-20, Germany) with a range of 0-20 kg with accuracy
100 of 0.5 g for children under 24 to 6 months. The height was measured with a sliding latch (Kern
101 MSF200, Germany) for children aged 12 to 48 months, or a length board (Kern MSA80, Germany) for
102 children less than 12 month.

103 The nutritional status of children was assessed by z-score according to the WHO new Growth
104 Standards in 2006 [15]. Stunting and underweight were defined as a z-score of height-for-age (HAZ)
105 and weight for age (WAZ) respectively below -2 . Stunting or chronic malnutrition was classified as
106 moderate when the z-score of height for age was between -2 and -3 and severe when below -3
107 compared to the reference population. Underweight was classified as moderate when the z-score of
108 weight for age was between -2 and -3 and severe when below -3 compared to the reference
109 population.

110 **2.5.2 Biochemical parameters**

111 Blood samples were collected from children. Before sample collection was carried out by a qualified
112 nurse, wearing gloves and labeling tubes with code number was mandatory. The blood was collected

113 from children following standard techniques of blood collection between 8 and 10 AM. The collected
114 blood was centrifuged at 3600 rpm for 10 minutes and the obtained serum was used for the
115 determination of albumin, zinc (Zn), phosphorus (P), iron, magnesium (Mg) and calcium (Ca) by
116 colorimetric method and the determination of their concentrations by means of a spectrophotometer
117 (URIT-810, China).

118 **2.6 Intervention**

119 **2.6.1 Zinc supplementation intervention**

120 In this pilot study, a sample of 50 children with stunting was selected and all of these children had
121 hypozincemia. Zinc supplementation group of children (ZSG, n= 25) received an oral dose of 10 mg of
122 zinc sulfate tablets per day for 14 days. The control group (CG, n=25) was formed by children whose
123 mothers (n=25) received nutrition counseling. In this nutrition counseling, the mothers were
124 encouraged to give regularly the food rich in zinc (fish, meat, eggs, dairy products and vegetables) to
125 their children. Before and after zinc supplementation, anthropometric parameters of children were
126 taken and the serum zinc concentration was evaluated.

127 **2.6.2 Nutrition education intervention**

128 Nutrition education sessions organized into modules was conducted on a sample of 75 mothers of
129 children. The information supplied was intended to facilitate a change in bad eating habits observed,
130 improve knowledge, attitudes and skills of mothers on child nutrition. The participatory approach based
131 on dialogue and demonstrations was adopted during this nutrition education which was held once
132 quarterly for nine months. The first nutritional session was held in June in the Bangang Medical Center
133 and the two others (September and December) in family homes by appointment made with mothers.
134 During the dialogue with the mothers, we were with community workers whose role was to ease local
135 language communication when necessary. Nutritional information was delivered individually to each
136 mother for those who were not in the same concession and group for those who were. The duration of
137 the interview varied from one mother to another, according to his capacity for understanding and
138 spoken national language. The information was grouped into four modules: In the food practice
139 module, the benefits of breast milk, the duration of the breastfeeding and the consequences of a poor
140 diet for children were clarified. In the food diversity module, the roles of food constituents from animal
141 and plant origin were taught. We also showed that for the harmonious development of a child, its diet
142 must be diversified. In the food supply module, choice of child's foods on the availability of food and
143 the cost was demonstrated. Processing and storage of food in times of plenty were encouraged. In the
144 socio-cultural and economic aspects module, it was recommended to avoid the consumption of foods
145 with low energy density and avoid selling all grown produce and livestock to market at the expense of
146 consumption. Before and after nutrition education of the mothers, anthropometric parameters of
147 children were taken and calcemia, zincemia, magnesemia, phosphoremia, serum iron and
148 albuminemia were evaluated.

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151 **2.7 Statistical analyses**

152 The analyses have been done by using the statistical software SPSS 16. Descriptive statistics were
153 used to determine the means and percentages of the various parameters. Student's t test was used to
154 compare the means values two by two and to appreciate the significance before and after nutrition
155 education and zinc supplementation. The Pearson chi-square test was used to analyze the difference
156 frequencies of food consumption between healthy and malnourished children. Results were
157 considered significant at $p < .05$.

158 **2. RESULTS AND DISCUSSION**

159 About 5.1%, 82.3% and 12.6% of the mothers said that they weaned their children before the age of
160 one year, before 2 years of age and 2 years of age respectively. Approximately 18.6% of mothers did
161 not know the value of colostrum. An hour after birth, 40.6% of mothers had not breastfed their children.
162 Several mothers, specifically 16.2% and 7.1% gave honey and water respectively on the first day of
163 birth of their children. The age of introduction of complementary feeding was not known by 49% of
164 mothers. Almost 23.2% and 34.1% of mothers had learned how to nurse their children through their
165 mothers and nurses respectively. All of these children ate the food, 42.6% once to twice a day and
166 57.4% three times a day.

167 **2.1 Food consumption**

168 **2.1.1 Frequency of consumption**

169 The food consumption was classified in two groups of children. The frequency of meals in healthy
170 children was 3 times a day and their diet was diversified. The frequency of meals in malnourished
171 children with stunting ranged from 1 to 2 times a day. The Table 1 shows that, eggs (7% to 1%; $P =$
172 .03), dairy products (12% to 4%; $P = .04$) and vegetables (24% to 12%; $P = .03$) consumption
173 frequency was significantly higher in healthy children than in malnourished children. Low consumption
174 of fruit in the two groups of children was observed (2%). The nutritional status of these children varied
175 according to the quality of food consumed, monotony and food diversification which justify that proper
176 nutrition helps to promote growth and harmonious development [16].

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Foods intake	Scientific names of the majority food	Frequency of consumption (%)		P-value
		healthy children	malnourished children	
Pounded Irish potatoes	<i>Solanum tuberosum</i>	67	89	<0,0002*
Rice / peanut sauce	<i>Oriza sativa</i>	47	23	<0,0003*
“Jallot” rice	<i>Oriza sativa</i>	29	35	0,36
“Jallot” potatoes	<i>Solanum tuberosum</i>	28	29	0,87
Corn meal / leaves	<i>Zea mays/Amaranthus</i>	24	12	0,03*
Banana stew	<i>Musa sapientum</i>	17	20	0,58
Cocoyam / yellow sauce	<i>Colocasia esculenta</i>	16	17	0,80
Corn porridge / soybean	<i>Zea mays</i>	11	3	0,03*
Corn porridge simple	<i>Zea mays</i>	15	14	0,84
Dairy products	-	12	4	0,04*
Corn meal / okra	<i>Hibiscus esculenta</i>	18	14	0,44
Rice / beans	<i>Phaseolus vulgaris</i>	1	5	0,10
Eggs	-	7	1	0,03*
Water	-	100	100	1
Fruits (orange, papaya, avocado)	<i>Citrus, Carica papaya, Citrullus lanatus</i>	2	2	1

191 * Significantly different

192 Table 2 shows the frequency of meals consumed by children during the harvest periods (greater
193 harvest "June" and small harvest "December") and the sowing periods (small sowing "September" and
194 large sowing "March").

195 Pounded Irish potatoes, Rice with peanut sauce, “Jallot” rice, “Jallot” potatoes, Corn meal with okra
196 and Corn meal with leaves were the regular meals and had a high frequency of consumption in
197 children in households during the different seasons (Table 2). The frequencies of consumed food in
198 harvest periods were higher than those in sowing periods. **This can be explained by monotonous**
199 **eating habits which do not take into account the different seasons but rather the cultural aspect.** This
200 poor nutrition in quality could be due to a poor knowledge of children's nutrition and the education level
201 of mothers and in long-term could be the cause of chronic malnutrition (stunting) in some children [9].

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204 **Table 2.** Food frequency consumed by children during different survey periods (n = 100)

Foods intake	Frequency of consumption (%)				Cumulative frequencies
	March	June	September	December	
Pounded Irish potatoes	32	50	35	38	155
Rice / peanut sauce	14	24	22	33	123
“Jallot” rice	13	22	26	27	88
“Jallot” potatoes	12	19	24	21	76
Corn meal / okra	7	13	19	23	62
Corn meal / leaves	8	13	24	23	68
Banana stew	7	12	19	17	55
Cocoyam / yellow sauce	7	8	16	14	45
Dairy products	4	5	10	16	35
Corn porridge	7	5	10	8	30
Rice / tomato sauce	7	5	9	8	29
Irish potato pure	4	5	9	9	27
Rice / beans	4	5	8	7	24
Corn porridge / soybean	3	6	5	7	21
Grounded cocoyam / peanut sauce	3	2	3	4	12
Fruits	2	3	4	2	11
Patatoes / leaves	2	1	1	2	6
Yam stew	1	0	1	3	5

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206 **2.1.2 Estimated daily energy and nutrient intakes**

207 The average micronutrient intakes are presented in Table 3. The daily intake of calcium and zinc did
 208 not cover the recommended needs of children in all age groups. Similarly, average daily iron intake did
 209 not cover the recommended needs of children in the age range 12 - 36 months. The coverage rates
 210 for the consumption of magnesium and phosphorus in these children were above 100% in all age
 211 groups (Table 3).

212 **Table 3.** Estimated and rates of coverage of micronutrient intakes in children (n = 100)

Nutrients	Ages (months)	P (mg)	Ca (mg)	Iron (mg)	Zn (mg)	Mg (mg)
Mean daily intake		466.4 ± 281.1	326 ± 72.2	10.5 ± 9.4	2.46 ± 1.2	99.6 ± 34.3
FAO/WHO daily needs	6-12	275	500	6-10	5	75
Rates of coverage		169.6	65.2	105	49.2	132.8
Mean daily intake		765.4 ± 77.9	297.4 ± 61.2	4.4 ± 1.1	3.9 ± 3.5	200.5 ± 26.2
FAO/WHO daily needs	12-36	450	700	7	7	130
Rates of coverage		170.1	42.5	62.8	55.7	123.2
Mean daily intake		782.5 ± 131.4	424.5 ± 132.8	7.3 ± 1.1	6.3 ± 3.6	201.3 ± 84.6
FAO/WHO daily needs	36-48	600	900	7	7	200
Rates of coverage		130.4	47.2	104.3	90	100.7

213 Values expressed are mean ± standard deviation

214 Table 4 shows that the energy consumed daily by children did not cover the recommended needs in
 215 all age groups, except for girls in age group 36 - 48 months. The most affected age groups for boys
 216 were 6 - 12 months and 24 - 36 months with coverage rates of 56.9% and 63.7% respectively. In girls,
 217 the most age groups concerned were those of 6 - 12 months and 12 - 24 months with a coverage rate
 218 of 67.3% and 67.0% respectively (Table 4).

219 The daily consumption in calcium, iron, zinc (Table 3) and total energy did not cover the recommended
 220 energy needs (Table 4). This poor nutrition in quantity could be due to a poor knowledge of children's
 221 nutrition and the education level of mothers. Although the level of education is not synonymous with
 222 knowledge of eating practices, it could influence the nutritional status of children due to poor
 223 understanding of the food needs and nutritional values of the foods served to children by mothers. The
 224 low coverage of energy needs is due to the insufficient quantity and quality of food consumed by
 225 children or to the consumption of food with low energy density which in the long term could lead to
 226 chronic malnutrition.

227 **2.2 Impact of interventions**

228 **2.2.1 Impact of nutrition education on the nutritional status of children**

229 After nutrition education, only 70 mothers and 92 children were presented. Before nutrition education
 230 with mothers, the anthropometric and biochemical parameters of 100 children were taken. After 9
 231 months of this intervention, only 92 children were present with age between 6 to 38 months. In Table 5
 232 the average values of HAZ index (-2.34 ± 1.4 to -1.9 ± 2 z-score, $P = .39$) and WAZ index (-0.42 ± 1.5
 233 to -0.46 ± 1.4 z-score, $P = .59$) were not varied significantly.

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235 **Table 4.** Daily intakes and coverage of energy by children (n = 100)

Age group (months)	Coverage daily energy					
	Boys (n = 46)			Girls (n = 54)		
	Daily energy intake (kcal)	Daily needs (kcal)	Coverage (%)	Daily energy intake (kcal)	Daily needs (kcal)	Coverage (%)
6 – 12	441.1 ± 189.6	775	56.9	479.5 ± 208.7	712	67.3
12 – 24	734.9 ± 336.2	950	77.4	569.4 ± 248.1	850	67.0
24 – 36	716.5 ± 197.4	1125	63.7	-	-	-
36 – 48	1048.3 ± 331.2	1250	83.9	1257.2 ± 709.2	1150	109.3

236 Values expressed are mean ± standard deviation

237 Before nutrition education, 56 (60.9%) and 36 (39.1%) children had stunting and a good nutritional
 238 status respectively and after, 46 (50%) children had stunting, 4 (4.3%) were underweight and 42
 239 (45.5%) had good nutritional status. These results showed a reduction of chronic malnutrition by
 240 10.9%, but also an increase of 6.6% of children with good nutritional status. The children with the most
 241 improved nutritional status were those in the 6 - 12 months age group. **This would be due to the**
 242 **improvement of the quality of the food of the children of this age group consisting of breast milk and**
 243 **complementary foods or family foods.** Table 5 shows significant improvement of phosphoremia ($P =$
 244 $.001$) and albuminemia ($P = .002$), which was not the case of the calcemia ($P = .35$), zincemia ($P =$
 245 $.29$), magnesemia ($P = .91$) and the serum iron ($P = .35$).

246 Before nutrition education on mothers, the prevalence of hypoalbuminemia, hypozincemia,
 247 hypomagnesemia, hypocalcemia, hypophosphoremia and deficiency of serum iron among children
 248 were 15%, 19%, 12%, 20%, 7% and 8% respectively. Micronutrients are essential and their
 249 deficiencies could be due to poor consumption of animal products and poor bioavailability of these
 250 micronutrients from plant based foods [17]. Dairy products are rich in nutrients that are essential for
 251 good bone health, including calcium, potassium and phosphorus in an easily absorbed form [18].
 252 Heme iron is estimated to contribute 10 - 15% of total iron intake in meat eating populations, and has
 253 better bioavailability. Iron bioavailability has been estimated to be in the range of 14 - 18% for mixed
 254 diets and 5 - 12% for vegetarian diets [19]. Meat, fish and certain shellfish such as oysters are good
 255 sources of zinc [17]. Insufficient coverage of micronutrients could also lead to stunting as zinc, calcium
 256 and iron are essential for growth, behavioral and neurological development of infants [17, 20]. For
 257 children, the magnesium and phosphorus coverage were greater than 100%, the serum deficiency in
 258 these micronutrients could be due to low consumption of animal products and interactions with other
 259 minerals. Meat, fish, milk and dairy products, even if they contain on the whole less magnesium and
 260 phosphorus some plants are good sources of these micronutrients due to better bioavailability [21, 22].
 261 The Bangang market had all the food groups, but children's diet was unbalanced in quality and
 262 quantity. This could be due to poor knowledge of the diets of children by their parents, but also due to

263 cultural factors. The average values of biochemical analyzes before and after nutrition education
 264 (Table 5) showed significant improvement in phosphoremia (3.6 ± 2.4 to 5.7 ± 1.8 mg/dl; $P = .001$) and
 265 albuminemia (34.8 ± 15.5 to 46.9 ± 9 g/l; $P = .002$), which was not the case of the calcemia (6.7 ± 3.1
 266 to 7.9 ± 0.9 mg/dl; $P = .35$), magnesemia (1.99 ± 1 to 2.01 ± 0.2 mg/dl; $P = .91$) and the serum iron
 267 (96.3 ± 62.9 to 108.9 ± 22.2 mg/dl; $P = .35$). This proves that nutrition education is a means of choice
 268 for improving the nutritional status in a population because it provides the ability to simultaneously
 269 improve not only micronutrient intake but also many dietary constituents [23]. Table 5 shows also that,
 270 height for age and weight for age indices were -2.34 ± 1.4 and -0.42 ± 1.5 respectively before nutrition
 271 education and -1.9 ± 2 and -0.46 ± 1.4 respectively after nutrition education. These differences of
 272 anthropometric indices were not significant; this could be justified by the fact that diet remained
 273 monotonous during the tracking period, but also the relatively short observation time (9 months). Some
 274 children, whose diet was as diverse and adequate in quantity, could have their nutritional status
 275 improved significantly only in the long term.

276

277 **Table 5.** Biochemical and anthropometric parameters according to the period of nutrition education

Nutrition education	Biochemical parameter						Anthropometric indices	
	Alb (g/l)	P (mg/dl)	Ca (mg/dl)	Zn (μ g/dl)	Mg (mg/dl)	iron (μ g/dl)	HAZ (z-score)	WAZ (z-score)
Before	34.8 ± 15.5	3.6 ± 2.4	6.7 ± 3.1	$74,9 \pm 25,8$	1.99 ± 1	96.3 ± 62.9	$-2,34 \pm 1,4$	$-0,42 \pm 1,5$
After	46.9 ± 9	5.7 ± 1.8	7.9 ± 0.9	$82,7 \pm 26,6$	2.01 ± 0.2	108.9 ± 22.2	$-1,9 \pm 2$	$-0,46 \pm 1,4$
P-value	0.002*	0.001*	0.35	0.29	0.91	0.35	0,39	0,59

278 Alb: Albuminemia; P: Phosphoremia; Ca: Calcemia; Mg: Magnesemia; iron: Serum iron; HAZ: height
 279 for age; WAZ: weight for age; Values expressed are mean \pm standard deviation; * Significantly
 280 different.

281 **2.2.2 Impact of zinc supplementation**

282 The zincemia of supplemented children varied between 20.3 to 63.7 μ g/dl before zinc supplementation
 283 and 45 and 165.1 μ g/dl after this intervention (14 days). Table 6 shows the variations of serum zinc
 284 concentration according to the period of zinc supplementation. The zincemia of these children
 285 increased significantly ($P = .0001$) after zinc supplementation (Table 6). For the control group, the
 286 zincemia varied between 30.4 and 64.4 μ g/dl the first day and 34 and 110 μ g/dl fifteenth day after the
 287 nutrition counseling to their mothers. Table 6 also shows that the zincemia of control group was not
 288 significantly increased ($P = .23$) after the nutrition counseling. After 14 days, the zincemia of
 289 supplemented children was significantly higher ($P = .0001$) than zincemia of control group (Table 6).
 290 This impact could be explained by rapid bioavailability of supplemented zinc. The results of this study
 291 corroborate with others results which showed that supplementation with zinc alone significantly
 292 increases the serum zinc concentration in children [24]. In addition to improving serum zinc status,
 293 zinc supplementation could also prevents and reduce morbidity and mortality in young children [25].

294 On the other hand, zinc supplementation in drug form costs more than the consumption of foods rich
 295 in zinc which are readily available (products of animal origin). For non-supplemented children (control
 296 group), the difference between zincemia before and after the observation period was not significant.
 297 This result could be explained by a low consumption of animal products [17], but also a high
 298 consumption of grains, beans, legumes and plant-based diets which affect a bioavailability of zinc due
 299 to the presence of anti-nutritional factors such as phytates and oxalates [26, 27].

300

301 **Table 6.** Variation of zincemia according to the period of zinc supplementation (n = 50)

Children' group	n	Zincemia (µg/dl)		
		First day	15 th day	P-value
Supplemented children	25	48.9 ± 12.7	92 ± 27.7	0.0001*
Control group	25	55.4 ± 9.9	60.4 ± 18.1	0.23
P-value		0.05	0.0001	

302 n: Number of children; Values expressed are mean ± standard deviation; * Significantly different

303 The main limitation of this study was the lack of formulation of food recipes based on locally available
 304 and accessible food resources. This should maximize the intake of micronutrients and essential
 305 nutrients in children. The strength of this study was an important contribution on nutrition public health
 306 interventions to reduce children malnutrition.

307

308 **3 CONCLUSION**

309 The study showed a positive impact of maternal education on biochemical and anthropometric
 310 parameters of the children. Zinc supplementation may be an effective intervention to promptly raise
 311 the zincemia levels. Additionally, our study highlights the low consumption of fruits and animal
 312 products among children from Bangang rural community.

313 **CONSENT**

314 Written informed consent was obtained from the parents.

315 **ETHICAL APPROVAL**

316 All authors hereby declare that all experiments have been examined and approved by the National
 317 Ethics Committee of Cameroon (N°: 177/CNE/SE/2012) and have therefore been performed in
 318 accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

319 **REFERENCES**

- 320 1. Akombi, BJ, Agho KE, Merom D, Renzaho AM, Hall JJ. Child malnutrition in sub-Saharan Africa: a
 321 meta-analysis of demographic and health surveys (2006-2016). PLoS One. 2017;12(5),e0177338.

- 322 2. Varma PM, Prasad KSV. Malnutrition and its related factors among children 0–5 years in rural
323 Shamirpet mandal, Ranga Reddy district. *India Inter J Bioassays*. 2017;6(4):5340 -5342.
- 324 3. Asres AG, Eidelman AL. Nutritional Assessment of the Children of the Beta Israel Community in
325 Ethiopia: A 2017 Update. *Breastfeeding Med*. 2018;13(2):149-154.
- 326 4. Spolidoro JV, Pitrez Filho ML, Vargass HT, Santana JC, Pitrez E, Hauschild JA, et al. Waist
327 circumference in children and adolescents correlate with metabolic syndrome and fat deposits. *Clin
328 Nutrition*. 2013;32:93-97.
- 329 5. WHO and UNICEF. Discussion paper: The extension of the 2025 Maternal, Infant and Young Child
330 nutrition targets to 2030. Geneva, Switzerland, 2014 Accessed 6 December 2017. .
331 <https://www.who.int/nutrition/global-target-2025/discussion-paper-extension-targets-2030.pdf>.
- 332 6. King JC, Brown KH, Gibson RS, Krebs NF, Lowe NM, Siekmann JH, Raiten DJ. Biomarkers of
333 nutrition for development (BOND)-Zinc. *Review J Nutr*. 2015;146(4):858 - 885.
- 334 7. Martorell BR, Horta LS, Adair AD, Stein L et al. "Weight Gain in the First Two Years of Life is an
335 Important Predictor of Schooling Outcomes in Pooled Analyses from Five Birth Cohorts from Low-
336 and Middle-Income Countries." *J Nutr*. 2010;140(2):348–354.
- 337 8. National Institute of Statistics (NIS). Multiple indicator cluster survey (MICS5), 2014, Key Results
338 Report. Yaoundé, Cameroon, 2015.
- 339 9. Nolla NP, Kana Sop MM, Mananga MJ, Tetanye E and Gouado I. "Assessment of nutritional
340 status of preschool children in the Bangang rural community, Cameroon". *Inter J Bioth Food Sci*.
341 2014;2(2):44-52..
- 342 10. Mananga MJ, Kana Sop MM, Nolla NP, Tetanye Ekoe and Gouado I. Feeding practices and
343 nutrition insecurity of infants and their mothers in Bangang rural community, Cameroon. *J Nutr
344 Food Sci*. 2014;4(2):264.
- 345 11. UNICEF. Improving child nutrition: The achievable imperative for global progress. Ed. Unicef, New
346 York, United Nations, 2013;132p.
- 347 12. WHO and UNICEF. Discussion paper: The extension of the 2025 Maternal, Infant and Young Child
348 nutrition targets to 2030. Geneva, Switzerland, 2014. <https://www.who.int/nutrition/global-target-2025/discussion-paper-extension-targets-2030.pdf>. Accessed 6 December 2017.
- 350 13. Fokou E, Ponka R, Tchinda DP, Domguia KH, Tchouba LB, Achu MB, et al. Methods of
351 preparation and nutritive value of some dishes consumed in the West Region of Cameroon. *Pask J
352 Nutr*. 2009;8(8):1190-1195.
- 353 14. Kouebou CP, Achu M, Nzali S, Chelea M, Bonglainsin J, Kamda A, et al. A review of composition
354 studies of Cameroon traditional dishes: Macronutrients and minerals. *Food Chem*. 2013;140:483-
355 494.
- 356 15. WHO. WHO child growth standards: length/height for age, weight-for-age, weight-for-length,
357 weight-for-height and body mass index-for-age, methods and development. Geneva: World Health
358 Organization; 2006. Available from: http://www.who.int/childgrowth/standards/Technical_report.pdf
- 359 16. Liu L, Johnson HL, Cousens S, Perin J, Scott S, Lawn JE, et al. Global, regional and national
360 causes of child mortality: An updated systematic analysis for 2010 with time trends since 2002.
361 *Lancet*. 2012;379:2151-2161.

- 362 17. Sobiecki JG, Appleby PN, Bradbury KE, Key TJ. (2016) High compliance with dietary
363 recommendations in a cohort of meat eaters, fish eaters, vegetarians, and vegans: results from the
364 European Prospective Investigation into Cancer and Nutrition–Oxford study. *Nutr Research*. 2016;
365 36(5):464–477. doi: 10.1016/j.nutres.2015.12.016
- 366 18. Górska-Warsewicz H, Rejman K, Laskowski W, Czczotko M. Milk and Dairy Products and Their
367 Nutritional Contribution to the Average Polish Diet. *Nutrients*. 2019;11(8):1771. doi:
368 10.3390/nu11081771.
- 369 19. Hurrell R, Egli I. Iron bioavailability and dietary reference values. *Ameri J Clin Nutr*. 2010; 91:1461–
370 1467.
- 371 20. McDaniel MH, Williams SE. Calcium Primer: Current Controversies and Common Clinical
372 Questions. *J Clin Densito*. 2013;16(4):389-393.
- 373 21. St Jules DE, Ram J, Lisa G, Kamyar KZ, Mary Ann S. Examining the proportion of dietary
374 phosphorus from plants, animals and food additives excreted in urine. *J Renal Nutr*. 2017;
375 27(2):78–83.
376
- 377 22. Schuchardt JP, Hahn A. Intestinal Absorption and Factors Influencing Bioavailability of Magnesium-
An Update. *Curr Nutr Food Scie*. 2017;13(4):260–278.
- 378 23. Goudet SM, Bogin BA, Madise NJ, Griths PL. Nutritional interventions for preventing stunting in
379 children (birth to 59 months) living in urban slums in low- and middle-income countries (LMIC).
380 *Cochr Database Syst Rev*. (2019);6(6):CD011695. doi: 10.1002/14651858.CD011695.pub2.
- 381 24. Barffour MA, Hinnouho GM, Wessells KR et al. Effects of therapeutic zinc supplementation for
382 diarrhea and two preventive zinc supplementation regimens on the incidence and duration of
383 diarrhea and acute respiratory tract infections in rural Laotian children: A randomized controlled
384 trial. *J Glob Health*. 2020;10(1):010424. doi: 10.7189/jogh.10.010424.
- 385 25. Penny ME. Zinc Supplementation in Public Health. *Ann Nutr Metabo*. 2013;62(1):31–42.
- 386 26. Masum A, Crawford H, Berthold J, Talukder ZI, Hossain K. Minerals (Zn, Fe, Ca and Mg) and
387 antinutrient (Phytic acid) constituents in common bean. *Ameri J Food Tech*. 2011;6(3):235-243.
- 388 27. Popova A, Mihaylova D. Antinutrients in Plant-based Foods: A Review. *Open Biotech J*.
389 2019;13:68-76.