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MINERAL ABSORPTION FROM CAMEROONIAN DIETS

(L'absorption minérale à partir de régimes alimentaires camérounais)

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SUMMARY

Mineral absorption from diets based on taro (*Colocasia esculenta*), *Sorghum* spp.), yam (*Dioscorea dumetorum*) or plantain (*Musa paradisiaca*) and containing only 5 per cent of animal food from fish flour, was investigated with rats. These diets were compared to a balanced diet based on starch and casein. The control group showed significantly higher values of weight gain, of iron and zinc absorptions and of femur calcium and phosphorus concentrations than the experimental ones. The groups fed on taro, sorghum or yam based diets showed similar values of weight gain and mineral utilization. Its balance was negative for zinc and nul for iron during the second balance test period ; its liver zinc concentration was 20 per cent less than the control groups. It is concluded that such diets may not meet calcium requirement and that a such diet based on plantain may in addition be harmful to zinc and iron status, especially on a monotonous pattern of feeding and over a long period, which is the case of rural populations in the Centre and South of Cameroon.

RESUME

L'absorption minérale à partir de régimes alimentaires à base de taro, sorgho, igname ou banane plantain et contenant seulement 5 pour cent d'aliment animal a été étudiée sur des rats. Ces régimes ont été comparés à un régime équilibré à base d'amidon et de caséine.

Le groupe nourri avec le régime à base de plantain a montré un équilibre négatif pour le zinc et son équilibre pour le fer a diminué et est devenu nul pendant la seconde période de l'étude. Le groupe témoin a montré des concentrations de calcium et des phosphore dans le fémur plus élevées. Le groupe nourri avec le régime à base de *plantain a montré une concentration de zinc dans le foie 20 pour cent plus faible que le témoin. Il n'y a pas eu de différence significative pour la concentration en fer dans le foie entre les différents groupes.*

On conclut que de tels régimes qui sont fréquents dans les zones rurales du Cameroun méridional peuvent ne pas satisfaire les besoins en calcium et qu'un tel régime à base de plantain peut être nocif quant aux taux de zinc et de fer et en particulier sur une longue période.

The diet of the population of the humid forest zone of Africa is generally poor in animal foods, especially in rural areas. Since minerals from vegetable foods are known to often be less bioavailable than those from animal foods (1,2) this may be of nutritional concern.

There is some information available about mineral contents of tropical foods, but data on bioavailability of minerals from tropical foods and diets are scanty. The ability of selected cereals (rice, wheat, millet, ragi, sorghum and maize) and pulses (soybean, cowgram dhal, redgram dhal and Bambara nut) to regenerate haemoglobin in the anemic rat has been reported to range between 17 per cent for ragi to 40 per cent for soybean, in terms of ingested iron utilised for haemoglobin synthesis (3,4). It has been observed that the addition of waxy and nonwaxy sorghum to wheat and bean mixed protein diets for human adults did not affect calcium and phosphorus balances (5). Mineral biovailabity from diets based on tropical root crops has been even less studied. Cassava starch has been reported not to be extremly inferior to rice and corn starch in regard to the effect on protein, calcium, magnesium, iron and copper balances (6). When comparing the effect of various tubers (cassava, taro and sweet potato), under a low protein dietary level, on protein, calcium, phosphorus and magnesium utilization, the lowest utilization of minerals was observed with taro root (7).

The present study was undertaken to determine mineral absorption from diets of cameroonian rural populations from which animal foods provide in average less than 5 per cent of the total energy. Another goal was to compare diets based on different staple foods commonly consumed in Cameroon such as tubers (taro and yam) and starchy fruits (plantain) eaten in the south forest zone ; or cereals (sorghum) eaten in the north savanah zone. The contribution of the staple food to mineral supplies may be important since it represents the main factor of the Cameroonian diet and provides 60 to 85 per cent of the total energy of the diet.

MATERIALS AND METHODS

Diets. The composition of the diets is shown in Table 1. The 4 experimental diets differ only by the staple food used. The staple foods studied are among the most commonly consumed in Cameroon : Taro (*Colocasia esculenta*, var. C 11 with white flesh tubers) in diet TA ; (*Sorghum* spp.) in diet SO ; yam (*Dioscorea dumetorum* Ex. *Jakiri*) in diet YA ; and plantain (*Musa paradisiaca*) in diet PL. They were prepared by usual cooking procedures in Cameroon, then they were vacuum dried at 60°C and ground into flour, using an electric grinder, before mixing with their respective diets. Taro and yam tubers were boiled unpeeled, then peeled and sliced before drying and grinding. Plantain was boiled after peeling. Sorghum flour was obtained by traditional processing ; the grains were washed with tap water, pounded in a mortar in way to separate the envelopes from the grains, washed a second time then sun dried and ground into flour with an electric grinder ; then the flour was sifted. Before mixing to the diet, the flour was boiled, vacuum dried and ground. Each staple food was mixed with the common ingredients of sauce as it is shown in Table 1. Peanut butter obtained after grilling and peeling of the grains ; smoked fish flour ; red palm oil ; green leaves (*Corchorus olitorius*) sun dried and pounded ; and table salt (*Selcam*).

The experimental diets are compared to a balanced control diet (diet C) of similar energy content and which meets the protein, mineral and vitamin requirements of the rat.

Just before serving the different diets, 3 per cent agar in boiling water was added to each to prevent spoiling by the rats.

Animals : Sprague - Dawley male weanling rats (57 g mean body weight, 25 days old) were used (n = 25). Animals were fed stock diet during 1 week adaptation and then randomly distributed into 4 experimental groups and 1 control group. They were housed individually in stainless metabolic cages in a temperature (22 - 23°C) and light (12 hrs light/dark cycle) controlled room. A one-week adaptation period to their respective diets was allowed.

Two consecutive 10 - days balance test periods were then conducted. Throughout the balance periods, urine and feces of each rat were collected daily. During the entire feeding period, the animals were fed *ad libitum* and food consumption and body weight were measured every two days. Deionized water was given *ad libitum*. The balances of calcium, iron and zinc were determined. After 35 days on their respective diets, the rats were killed. Serum, liver, kidneys and left femur were collected for mineral analysis.

Analyses : Diets were analysed for energy, using an adiabatic bomb calorimeter (PARR n° 1242) ; for proteins by the micro-kjeldahl method (kjeltec auto 1030 analyzer tecator, Herndon, VA) ; the factor of conversion of total nitrogen to proteins was 6.25. Diets were also analysed for amino acid composition, minerals and phytate. Calcium,

TABLE 1

COMPOSITION OF THE DIETS (g/kg)

Control diet (C)		Experimental diets	
- Corn starch	701	- Staple food, dried Taro (Diet TA) Sorghum (Diet SO) Yam (Diet YA) Plantain (Diet PL)	700
- Casein	118		
- CL-Methionine	6		
- Corn oil	50	- Peanut butter	100
- -cellulose	50	- Fish flour, smoked	50
- Vitamin mix, complete[(1)]	15	- Red palm oil	45
- Mineral mix, complete[(2)]	60	- Green leaves (Corchorus olitorious), dried	95
- Agar (added after mixing the diet)	30	- Table salt (Selcam)	10
		- Agar (added after mixing the diet)	30

(1) Contained in g/kg mix ; Biotin, 0.0125 ; folic acid, 0.03 ; Rovimix AD_3 - 325/325, 0.23 ; p. aminobenzoic acid, 0.5 ; riboflavin, 0.5 ; menadione, 1.25 ; nicotinic acid, 1.5 ; pyridoxine hydrochloride, 1.5 ; thiamine hydrochloride, 1.5 ; Vit. B_{12} with mannitol, 1.5 ; Rovimix A-250, 2.73 ; calcium pantothenate, 2.5 ; ascorbic acid, 5.0 ; Rovimix E.50 %, 11.9 ; inositol, 25.0 ; choline chloride, 50.0 ; glucose monohydrate (Cerelose), 895.0.

(2) Contained in g/kg mix : $CaDO_3$, 340 ; Mg SO_4, 97 ; $CaHPO_4$, 60 ; K_2HPO_4, 321 ; NaCe, 168 ; $C_rK\ (SO_4)_2\ 12H_2O$, 0.40 ; $MnSO_4\ H_2O$, 2.56 ; KI, 0.20 ; Z_nCO_3, 3.20 ; $FeSO_4\ 7H_2O$, 10.0 ; $CuSO_4\ 5H_2O$, 0.33.

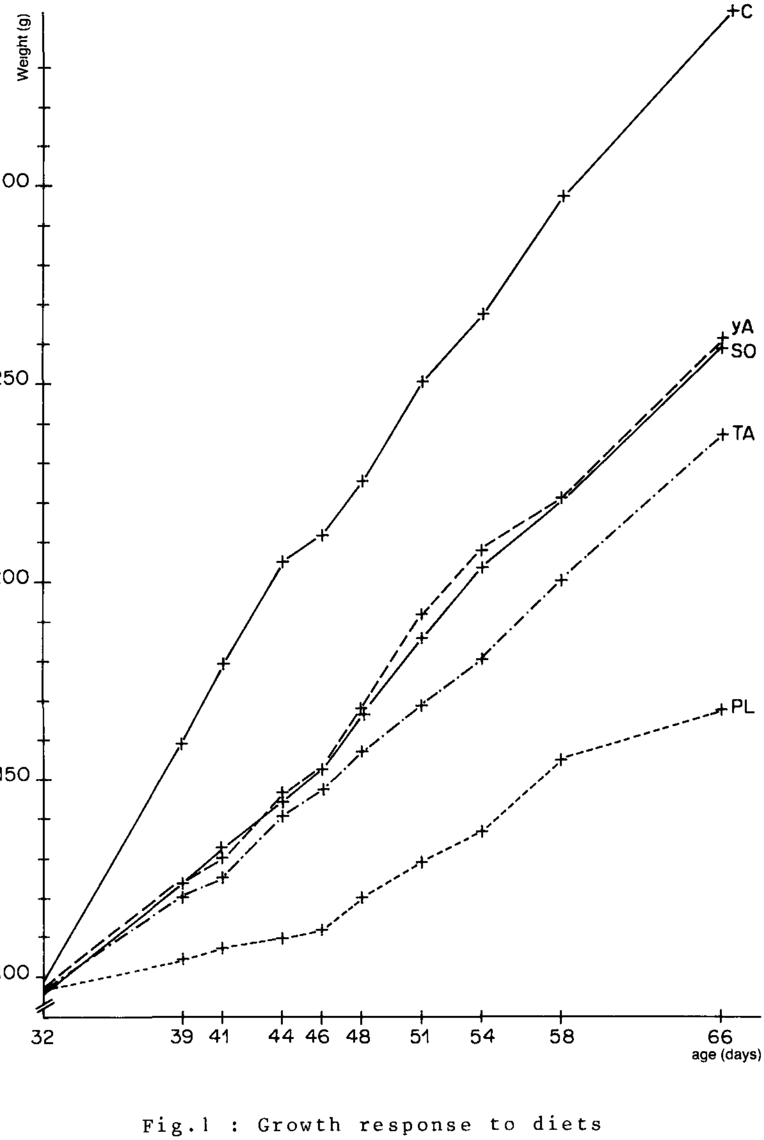

Fig.1 : Growth response to diets

magnesium, iron, zinc and copper were determined by flame atomic absorption spectrophotometry (Instrumentation laboratory aa/ae spectrophotometer 157, Wilmington, Mass.) after wet ashing with the nitric acid (8). Phosphate was determined by the colorimetric method of EIBL and LANDS (9), using a Varian Cary 219 spectrophotometer (Varian, TX). Phytate phosphorus on diets was determined by the colorimetric method of DAVIES and REID (10) ; the conversion factor of phytate phosphorus to phytate was 3.55. Data were statistically analysed by analysis of variance. Differences between the experimental diets were determined using the FISHER LSD test (p 0.05), (11).

RESULTS

Nutrient contents of the diets are shown in Table 2 and 3.

All the 4 experimental diets are low in calcium. The phosphorus contents are also relatively low, except for diet TA. Phytate phosphorus, expressed as a percentage of total phosphorus, is higher in diets SO and TA and in a less extent, in diet PL. This last result reflects the higher contribution of phytate phosphorus from peanut to total phosphorus. Iron contents are lower in the experimental diets compared to the control except for diet YA. But diets TA and SO are still above 120 ppm which is considered adequate for rats. The high iron content of diet YA is probably due to high contamination with soil, water, peel and cooking ustensils used during the boiling of the unpeeled yam tubers. All diets are adequate in magnesium compared to the control. Zinc contents are high in diets TA, SO and YA compared to the control. High Zn content is probably due to preparation procedures (boiling of unpeeled tubers and sun drying). Besides calcium and iron, diet PL is also low in zinc and cooper, compared to the control, so is diet SO for copper.

The protein contents of the experimental diets appear adequate except for the diet PL which is low in protein. However, Table 3 shows a deficit in lysine for all experimental diets except diet YA, and probably in sulfur amino acids for all 4 experimental diets although we lack data on cysteine contents.

Weight gain, food efficiency and nitrogen efficiency were significantly higher for the control group than the other groups (Table 4). Group PL showed the lowest values ; its average weight gain was 4 times less than the control during the first balance test period ; during the second period, it tented to catch up an its weight was half of the control group.

It was noticed that diets based on tubers like taro or *Dioscorea dumetorum* (this specie of yam is higher in proteins, minerals and vitamins than other common yam species) showed

TABLE 2

NUTRITIENS ONTENTS OF THE DIETS (per 100 g DM)

Diet	Energy Kcal	Tot. Proteins g	Ca mg	Mg mg	Fe mg	Zn mg	Cu mg	Tot. P mg	Phytate mg	$\frac{P_P}{Pt} \times 100$
C	444	12,5	913	88	38,9	1,780	842	846	–	–
TA	472	14,1	521	164	16,0	3,420	729	681	1,269	52
SD	487	15,4	288	129	17,7	2,410	332	384	1,093	80
YA	478	14,7	321	111	46,7	1,800	549	382	493	36
PL	484	11,0	275	110	9,0	930	321	224	380	47

TABLE 3

AMINO ACIDS OF THE EXPERIMENTAL DIETS (g/100 g DW)

	C	TA	SO	YA	PL
Alanine	0.27	0.63	1.06	1.08	0.50
Arginine	0.37	0.91	0.76	1.45	0.60
Aspartic acid	0.67	1.44	1.21	2.18	0.96
Cysteine	0.04				
Glutamic acid	2.18	1.70	2.74	2.75	1.34
Glycine	0.19	0.62	0.59	0.95	0.50
Histidine	0.27	0.24	0.31	0.41	0.26
Isoleucine	0.50	0.45	0.57	0.77	0.35
Leucine	0.91	0.89	1.55	1.50	0.62
Lysine	0.77	0.59	0.62	1.21	0.51
Methionine	0.59	0.16	0.20	0.26	0.14
Phenylalanine	0.51	0.60	0.71	0.88	0.40
Proline	1.22	0.50	0.93	0.74	0.36
Serine	0.56	0.56	0.59	0.88	0.35
Threonine	0.38	0.43	0.48	0.76	0.31
Tryptophane	0.12				
Tyrosine	0.55	0.44	0.47	0.69	0.28
Valine	0.59	0.63	0.76	1.03	0.44

TABLE 4

AVERAGE FOOD INTAKE, WEIGHTGAIN,

FOOD EFFICIENCY AND NITROGEN EFFICIENCY DURING

THE BALANCE TEST PERIOD I

Diet	Food intake g DW/day	Weight gain g/day	Food efficiency	Nitrogen efficiency
C	21.9 ± 1.0	7.4 ± 1.4[c]	0.34 ± 0.00[c]	2.70 ± 0.44[c]
TA	18.5 ± 4.7	3.9 ± 1.7[b]	0.20 ± 0.04[b]	1.42 ± 0.31[ab]
SO	18.1 ± 1.3	4.7 ± 0.8[b]	0.26 ± 0.04[b]	1.69 ± 0.23[b]
YA	18.5 ± 1.9	4.8 ± 0.5[b]	0.26 ± 0.03[b]	1.77 ± 0.20[b]
PL	13.1 ± 3.2	1.7 ± 1.4[a]	0.11 ± 0.07[a]	1.01 ± 0.68[a]

Values are mean ± SEM (n = 5)

Numbers within a column with different superscripts are significantly different ($P<0.05$

NB. The results of the balance test period II being not different as a rule from the results of the balance test period I, only this one has been reproduced. An exception is for PL were the values doubles more or less, but for food intake. (Edit. Note)

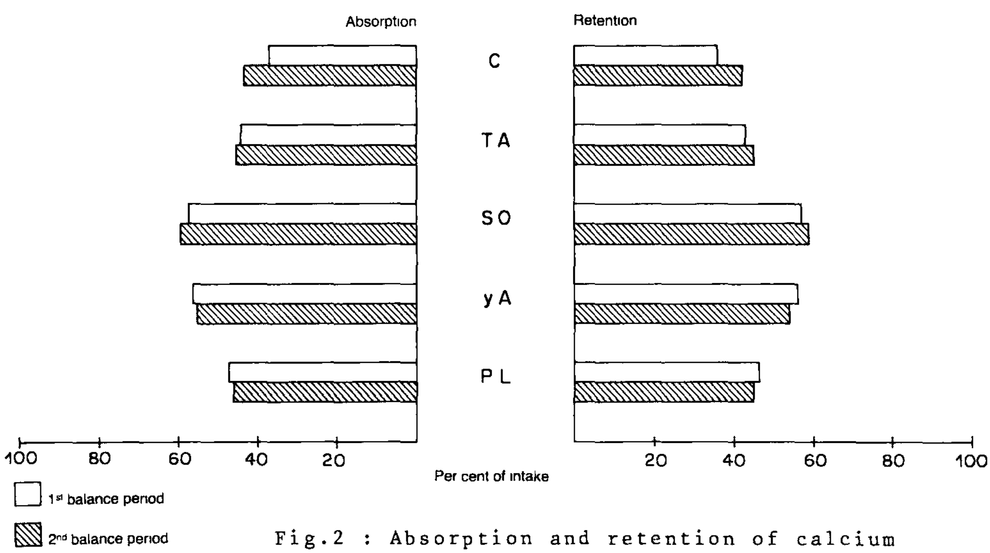

Fig.2 : Absorption and retention of calcium with the experimental diets

values as high as a cereal-based diet with sorghum. These 2 tubers are in fact similar to cereals in terms of protein contents. 7.3 and 8.3 per cent of the dried product compared to 8.9 per cent for sorghum flour. But the taro, yam and plantain fed groups showed significantly higher weight of caecum, compared to the control and SO groups ; both with and without contents for group TA and only with contents for groups YA and PL (Table 5). SUZUKI et al (7) made the same observation with taro root compared to cassava and sweet potato.

Balance studies

Calcium balance was positive for all groups during the two balance test periods (Fig. 2). The retention of calcium was 36, 43, 57, 56 and 46 per cent of the intake for groups C, TA, SO, YA and PL respectively during the first balance test period. The values were respectively 43, 45, 59, 55 and 45 during the second balance test period. Diets SO and YA which showed the highest values were among the poorest in calcium but with high protein contents. Since the urinary output of calcium was very small (C;1 to 1 per cent of the intake), calcium retention was a linear function of absorbed calcium. Such observations have been previously reported (12, 13). No differences were observed between the first and the second balance periods.

Iron balance. Iron retention was relatively low : 16, 10, 10, 11 and 19 per cent of the intake for diets C, TA, SO, YA and PL respectively during the first balance test period (Fig. 3). During the second balance test period, the values were 12, 7, 12, 9 and 0 per cent respectively. Experimental groups were not different from the group fed the control diet which contained 70 per cent of starch and 12 per cent of casein, except for group PL. This last group showed great differences between the first and the second balance test periods. Its iron retention, similar to the control during the first period, decreased and was nul during the second period. Iron retention also was a linear function of absorbed iron since the urinary output of iron was very small (0 to 1 per cent of the intake). Although iron content was higher in diet YA, absorption and retention were not increased in this group (11 and 9 per cent during the first and the second balance test periods, respectively) compared to the control group (17 and 12 per cent respectively).

Zinc balance. Zinc retention was 34, 11, 26 and 24 per cent of the intake for groups C, TA, SO and YA respectively during the first balance test period (Fig 4). During the second balance test period, the values were 31, 14, 20 and 8 per cent respectively. Zinc balance was negative in group PL during the two balance test periods (-11 and -13 per cent respectively). Zinc retention also was a linear function of absorbed zinc since the urinary output of zinc was small (0,4 to 3 per cent of the intake).

TABLE 5

THE MEAN WEIGHT OF FECES, STOMACH AND CAECUM

Diet	Fecal wet weight g/day		Stomach g		Caecum g	
	I	II	A	B	A	B
C	2.7^{a}	3.6^{a}	3.5	1.8^{c}	4.2^{a}	0.90^{a}
TA	6.0^{a}	7.2^{c}	5.4	1.4^{b}	6.5^{b}	1.4^{b}
SO	3.7^{ab}	4.8^{ab}	5.4	1.3^{ab}	3.8^{a}	0.80^{a}
YA	5.0^{bc}	5.9^{bc}	5.7	1.4^{b}	6.0^{b}	1.2^{ab}
PL	3.1^{a}	3.7^{a}	2.9	0.99^{ε}	5.9^{b}	0.95^{ab}
			NS			

A= including the contents B= canal only

Values are mean $\pm$ SEM (n = 5)
(NB : $\pm$ SEM have not been reproduced, from editorial. constraints Ed. Note).

Numbers within a column with different superscripts are significantly different ($P<0.05$).

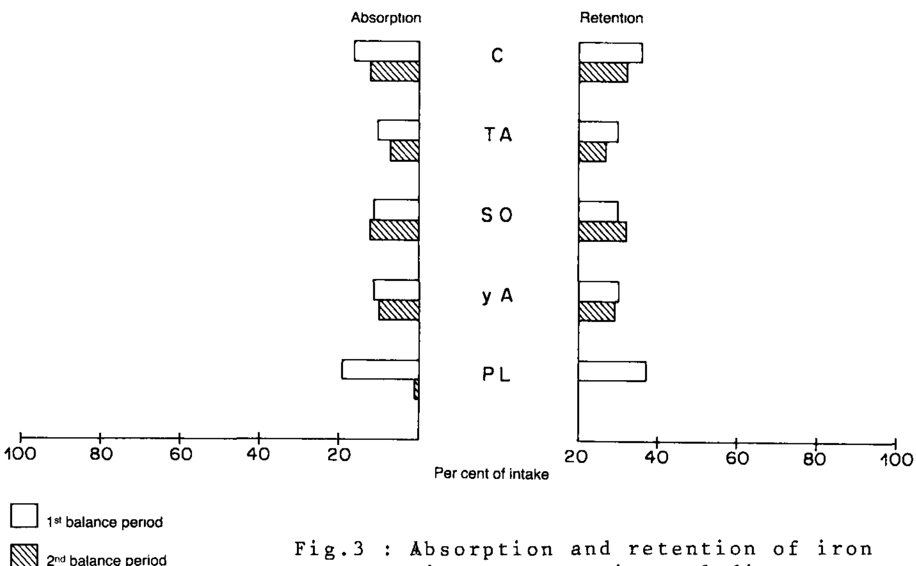

Fig.3 : Absorption and retention of iron with the experimental diets

TABLE 6

EFFECT OF DIET ON LIVER WEIGHT, IRON, ZINC AND COPPER CONCENTRATIONS

Diet	WW g	WW/BW x 100	Fe mg/g WW	Zn mg/g WW	Cu mg/g WW
C	16.6	4.8^{b}	100.9^{a}	19.7^{b}	3.5
TA	9.7	4.0^{a}	91.0^{a}	22.9^{c}	5.8
SO	10.5	4.0^{a}	103.1^{a}	20.6^{bc}	3.2
YA	10.2	3.8^{a}	131.3^{a}	21.2^{bc}	4.4
PL	6.8	4.0^{a}	93.9^{a}	15.6^{a}	3.7
					NS

Values are mean ± SEM (n = 5) (see Table 5 Ed. Note)

Numbers within a column with different superscripts are significantly different ($P<0.05$).

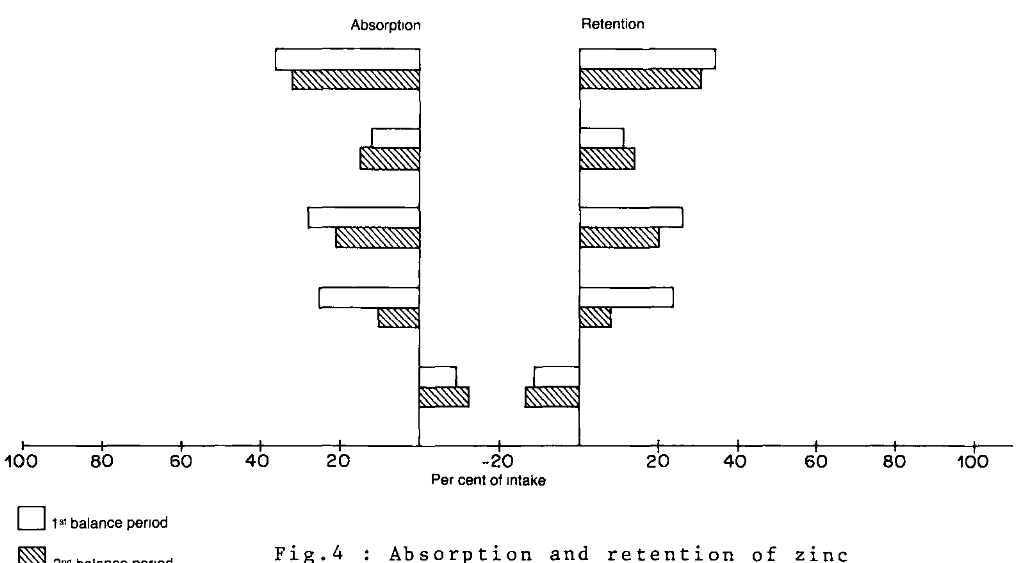

Fig.4 : Absorption and retention of zinc with the experimental diets

Mineral concentrations of tissues

Liver. The difference of liver weight, expressed as a percentage of body weight, between the control group and the 4 experimental groups was small (17 per cent) but significant (Table 6). Liver iron concentration did not differ significantly between the control and the experimental groups, except for group YA which was higher.

All experimental groups showed liver zinc concentrations comparable to the control group, except the group PL which was 20 per cent lower (p 0,05).

The liver copper concentrations did not show significant differences between the groups.

Kidney. Kidney calcium concentration was higher in the control group (7 to 10 per cent) compared to the experimental groups (Table 7), Kidney zinc concentrations showed only small differences. There were no significant differences in kidney phosphorus and coppper concentrations between the 5 groups.

Serum calcium. Experimental groups SO and PL showed lower values than the control group.

Femur. Femur calcium and phosphorus concentrations were higher in the control group than the other groups (Table 9) group PL showed the lowest values (14 and 17 per cent less than the control group for calcium and phosphorus respectively). This group also showed the lowest femur zinc concentration but the difference from the control group was small (3 per cent).

DISCUSSION AND CONCLUSIONS

Growth and its effects. All 4 experimental groups showed a significantly lower growth rate than the control group. The consequence was smaller tissue weights and lower total mineral contents in tissues for all minerals and tissues studied, except liver copper content of groups TA and YA. Except for femur calcium and phosphorus concentrations, the difference in tissue mineral concentrations were not important between groups TA, SO, YA and the control group. For animals fed on diet PL, the lowest in minerals and proteins, the reductions of tissue mineral concentrations were dramatic : 20 per cent less than the control group for liver zinc concentration ; 20 per cent less for serum calcium ; 18 per cent less for kidney calcium concentration ; 14 per cent less for femur calcium concentration and 17 per cent less for femur phosphorus concentration. It appears that under a marginal diet, the animal first decreases its growth and keeps the more possible its tissues quality. In the present study, the animals have been fed on their respective diets for 35 days only. It would be of interest to observe what would happen over a long period.

TABLE 7

EFFECT OF DIET ON KIDNEY WEIGHT, CALCIUM, PHOSPHORUS, ZINC AND COPPER CONCENTRATIONS

Diet	WW, g	$\frac{WW}{BW}$ x 100	Ca mg/g WW	P mg/g WW	Zn mg/g WW	Cu mg/g WW
C	2.86	0.83^{bc}	48.8^{b}	2.223	18.5^{a}	4.4
TA	1.97	0.83^{bc}	41.4^{a}	2.548	20.6^{bc}	3.7
SO	1.92	0.74^{a}	38.5^{a}	2.497	20.7^{c}	3.6
YA	2.06	0.79^{ab}	40.6^{a}	2.082	18.9^{ab}	3.4
PL	1.48	0.89^{c}	39.9^{a}	2.711	20.8^{c}	3.9
						NS

Values are mean $\pm$ SEM (n = 5) (See Edit. Note, table 5)

Numbers within a column with different superscripts are significantly different ($P<0.05$).

TABLE 8

EFFECT OF DIET ON SERUM CALCIUM

Diet	Serum Ca mg/g
C	109.2 ± 7.9^{c}
TA	103.0 ± 3.4^{bc}
SO	95.8 ± 8.4^{ab}
YA	103.8 ± 3.6^{bc}
PL	87.4 ± 1.8^{a}

Values are mean $\pm$ SEM (n = 5)

Numbers within the column with different superscripts are significantly different ($P<0.05$).

TABLE 9

EFFECT OF DIET ON FEMUR, WEIGHT, CALCIUM, PHOSPHORUS AND ZINC CONCENTRATIONS

Diet	Dry Weight g	Ca mg/g DW	P mg/g DW	Zn mg/g DW
C	0.51	205.3[b]	114.3[c]	178.8[b]
TA	0.38	182.3[a]	105.1[b]	202.8[b]
SO	0.35	184.4[a]	105.4[b]	185.0[c]
YA	0.39	179.7[a]	105.8[b]	182.5[bc]
PL	0.28	175.6[a]	94.8[a]	172.8[a]
	NS			

Values are mean ± SEM (n = 5)   (See Table 5 Ed. Note)

Numbers within a column with different superscripts are significantly different ($P<0.05$).

Calcium bioavailability from Cameroonian diets and calcium status. although the calcium balance was positive for all groups, the 4 experimental groups showed femur calcium and phosphorus concentrations lower than the control group. The groups fed on diets SO and PL, the lowest in calcium, had lower serum calcium levels. In reality, calcium consumption appear to be low in Cameroon. For infants in Yaounde aged 6 to 24 months, it has been reported to be only half of the recommended dietary allowances (14). Similar observations were made on young children (6 - 10 years old) and pregnant women in the same town (15-16). But this was not associated with clinical signs of calcium deficiency. Adequate protein and vitamin D supplies in those urban populations may inhance dietary calcium utilization. For rural populations of Cameroon, animal proteins consumption is lower and the adaptation of those rural populations to a low calcium diet need to be studied.

Iron bioavailability from Cameroonian diets and iron status. Low iron absorption was observed from these diets (0 to 16 per cent supplying in average 0 to 3 mg per day to adults). HALLBERG et al. (17,18) also reported low iron absorption from Southeast Asian diets composed of rice, cooked vegetables and spices (0.8 mg per day). Liver iron concentration was higher in group YA compared to the control group.

This may be explained by a difference in liver weight (16.6 g and 10.2 wet weight, respectively for groups C and YA) rather than by a difference in iron bioavailability (12 and 9 per cent, respectively) since total liver iron content was lower in group YA in spite of high iron content of this diet. It appears that at this level of iron absorption there may not be problem for such diets based on sorghum or yam that approach nutritionally balanced diet. Diet TA with relatively low iron retention (7 per cent) may be insufficient for weaning infants (9 - 12 months old) when the quantity of food eaten is small, since breast milk is poor in iron. In these conditions, diet TA is unable to provide 1 mg of iron per day necessary at that age. The situation is worst with diet PL which could not sustein a positive iron balance during the second period of the study. This may be a result of the higher metabolic rate in the animals which had greater growth rate during the second period than the first. It has already been noticed also that mineral balances are more likely to fluctuate when levels of intake are marginal (19). A such diet like PL is usually consumed by rural populations of the Centre and South Cameroon in a monotonous pattern of feeding ; fortunately, these populations often consume a lot of groundnut. In Yaounde Iron consumption has been reported to be only 35, 52 and 72 per cent of the recommended dietary allowances in infants aged 6, 9 and 14 months respectively (14). Iron supplies are adequate only after weaning is over (14, 15). A national survey (20) indicated that 44,7 per cent of Cameroonian infants aged 6-59 months are anemic. There is little difference between the different regions. Before 2 years, poor iron consumption, malaria, and parasitism may explain this situation. After 2 years, the frequence of malaria and parasitism may explain this situation. After 2 years, the frequence of malaria and parasitism may be a factor more important than poor nutrition. KOMBOU et al. (15) reported low iron consumption during the second half of pregnancy also and relatively high incidence of anemia.

Zinc biovalability from cameroonian diets and zinc status. Although the retention of zinc was in general less in the experimental groups compared to the control (Fig. 3 and 4), total absorbed zinc from diets TA and SO were not different from the control diet as these diets are rich enough in zinc. Absorbed zinc is lower for diet YA and the situation is quite dramatic for the group fed on diet PL who showed a negative balance for zinc and a decreased liver zinc concentration. Endogenous losses and the low protein content of the diet may explain this result. Information about zinc nutrition of Cameroonian populations is still inexistant. But, it may be poor among rural populations of the Centre and South whose diet is monotonous and largely based on plantain.

In the present study, diets SO and YA were almost equal in regard to mineral absorption. Diet TA showed also close values with the former ones. Diet PL showed the lowest values of mineral utilization ; it was also the poorest in minerals and proteins. Besides the mineral content, the protein content of the diet is of importance. Improvement of mineral utilization from Cameroonian diets by the dietary protein need to be studied. It has already been observed that low protein diets reduced absorption of iron (21,22) and zinc (23) and that meat, fish and cysteine enhance iron utilization (24,25 and 26). As animal foods are not largely available in rural areas of Cameroon where prevails an economy of subsistence, the results obtained with diets SO and YA suggest a possibility of improvement even with vegetable foods. It appears that the first practical way of preventing mineral disorders is to vary enough the diet, including the staple food which contribution is important in Cameroonian diet.

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