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Research Article

Food Porridges Based on Quinoa, Amaranth and Cañahua Complemented with More Flavoring Milk Powder, for a Children's Population Under 2 Years Old

Luz Mirian Vargas Coca*

Center for Food and Natural Products, Faculty of Sciences and Technology, University Mayor de San Simon, Cochabamba, Bolivia

Abstract

Children's nutrition is affected by the great changes produced by the lifestyles of populations. The nutritional status in children was ignored for quite a long time; today many countries are looking for solutions to the problems of malnutrition and poor nutrition, causing nutritional deficit in children due to various factors, such as economic, social, cultural and food availability. Scientific evidence has shown that adequate nutrition can help the population promote optimal health. Therefore, the objective is the "Biological study of food porridge based on quinoa, amaranth and cañahua complemented with more flavored milk powder, for a child population under 2 years of age." Through processes of obtaining flour, formulation, production, biological evaluation and analysis of iron and zinc minerals in mixtures of food porridge, liver, thymus and femur. The result of the theoretical formulation for the Standard Diet presents 11,7 g of protein and 419 kcal, iron 0,1 mg, zinc 1,5 mg, for the food mixtures based on Andean grains plus flavoring have a range of 11,6-12,1 g of protein, 380,6-389,6 kcal, iron 6,4-10,4 mg, 0,0-2,9 mg of zinc. The biological parameters for the Standard Diet present a IP of 142,8, REP 2,7 and %Da 89,2; for the food mixtures based on Andean grains plus flavoring, they fluctuate from 26,8-72,9 for the IP, the REP with 1,0-1,9 and %Da 65,4-81,9, lower than the Standard Diet. For the food mixtures based on Andean grains plus flavoring and milk powder, they present values in a range of 11,6-11,7 g of protein, 382,3-388,0 kcal, iron 2,8-4,9 mg and zinc 1,0-2,4 mg, the IP of 173,3-185,6, REP 2,9-3,5 and %Da of 79,2-85,8 higher than the Standard Diet in terms of IP and REP. In conclusion, the proposed food mixtures based on Andean grains plus flavoring and milk powder are excellent for the preparation of food porridges.

Keywords

Andean Grains, Porridge, Biological Parameters, Child Population

1. Introduction

The nutritional status of children was ignored for quite some time. Today, many countries are looking for solutions to the problems of malnutrition and undernutrition, especially in rural areas where there is no knowledge about proper nutrition and feeding; causing nutritional deficit in children due to several factors, including economic, social, cultural and food availability.

"Carbajal (2013) in reference, states that a nutrient is es-

*Corresponding author: mi.vargas@umss.edu (Luz Mirian Vargas Coca)

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sential for maintaining health, however, unlike others, it cannot be formed or synthesized within our body, so it must be provided in quantity and quality through foods in the diet, to prevent certain diseases. [1]"

"Tapia (2018) indicates that Andean grains (quinoa, amaranth and cañahua), are recognized in the international scientific world for their high protein quality and essential amino acids. [2]". Rojas *et al*. (2010), mentions that they are far superior to those of cereals, with an adequate balance of essential amino acids such as lysine. [3]

Royo (2007) also mentions that these proteins are usually incomplete and have lower digestibility, therefore, their biological value is lower than that of animal origin. [4]

(Hidalgo & Güemes, (2011) they provide the energy that is the basic requirement of the diet. [5]

López & Suárez (2017) mention, that nutrients are those substances that are normal components of our body and food, whose absence or decrease below a minimum limit produces a deficiency disease. [6]

According to López, et al., 2010, the importance of zinc as an essential nutrient is widely known, it participates in a range of biochemical processes related to human metabolism, multiple physiological and metabolic functions are altered when its deficiency occurs. [7]

Tandara & Salamunic (2012) Mention that iron is a vital element found in foods of animal origin. [8]

Quispe, 2013, maintains that studies on food mixtures based on different foods arose in the past, which were highly acceptable to consumers. [9]

According to Álvarez et al., (2012), porridges are mixtures of nutrients, including milk powder and dairy products (powdered milk, powdered whey), various types of cereals and sugars, fortified with vitamins and minerals, emulsifiers and flavourings. All of these components are very important because they help to cover the nutritional requirements of young children (1-3 years) and growing children; they provide a good nutritional balance of carbohydrates, proteins, vitamins and minerals. [10]

Reasons why the objective of the research was, "Biological study of food porridges based on quinoa, amaranth and cañahua supplemented with milk powder plus flavoring, for a child population under 2 years old", methodologically the selection of foods was carried out, the food mixtures were formulated according to the nutritional requirements of the experimental animals, the processes for obtaining the flours for the preparation of the mixtures were carried out, they were evaluated in vivo by means of biological tests and analysis of iron and zinc minerals as functional foods, in mixtures, liver, thymus and femur.

Food porridges enriched with Andean grains, plus flavorings used to increase the flavor, acceptance and consumption of food, is an excellent alternative for the preparation of porridges with a good nutritional contribution, thus helping the population to promote optimal health.

2. Methodology

The development of the research work was carried out at the Center for Food and Natural Products (CAPN) in the Nutrition Area, with the following steps:

2.1. Methodological Design

2.1.1. Selection of Raw Materials for the Formulation of Food Mixtures

The raw materials (quinoa, amaranth and cañahua), powdered milk were selected based on the nutritional value of protein and energy, accessibility and cost; obtained in the common market (La Pampa) of the city of Cochabamba – Cercado.

2.1.2. Process of Transformation of Raw Materials for the Development of Porridge

Based on the methodology used by Mendoza (2003), the production process was carried out, applying a set of actions or procedures to transform the raw material into a final product, with the use of a certain technology. [11]

a) Obtaining Andean grain flour

The grains were received, weighed, selected, cleaned and washed with water to remove saponins, cooked for 20 minutes at 92 ℃ to partially remove phytates, dried in an oven with air circulation for 24 hours at a temperature of 60 ℃, ground in a screw press to reduce the size of the grains, then ground in a blade mill, refined and sifted, obtaining fine flours from Andean grains (quinoa, amaranth and cañahua) (Figure 1).

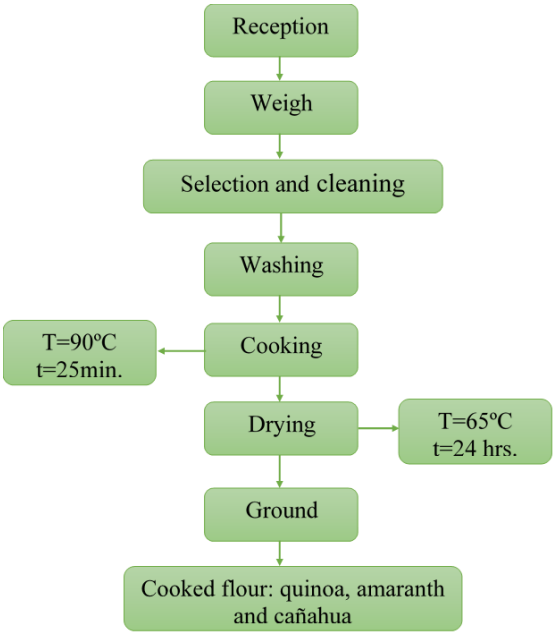

Figure 1. *Flowchart of the process of obtaining cooked flour from quinoa, cañahua and amaranth.*

2.1.3. Formulation of Food Mixtures

The mentioned formulations were made based on the Food composition table (2005), which were adjusted to 12% protein and 380 to 420 kcal of energy. [12] According to the nutritional requirements of the experimental animals, according to the objective of the experimental design, a standardized method in the Nutrition Area of (CAPN).

2.1.4. Formulation of Food Mixtures of Andean Grains Plus Flavoring

The theoretical formulation of 100 g of food mixtures for porridges was made based on Andean grains (quinoa, amaranth and cañahua), sugar, oil as an energy source and flavoring to reinforce the transmission of flavor and aroma coded as: Cooked Quinoa Diet plus Flavoring (DQ+ Fla), Cooked Amaranth Diet plus Flavoring (DA+Fla) and Cooked Cañahua Diet plus Flavoring (DC+Fla) respectively.

2.1.5. Formulation of food Mixtures of Andean Grains Plus Powder Milk and Flavoring

The theoretical formulation of 100 g of the food mixture for porridges based on quinoa, amaranth and cañahua supplemented with powder milk, sugar, cornstarch and flavoring, coded as: Cooked Quinoa Diet plus powder milk and Flavoring (DQ+Lchp+Fla), Cooked Amaranth Diet plus milk powder and Flavoring (DA+Lchp+ Fla) and Cooked Cañahua Diet plus milk powder and Flavoring (DC+Lchp+Fla) respectively.

2.1.6. Formulation of Standard Diet

The Standard Diet was formulated based on powdered milk and cornstarch coded as: (StanD).

2.1.7. Biological Evaluation of the Food Mixtures for the Study of Porridges

The biological evaluation of the food mixtures for the study of porridges was carried out based on the method of Pellet and Young with the change in body weight of the growing animal. [13] Using Wistar rats, with an average weight of 60-65 g, in optimal environmental conditions of light, humidity, temperature and ventilation recommended by (Mendoza *et al*., 2008). [14] In the Experimental Bioterio Laboratory, belonging to the Nutrition Area of the (CAPN) of the Faculty of Science and Technology (FCyT) of the UMSS.

The experimental animals used in the research work were male albino rats of the Wistar strain, with an average weight of 60-65 g. kept in an environment under optimal conditions of temperature (20 to 25 ℃), relative humidity (40-70%) and 12 hours of light and 12 hours of darkness (Fuentes *et al*., 2008). [15] (Figure 2)

The rats were randomly selected in groups of 6 according to the experimental model of Completely Randomized Design (CRD), housed individually in cages with their respective water bowl, feeder and identification, composed of a metal mesh floor that allows the animal's feces to fall, a tray at the bottom for collecting them (Figure 3).

Figure 2. *Wistar strain rats.*

Figure 3. *Wire mesh cage.*

Water and diet were supplied ad libitum for 28 to 30 days (Figure 4). Animals were weighed daily to obtain biological parameters, weight gain (IP), feed offered and rejected to determine the difference in feed consumed and to estimate the Protein Efficiency Ratio (REP) (Figure 5). Feces were collected from the fifteenth day for analysis of fecal nitrogen and to calculate apparent digestibility (%Da) (Figure 6).

Figure 4. *Diets provided.*

Figure 5. *Weighing animals.*

Figure 6. Fecal collection.

2.1.8. Biological Parameters

IP= Final weight-Initial weight
REP= IP (g)/g protein consumed
%Da= NI -NF/NI*100
NI = Ingested nitrogen
NF = Fecal nitrogen

2.2. Dissection of Experimental Animals

Once the experimental period of the biological evaluation was concluded, the organs (liver and thymus) and right femur were dissected and extracted. These were weighed and dried in a Binder oven at 105 ℃/24 hours (Figure 7). The grinding and homogenization were then carried out for mineral analysis.

Throughout the trial, the regulations on the protection of animals used for experimentation and other scientific purposes were complied with (Royal Decree, 2005). [16]

Figure 7. Dissection of experimental animals and extraction of organs (liver-thymus) and femur.

2.3. Mineral Analysis of food Mixtures for the Study of Porridge

The mineral analysis was carried out by acid digestion (65% nitric acid HNO_3 and 30% hydrogen peroxide H_2O_2), in a MULTIWAVE 3000 microwave oven, ANTON PAAR brand, for subsequent reading of the iron and zinc concentrations in the Flame Atomic Absorption Spectrometer (FASS) brand PERKIN ELMER, a standardized method in the mineral analysis laboratory in the Nutrition Area of (CAPN) (Figure 8).

Figure 8. Mineral analysis.

3. Results and Discussion

3.1. Results of the Selection of Raw Materials for Food Mixtures Porridges

Quinoa, cañahua and amaranth were selected as raw materials for the mixtures due to their good nutritional content, good quantity and quality of their amino acids (Figure 9).

Figure 9. Quinua, cañahua y amaranto.

3.2. Results of the Flour Production Process

The flours obtained through appropriate unit processes are of good nutritional quality.

3.3. Results of the Formulation of Food Mixtures for the Development of Porridges

The results of the theoretical formulation per 100 g. for the Standard Diet (Table 1) and food mixtures based on Andean grains (quinoa, amaranth and cañahua) plus flavoring (Table 2), were: 12% protein and 380-420 Kcal., similar to those obtained in research work carried out by (Vargas *et al*., 2018). [17].

Table 1. Formulation of 100 g Standard Diet (StanD).

Standard Diet	Lchp P (g)	Al (g)	Protein (g)	Energy (kcal)	Fe (mg)	Zn (mg)
StanD	45	55	11,7	419	0,1	1,5

StanD= Standar Diet, Lchp = milk powder, Al= starch

Table 2. *Formulation of 100 g of Andean grain mixes plus flavoring.*

Diet Quinoa	Q (g)	Az (g)	ac (g)	*Fla* (g)	Pr (g)	E Kcal	Fe (mg)	Zn (mg)
DQ+Fla	89	3	4	4	11,7	380,6	6,7	2,9
Diet Amaranth	A (g)	Az (g)	ac (g)	*Fla* (g)	Pr (g)	E kcal	Fe (mg)	Zn (mg)
DA+ Fla	87	6	3	4	11,7	383,6	6,4	2,3
Diet Cañahua	C (g)	Az (g)	ac (g)	*Fla* (g)	Pr (g)	E kcal	Fe (mg)	Zn (mg)
DC+ Fla	80	11	4	5	12,1	389,6	10,4	-

Q(g)=quinoa, A(g)=amaranth, C(g)= cañahua, Az(g)=sugar, ac (g)=oil, Fla (g)=flavoring, Pr(g)=protein, E(kcal)=energy

Table 3. *Formulation of 100 g of Andean grain mixtures supplemented with milk powder plus flavoring.*

Diet Quinoa	Q (g)	Lchp (g)	Az (g)	Al (g)	*Fla* (g)	Pr (g)	E (kcal)	Fe (mg)	Zn (mg)
DQ Lchp+Fla	40	25	11	20	5	11,6	382,3	2,8	2,4
Diet Amaranth	A (g)	Lchp (g)	Az (g)	Al (g)	*Fla* (g)	Pr (g)	E (kcal)	Fe (mg)	Zn (mg)
DA Lchp+Fla	40	25	10	21	4	11,7	382,7	2,8	2,1
Diet Cañahua	C (g)	Lchp (g)	Az (g)	Al (g)	*Fla* (g)	Pr (g)	E (kcal)	Fe (mg)	Zn (mg)
DC Lchp+Fla	36	24	6	30	4	11,6	388,0	4,9	1,00

Q(g)=quinoa, A(g)=amaranth, C(g)=cañahua, Az(g)=sugar, Lch p(g)=milk powder, Al=starch, Fla (g)=flavoring, Pr(g)=protein, E(kcal)=energy

3.4. Results of the Biological Evaluation of the Formulated Food Mixtures for Porridges

The results of the biological parameters Weight Gain (IP), Protein Efficiency Ratio (REP) and percentage of apparent digestibility (%Da) of the Standard Diet, food mixtures based on Andean grains plus flavoring and Andean grains supplemented with milk powder plus flavoring are shown in (Tables 4 and 7). The results of the physicochemical analysis of total nitrogen in feces are necessary to calculate.

The apparent digestibility (%Da) of the standard and the experimental mixtures.

3.4.1. Results of the Biological Evaluation of the Food Mixtures for Porridges Based on Andean Grains Plus Flavoring

The results of the biological parameters of the food mixtures based on Andean grains (quinoa, amaranth and cañahua) are shown in (Table 4).

Table 4. *Results of the biological parameters of the food mixtures for porridges based on Andean grains plus flavoring.*

	IP ±SD [g]	**REP ±SD**	**%Da ±SD**
StanD	142,8 ±24,6	2,7 ±0,3	89,2 ±1,2
DQ+ Fla	58,7 ±6,4	1,8 ±0,2	81,9 ±2,2
DA+Fla	26,8 ±10,1	1,0 ±0,4	75,5 ±4,2
D C+Fla	72,9 ±9,1	1,9 ±0,3	65,4 ±1,1

Table 4 reports that the IP of the StanD is > at DC+ Fla >DQ+ Fla >DA+ Fla

For the REP of the StanD it is > at DC+ Fla >DQ+ Fla >DA+ Fla

For the %Da of the StanD it is > at DQ+ Fla >DA+ Fla >DC+ Fla respectively.

(i) Results of the Weight Gain (IP) of the food mixtures for porridges based on Andean grains plus flavoring compared to the Standard Diet

The results of Weight Gain (IP) of the experimental animals of the Standard Diet and the food mixtures based on Andean grains plus flavoring are observed in (Table 4) respectively, they were used for the statistical analysis of the IP, carried out with the "Completely Randomized Design" (CRD) and the statistical tool Comprehensive Statistical Analysis Software (SAS), which reports the following results.

Results of the statistical analysis of the (IP) of the Diets based on Andean grains plus flavoring and the Standard Diet

The results of the IP of the diets based on Andean grains (quinoa, amaranth and cañahua) plus flavoring and the Standard Diet, show that they meet the condition of the level of significance of risk 0,0001 < 0,05, where the Null Hypothesis (Ho.) is in the rejection region, therefore, the Alternate Hypothesis (Ha.) is accepted, which indicates that there are significant differences between the diets with 95% confidence (Table 5).

Table 5. *Analysis of Variances (ANVA) table of IP of the Standard Diet and food mixtures based on Andean grains (quinoa, amaranth and cañahua) plus flavoring.*

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	29063.665	9687.888	166.20	<.0001
Error	20	1165.805	58.290		
Corrected	23	30229.470			
Total					

The comparison of IP means of the food mixtures based on Andean grains (quinoa, amaranth and cañahua) plus flavoring and the Standard Diet are shown in (Table 6).

Table 6. *Contrast of means of food mixtures for porridges based on Andean grains (quinoa, amaranth and cañahua) plus flavoring and the Standard Diet.*

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
StanD - DC+ Fla	1	7645.701	7645.701	131.17	<.0001
DC+ Fla - DQ+ Fla	1	599.253	599.253	10.28	0.0044
DQ+ Fla - DA+ Fla	1	3052.830	3052.830	52.37	<.0001

The comparison between the StanD - DC+Fla diets obtained a probability less than 0,05, therefore the null hypothesis (Ho.) is rejected and the alternate hypothesis (Ha.) is accepted, which indicates with 95% confidence that the Standard Diet (StanD) is better compared to the DC+ Fla (StanD > DC+ Fla > DQ+ Fla > DA+ Fla) (Table 6).

In (Figure 10), it is observed that the Weight Gain (IP) of the Standard Diet (StanD) is greater with 142,8 g., followed by the DC+ Fla, DQ+ Fla with 72,9 g., 58,7 g. respectively and finally the DA+ Fla with 26,8 g., for which the result obtained in the experimental design (SAS) is accepted.

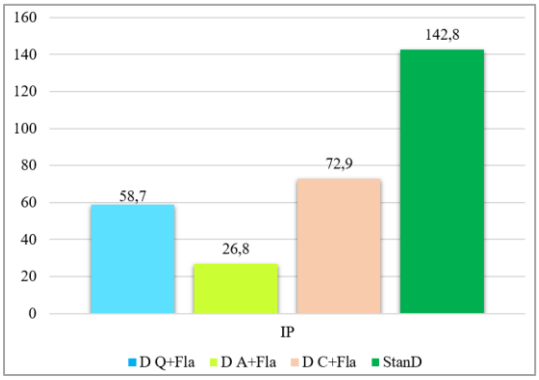

Figure 10. *Comparison of averages of (IP) diets based on Andean grains plus flavoring and the Standard Diet.*

(ii) Results of the Protein Efficiency Ratio (REP) of the food mixtures for porridges based on Andean grains plus flavoring and the Standard Diet

The results of the REP of the diets based on Andean grains plus flavoring present a lower REP compared to the Standard Diet (StanD) of 2,7, followed by DC+Fla with 1,9 and DQ+Fla 1,8 respectively, said values are greater than 1,5 (reference value) which attributes that there is a good use of the protein in the organism, on the other hand, DA+Fla reports 1,0, indicating that there was not a good use of the protein (Figure 11).

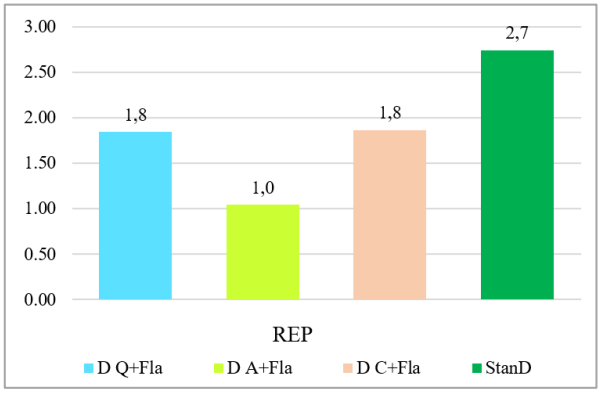

***Figure 11**. Protein Efficiency Ratio of food mixes for porridges based on Andean grains plus flavoring and standard diet.*

(iii) Results of the percentage of apparent

Digestibility (%Da) of the food mixtures for porridges based on Andean grains plus flavoring and standard diet

The results of the apparent digestibility percentage (%Da) report that the DQ+ Fla with 81,9%, DA+ Fla with 75,5% and finally the DC+ Fla with 65,4%, these being lower than the standard diet 89,2% (Figure 12).

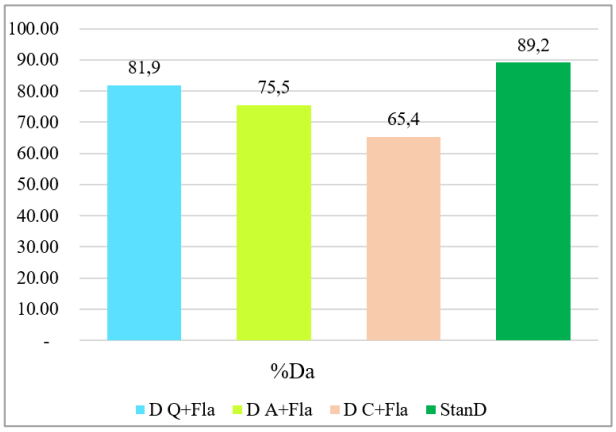

***Figure 12**. Apparent digestibility percentage (%Da) of the diets for porridges based on Andean grains plus flavoring and standard diet.*

3.4.2. Comparison of Biological Parameters of Flavored Andean Grains, Andean Grains Plus Flavored Powdered Milk, and Standard Diet

The results of the biological parameters of the food mixtures based on Andean grains (quinoa, amaranth and cañahua) supplemented with milk powder plus flavoring are shown in (Table 7).

***Table 7.** Results of the biological parameters of the food mixtures for porridges based on Andean grains supplemented with milk powder plus flavoring.*

DIET	IP ±SD [g]	REP ±SD	%Da ±SD
StanD	142,8 ±24,6	2,7 ±0,3	89,2 ±1,2
DQLchp+Fla	173,5 ±11,7	2,9 ±0,2	85,8 ±0,8
DALchp+Fla	173,3 ±26,5	3,5 ±0,2	80,1 ±3,0
DCLch +Fla	185,6 ±19,7	3,2 ±0,2	79,2 ±1,3

±SD= standard deviation

(i) Weight Gain (IP) results of feed mixtures for porridges based on Andean grains supplemented with milk powder plus flavoring and standard diet

The results of Weight Gain (IP) of the experimental animals of the Standard Diet and feed mixtures for porridges based on Andean grains supplemented with milk powder plus flavoring are presented in (Table 7).

The statistical analysis of the IP of feed mixtures for porridges based on Andean grains (quinoa, amaranth and cañahua) supplemented with milk powder plus flavoring (DQ Lchp+Fla DA Lchp+Fla and DC Lchp+Fla) and Standard Diet, carried out by "Completely Random Design" (CRD), using the SAS statistical tool, presents the following results.

Result of the statistical analysis of the (IP) of the diets for porridges based on Andean grains supplemented with milk powder plus flavoring and Standard Diet

The results of the statistical analysis of the IP of the experimental animals evaluated with the food mixtures for porridges based on Andean grains (quinoa, amaranth and cañahua), supplemented with milk powder and flavoring and Standard Diet, reject the null hypothesis (Ho) obtaining a probability less than 0,05 (0,0001 < 0,05), therefore the alternate hypothesis (Ha) is accepted, which indicates that there are significant differences between the diets with 95% confidence (Table 8).

Table 8. *Analysis of Variance ANVA table of the IP of food mixtures for porridges based on Andean grains supplemented with milk powder plus flavoring and Standard Diet.*

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Model	3	13764.215	4588.071	14.85	<.0001
Error	20	6178.295	308.915		
Corrected	23	19942.510			
Total					

In Table 9, the comparison of means between the food mixtures DC Lchp+Fla, DQ Lchp+Fla, DA Lchp+Fla and StanD can be observed.

Table 9. *Contrast of means of food mixtures for porridges based on Andean grains supplemented with milk powder plus flavoring and Standard Diet.*

Contrast	DF SS	Contrast Square	Mean Value	F	Pr > F
DC Lchp+ Fla - DQ Lchp+ Fla	1	440.441	440.441	1.43	0.2464
DQ Lchp+ Fla - DA Lchp+ Fla	1	0.101	0.101	0.00	0.9858
DA Lchp+ Fla - StanD	1	453.870	453.870	1.47	0.2396

The results of the contrast of means between DCLchp+Fla – DQ Lchp+Fla report a probability less than 0,05, therefore the null hypothesis (Ho.) is rejected and the alternate hypothesis (Ha.) is accepted, with 95% confidence, where DC Lchp+Fla is better compared to DQ Lchp+Fla followed by DA Lchp+Fla and finally the Standard Diet (StanD), highlighting DC Lchp+Fla > DQ Lchp+Fla > DA Lchp+Fla > StanD (Table 9).

Therefore, in (Figure 13), it is observed that the food mixtures had a higher IP than the Standard Diet, likewise the diet with the greatest Weight Increase was DCLchp+ Fla accepting the results of the SAS.

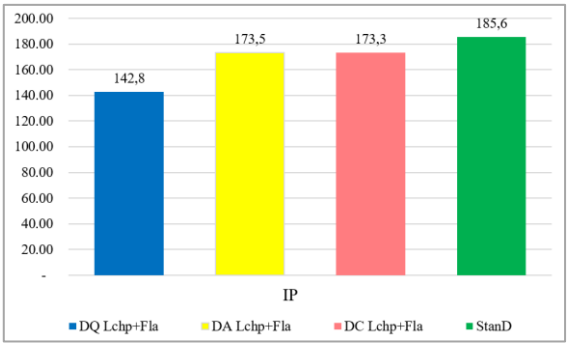

Figure 13. *Comparison of averages of (IP) of the food mixtures for porridges based on Andean grains supplemented with milk powder plus flavoring and Standard Diet.*

(ii) Results of the Protein Efficiency Ratio (REP) of the food mixtures for porridges based on Andean grains supplemented with milk powder plus flavoring and Standard Diet

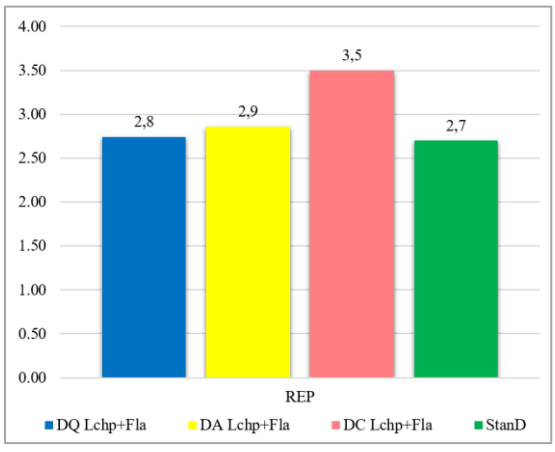

Figure 14. *Protein Efficiency Ratio (REP) of feed mixes for porridges based on Andean grains supplemented with milk powder plus flavoring and Standard Diet.*

The results of the REP of the food mixtures based on Andean grains supplemented with milk powder plus flavoring,

report that the diets present a REP greater than 2,0 (reference value) therefore it is considered a good use of protein in the body, likewise these values are higher compared to the Standard Diet (Figure 14).

(iii) Results of the apparent digestibility percentage (%Da) of the food mixtures for porridges based on Andean grains supplemented with milk powder plus flavoring and Standard diet

The percentage results (%Da) are reported for the DQ Lchp+Fla with 85,8%, the DA Lchp+Fla with 80,1% and DC Lchp+Fla with 79,2% respectively, which are lower than the Standard Diet with 89,2% (Figure 15).

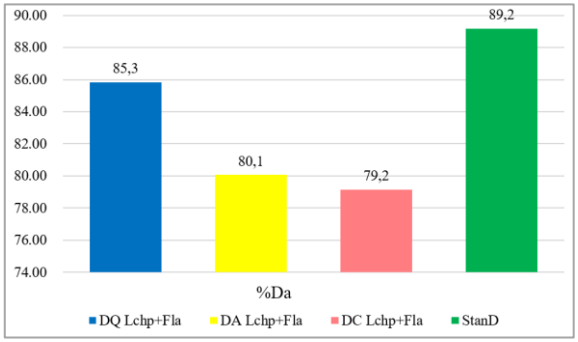

Figure 15. *Apparent digestibility percentage (%Da) of the diets for porridges based on Andean grains supplemented with milk powder plus flavoring and Standard Diet.*

3.4.3. Result of Biological Parameters of Andean Grain Mixtures and Flavoring, Supplemented with Milk and Flavoring and Standard Diet

(Figure 16) reports the comparison of the results of the biological parameters, where the IP in the food mixtures based on Andean grains supplemented with milk powder plus flavoring fluctuates between 173,5 – 185,6 g. higher compared to the diets based on Andean grains plus flavoring that present between 26,8 – 72,9 g. and the Standard Diet (StanD) with 142,8 g.

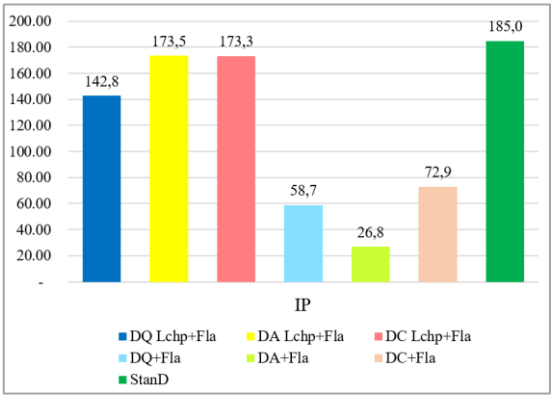

Figure 16. *Comparison of Weight Gain (IP) of feed mixes for porridge and Standard Diet.*

In (Figure 17), the results of the Protein Efficiency Ratio (REP) are observed, which shows that diets based on Andean grains supplemented with milk powder plus flavoring report values between 3,0 – 3,5, being higher compared to diets based on Andean grains plus flavoring, which present values between 1,0 – 1,9 and the Standard Diet (StanD) reports a REP of 2,7.

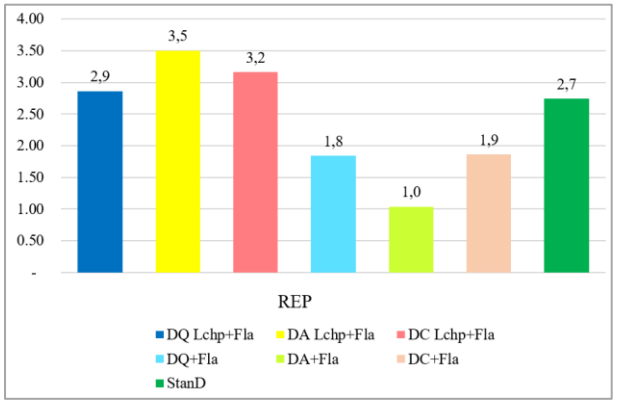

Figure 17. *Comparison of the Protein Efficiency Ratio (REP) of feed mixes for porridge and Standard Diet.*

(Figure 18) shows the comparison of the results of the percentage of apparent digestibility (%Da), where the diets based on Andean grains supplemented with milk powder plus flavoring report values between 79, 2% - 85,8% slightly higher than the diets based on Andean grains plus flavoring, which present values between 65,4% - 81,9% and the Standard Diet (StanD) being 89,2% higher than the food mixes for porridge.

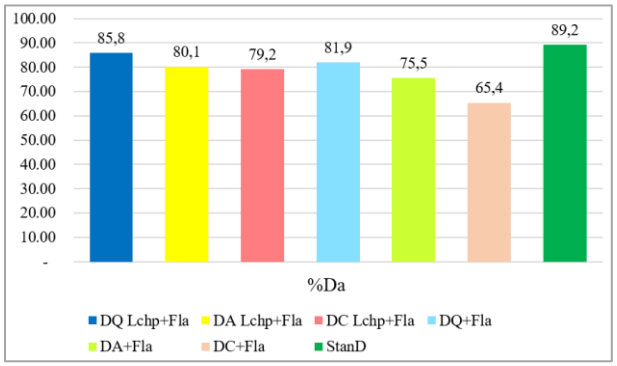

Figure 18. *Comparison of apparent digestibility percentage (%Da) of feed mixtures for porridges and Standard Diet.*

3.4.4. Results of Mineral Analysis (Iron and Zinc) of Food Mixtures

(i) Results of mineral analysis (iron and zinc) of food mixtures based on Andean grains (quinoa, amaranth and cañahua) plus flavoring

The iron (Fe) and zinc (Zn) results of the food mixtures

based on Andean grains (quinoa, amaranth and cañahua) plus flavoring are observed in (Figures 19 and 20).

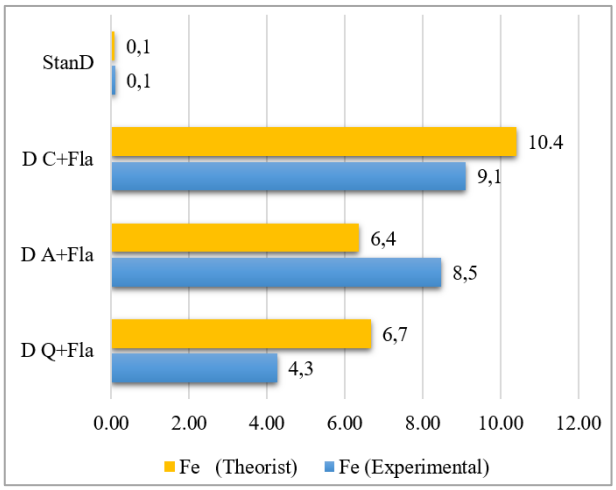

Figure 19*. Iron content [mg] of food mixtures based on Andean grains plus flavoring in 100 g. and Standard Diet.*

The results of the theoretical values of the iron (Fe) content of DC+Fla and DQ+Fla are higher and DA+Fla is lower compared to their experimental values. The results of the experimental analyses of the iron (Fe) content of DC+Fla with 9,1 mg., followed by DA+Fla with 8,5 mg. and finally DQ+Fla with 4,3 mg., observing that the three diets exceed the Standard Diet by 0,1 mg. (Figure 10).

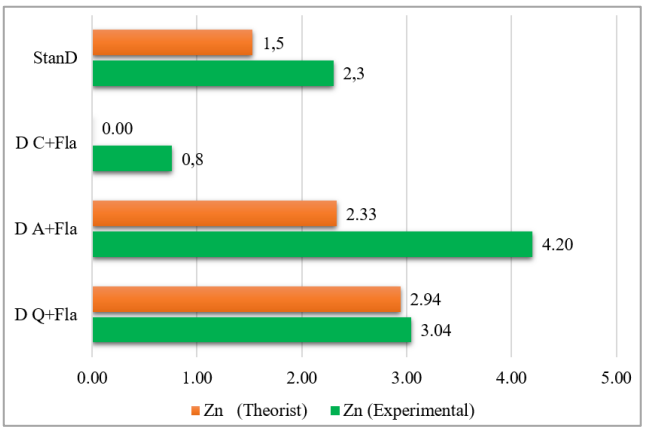

Figure 20*. Zinc content of food mixtures based on Andean grains plus flavoring in 100 g. and Standard Diet.*

The theoretical values of zinc (Zn) indicate that DQ+Fla and DA+Fla are higher than the Standard Diet (StanD), whereas DC+Fla does not contain zinc, these results are lower compared to their experimental values (Figure 11). Regarding the experimental values of zinc (Zn) content, it is observed that DA+Fla followed by DQ+Fla are similar to the Standard Diet (StanD) and finally DC+Fla with a much lower value.

(ii) Results of mineral analysis (iron and zinc) of food mixtures based on Andean grains (quinoa, amaranth and cañahua) supplemented with milk powder plus flavoring

The iron and zinc mineral results of the food mixtures based on Andean grains (quinoa, amaranth and cañahua) supplemented with milk powder plus flavoring are reported in (Figures 21 and 22).

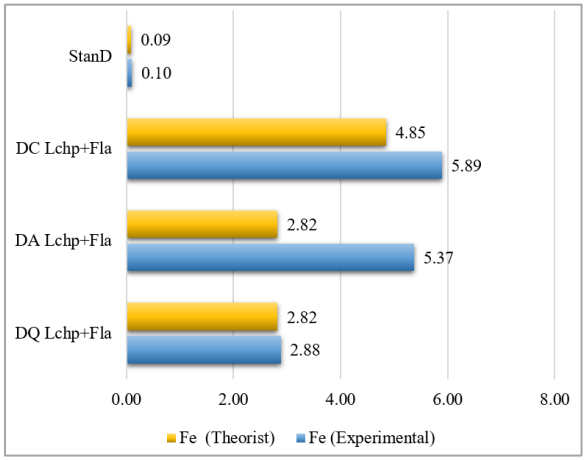

Figure 21*. Iron (Fe) content of food mixtures based on Andean grains supplemented with milk powder plus flavoring in 100 g.*

The theoretical values of iron (Fe) content report that DC Lchp+Fla, DA Lchp+Fla and DQ Lchp+Fla are lower compared to the experimental values but higher than the Standard Diet (StanD). In (Figure 12), the results of the iron (Fe) content of the experimental feed mixtures are observed where DC Lchp+Fla, DA Lchp+Fla and DQ Lchp+Fla are higher than the Standard Diet (StanD).

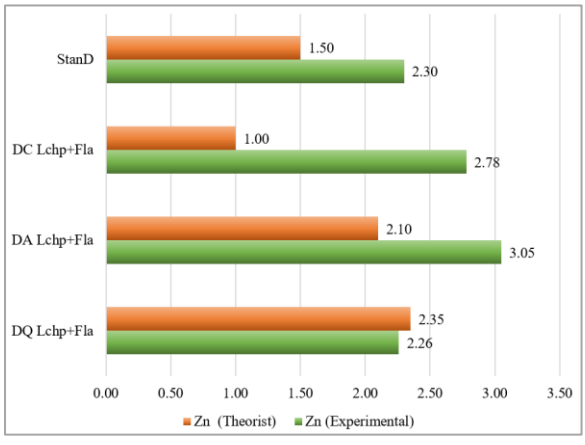

Figure 22*. Zinc (Zn) content of food mixtures based on Andean grains supplemented with milk powder plus flavoring in 100 g.*

The results of the theoretical values of zinc (Zn) report that the DQ Lchp+Fla and DA Lchp+Fla are higher and the DC Lchp+Fla lower with respect to the Standard Diet (StanD),

likewise they are lower than the experimental ones. The results of the zinc (Zn) content of the experimental feed mixtures where the DA Lchp+Fla, DC Lchp+Fla and DQ Lchp+Fla the three formulations are similar to the Standard Diet (StanD) (Figure 13).

3.4.5. Results of Mineral Analyses (Iron and Zinc) of Organ Samples (Liver - Thymus) and Femur of Experimental Animals

(i) Results of mineral analyses (iron and zinc) of organs (liver - thymus) and right femur of experimental animals from food mixtures based on Andean grains plus flavoring

The results of the mineral analyses of iron (Fe) and zinc (Zn) in (liver - thymus) and right femur of the Standard Diet (StanD) and the food mixtures based on Andean grains (quinoa, amaranth and cañahua) plus flavoring are shown in (Table 10) respectively.

Table 10. *Results of iron (Fe) and zinc (Zn) in: a) liver, b) thymus and c) right femur of the experimental animals of the food mixtures based on Andean grains plus flavoring in 100 g of dry sample.*

Diet	a) Liver	
	Fe [mg]	Zn [mg]
StanD	128,74 ±5,37	7,12 ±0,29
DQ+ Fla	102,87 ±35,37	3,21 ±0,83
DA+ Fla	144,63 ±6,95	2,18 ±0,63
DC+ Fla	96,20 ±1,40	2,55 ±0,03

Diet	b) Thymus	
	Fe [mg]	Zn [mg]
StanD	16,39 ±0,0	6,44 ±0,0
DQ+ Fla	23,18 ±0,0	7,88 ±0,0
DA+ Fla	32,74 ±0,0	6,39 ±0,0
DC+ Fla	16,43 ±0,0	3,93 ±0,0

Diet	c) Right Femur	
	Fe [mg]	Zn [mg]
StanD	4,84 ±0,45	24,65 ±1,01
DQ+ Fla	10,56 ±2,61	18,13 ±4,69
DA+ Fla	18,79 ±5,44	19,42 ±7,53
DC+ Fla	12,30 ±4,65	20,80 ±1,79

(ii) Results of mineral analyses (iron and zinc) of organs (liver-thymus) and right femur of experimental animals on the Andean grain diets supplemented with milk powder plus flavoring

The results of iron and zinc minerals in (liver-thymus) and right femur of experimental animals evaluated with the Standard Diet (StanD) and food mixtures based on Andean grains (quinoa, amaranth and cañahua) supplemented with milk powder plus flavoring are shown in (Table 11) respectively.

Table 11. *Results of iron (Fe) and zinc (Zn) in a) liver, b) thymus and c) right femur of the experimental animals of the food mixtures based on Andean grains supplemented with milk powder plus flavoring in 100.*

Diet	Liver	
	Fe [mg]	Zn [mg]
StanD	128,74 ±5,37	7,12 ±0,29
DQLchp+ Fla	243,01 ±42,47	6,78 ±1,55
DALchp+ Fla	232,15 ±97,46	7,39 ±0,43
DCLchp+ Fla	279,89 ±13,76	7,60 ±1,63

Diet	Thymus	
	Fe [mg]	Zn [mg]
StanD	16,39 ±0,0	6,44 ±0,0
DQLchp+ Fla	11,85 ±3,56	5,93 ±0,03
DALchp+ Fla	13,62 ±5,08	6,81 ±0,01
DCLchp+ Fla	11,85 ±0,79	5,922 ±0,03

Diet	Right Femur	
	Fe [mg]	Zn [mg]
StanD	4,84 ±0,45	24,65 ±1,01
DQLchp+ Fla	9,26 ±2,47	20,21 ±2,14
DALchp+ Fla	11,06 ±0,60	23,17 ±7,46

Diet	Right Femur	
	Fe [mg]	Zn [mg]
DCLchp+ Fla	9,19 ±1,47	20,59 ±5,29

(iii) Comparison of iron and zinc mineral results in (liver-thymus) and right femur of experimental animals with food mixtures based on Andean grains plus flavoring and supplemented with milk powder and flavoring

(Figure 23) reports that the DC Lchp+Fla, DQ Lchp+Fla and DA Lchp+Fla have a higher iron (Fe) content in liver with values between 232,15 mg. to 279,89 mg., compared to the Standard Diet (StanD) and the DA+Fla, DQ+Fla and DC+Fla have values between 96,20 to 144,63 mg of Fe, being the DQ+Fla and DC+Fla lower than the Standard Diet (StanD), and the DA+Fla slightly greater than the Standard Diet (StanD).

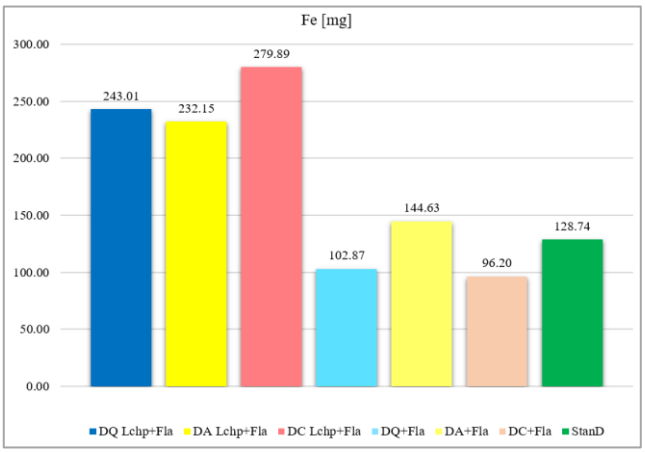

Figure 23. *Comparison of iron (Fe) in liver in Andean grains diets (quinoa, amaranth and cañahua) supplemented with milk powder plus flavoring and Andean grains plus flavoring.*

In (Figure 24), it is observed that DC Lchp+Fla, DA Lchp+Fla and DC Lchp+Fla present values between 6,78 to 7, 60 mg. of Zn in the liver, being similar in comparison to the StanD which contained 7,12 mg. and finally the DQ+Fla, DC+Fla and DA+Fla, which report values of 2,18 to 3,21 mg., lower than the StanD.

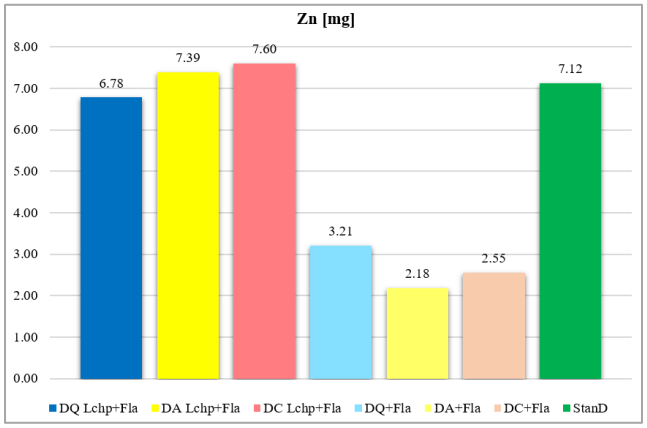

Figure 24. *Comparison of zinc (Zn) in liver in food mixtures based on Andean grains (quinoa, amaranth and cañahua) supplemented with milk powder plus flavoring and Andean grains plus flavoring.*

(Figure 25) shows that DA+Fla, DC+Fla and DQ+Fla present greater Fe storage in the thymus, with values between 16,43 and 32,74 mg, which are higher than the StanD, which reports 16,39 mg. However, DA Lchp+Fla, DQ Lchp+Fla and DC Lchp+Fla present values between 11,85 and 13,62 mg. Fe, which are lower than the StanD.

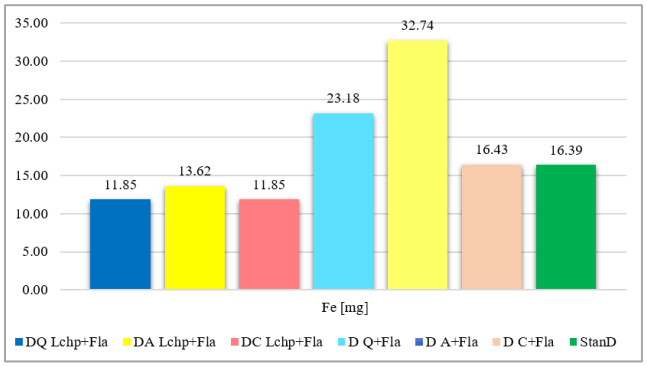

Figure 25. *Comparison of iron (Fe) in thymus in food mixtures based on Andean grains (quinoa, amaranth and cañahua) supplemented with milk powder plus flavoring and Andean grains plus flavoring.*

The results report that DQ+Fla, DA+Fla and DC+Fla present values between 3,93 to 7,88 mg. of zinc in the thymus, with DQ+Fla being slightly higher than StanD, which presents 6,44 mg. and DALchp+Fla, DQLchp+Fla and DCLchp+Fla, present values between 5,92 to 6,81 mg. of Zn, and DALchp+Fla being higher than StanD (Figure 26).

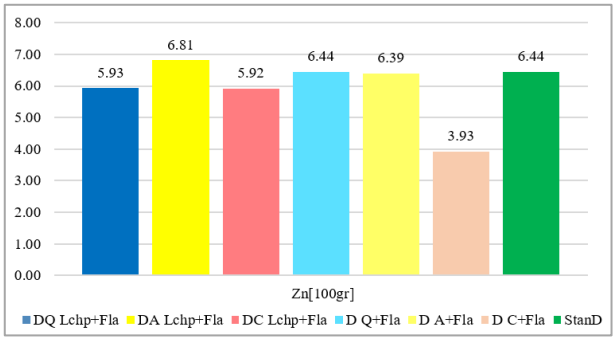

Figure 26. *Comparison of zinc (Zn) in thymus in food mixtures based on Andean grains (quinoa, amaranth and cañahua) supplemented with milk powder plus flavoring and Andean grains plus flavoring.*

The results of the iron (Fe) content in the right femur of DA+Fla, DC+Fla and DQ+Fla report values between 10,56 and 18,79 mg of iron (Fe), followed by DALchp+Fla, DQLchp+Fla and DCLchp+Fla, which present values between 9,29 and 11,06 mg. These mixtures exceed the StanD which reports 4,84 mg of Fe (Figure 27).

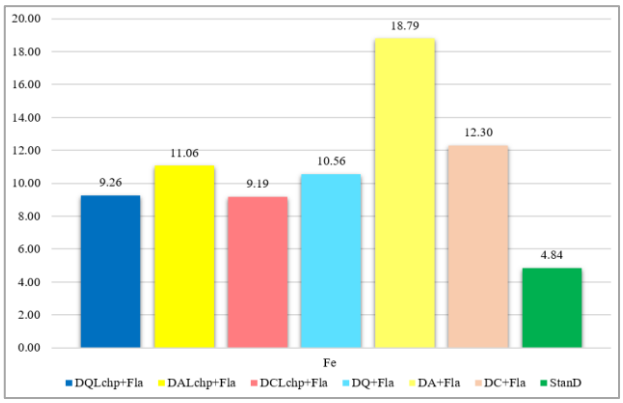

Figure 27. *Comparison of iron (Fe) in the right femur of food mixtures based on Andean grains (quinoa, amaranth and cañahua) supplemented with milk powder plus flavoring and Andean grains plus flavoring.*

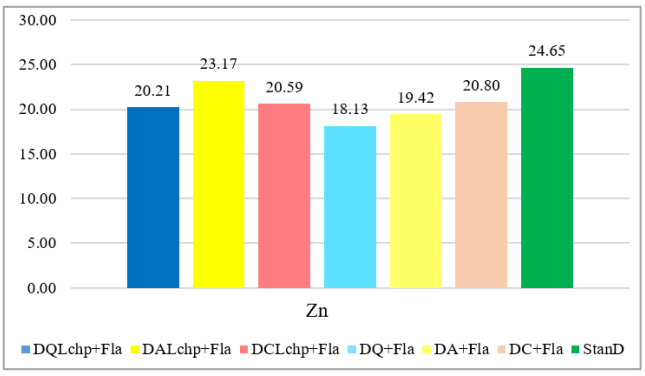

Figure 28. *Comparison of zinc (Zn) in right femur or in food mixtures based on Andean grains (quinoa, amaranth and cañahua) supplemented with milk powder plus flavoring and Andean grains plus flavoring.*

In (Figure 28), it is observed that the StanD contains 24,65 mg of (Zn), being greater than the DC+Fla, DA+Fla and DQ+Fla which report values between 18,13 to 20,80 mg. of Zn and the DALchp+Fla, DCLchp+Fla and DQLchp+Fla present values between 20,21 to 23,17 mg. of Zn.

4. Discussion

The theoretical formulations of the food mixtures for porridge and the standard diet, with 12% protein and 380 – 420 Kcal per 100 g, made based on the nutritional requirements of the experimental animals raised in the methodology, coincide with the formulations used in research work research by (Vargas *et al.*, 2018). [17]

Numerous investigations address different technological processes to improve the nutritional value of foods, as mentioned by Carmody and Grangham, (2009). [18] In the present research work, it was considered to use technological processes, in particular thermal treatments of Andean grains (quinoa, amaranth and Cañahua), considering reducing anti-nutritional compounds and improving the availability of nutrients by obtaining flours from Andean grains, with the which food diets were formulated, this process agrees with Vargas, (2020), in his work evaluating thermal processes applied to Andean grains to improve the availability of nutrients protein, iron and Zinc. [19]

Royo *et al.*, (2007) mentions that the addition of an animal protein improves digestibility, as demonstrated by the results of this research; Diets based on Andean grains and flavoring and milk powder have better digestibility than diets based on Andean grains plus flavoring, which are only proteins of plant origin. [4]

In reference to the iron and zinc present in the liver, thymus and femur, the DA+Flay Milk powder diet is the highest amount

The DA+Fla y Powdered Milk diet is the one with the highest amount of iron and zinc in the liver, thymus and femur. However, a greater amount of zinc is justified in the standard diet because the formulation is based on fortified powdered milk.

5. Conclusions

According to the objectives set and the results obtained in this research work, the following conclusions are established:

It is concluded that the formulations of the food mixtures for porridges based on Andean grains plus flavoring and supplemented with milk powder, met the nutritional requirements of protein-energy of the experimental animals.

Based on the results of the biological parameters, it is concluded that the food mixtures based on Andean grains supplemented with milk powder and flavoring surpass the Standard Diet and the food mixtures based only on Andean grains and flavoring.

It is concluded that the food mixtures based on Andean grains supplemented with milk powder and flavoring are the most optimal for the Garation of the proposed products, porridges.

Regarding the analysis of iron and zinc minerals, it is concluded that iron is better in the food mixtures based on Andean grains and flavoring, while the mixtures completed with milk powder and flavoring provide a greater amount of zinc.

Based on the results of minerals in organs (liver - thymus) and right femur, it is concluded that the storage of iron and zinc is greater with food mixtures based on Andean grains supplemented with more flavored milk powder.

Abbreviations

UMSS	University Mayor de San Simón
FCyT	Faculty of Sciences and Technology
CAPN	Center for Food and Natural Products
IP	Increase in Weight
REP	Real Protein Efficiency
Da	Apparent Digestibility
NI	Ingested Nitrogen
NF	Fecal Nitrogen
DQ+ Fla	Cooked Quinoa Diet Plus Flavoring
DA+Fla	Cooked Amaranth Diet Plus Flavoring
DC+Fla	Cooked Cañahua Diet Plus Flavoring
DQ+Lchp+Fla	Cooked Quinoa Diet Plus Powder Milk and Flavoring
DA+Lchp+ Fla	Cooked Amaranth Diet Plus Milk Powder and Flavoring
DC+Lchp+Fla	Cooked Cañahua Diet Plus Milk Powder and Flavoring
StanD	Standard Diet
CRD	Completely Randomized Design
NI	Ingested Nitrogen
NF	Fecal Nitrogen
FASS	Flame Atomic Absorption Spectrometer
Lchp	Milk Powder
Al	Starch
Q	Quinoa
A	Amaranth
C	Cañahua
Az	Sugar
ac	Oil
Fla	Flavoring
Pr	Protein
E	Energy
SAS	Statistical Analysis Software
Ho	Null Hypothesis
Ha	Alternate Hypothesis
±SD	Standard Deviation
ANVA	Analysis of Variance

Author Contributions

Luz Mirian Vargas Coca is the sole author. The author read and approved the final manuscript.

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Data Availability Statement

The data supporting the outcome of this research work has been reported in this manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

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Biography

Luz Mirian Vargas Coca, Research Professor-Universidad Mayor de San Simón (UMSS)-Head of the Immunonutrition Area at the Faculty of Science and Technology (FCyT), Center for Food and Natural Products (CAPN), 42 years of experience to date. Diploma in Higher Education, UMSS Graduate School. 2006 Specialization in Immunonutrition-University of Buenos Aires-(UBA) Argentina 1989. Specialization in Scientific Research-Food Security and Human Development (UMSS)-Association of Promotion and Education Institutions (AIPE) Center for the Development of Social Management (CEDEGES)- Directorate of Scientific and Technological Research (DICYT) 2000. Master's Degree in Scientific and Technological Research UMSS-(CEDEGES). Management and Technology (DICYT) 2000. Master's Degree in Food Safety and Human Development (UMSS) - (AIPE) 2001. Tutor and advisor of undergraduate and graduate projects. Recognition for the Patent of Invention "Immunorestore Mixtures" National Intellectual Property Service (SENAPI) 2023. Appointment as a reviewer of International Journal of Nutrition and Food Sciences (IJNFS) 2023-2027.

Research Field

Luz Mirian Vargas Coca: Immunonutrition, Food Safety, Scientific and Technological Research, Biological studies of foods and natural products, Development of mixtures and food products, Study and development of foods based on Andean grains, Research of the influence of Andean grains on cardiovascular diseases.