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Quality assessment *in vivo* (wistar rats) of cereal flours enriched by sesame (*Sesamum indicum*) and moringa (*Moringa oleifera*) as weaning food

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ABSTRACT: This study contributes to the exploration of the nutritional potential of under-exploited local resources (sesame and moringa) in weaning food. So, eight diets (MiS, MiSMo5, MiSG, MiSGMo5, MaS, MaSMo5, MaSG and MiSGMo5) were formulated from cereal flours (millet or maize), sesame seed (ungerminated or germinated) and moringa leaf. Commercial weaning foods (AT1 and AT2) were used as control. The biochemical composition and nutritional quality in growing Wistar rats of the various flours was determined. The results showed that the moisture, protein, ash, fat, fiber, carbohydrate and energy content of the formulations are within the recommended standard for weaning foods. Also, the formulated diets have induced weight gain of rats. The BMI of rats fed formulated diets (0.49 - 0.51 g/cm^2) is similar to that of AT2 (0.46 g/cm^2) control rats. The formulated diets had FER, PER, TD and BV values ranging from (0.18 - 0.23), (1.38 - 1.64), (85.18 - 93.55 %) and (86.64 - 94.91 %) respectively. Any abnormalities were not identified as far as concern rat's organs (liver and kidney). The total cholesterol and HDL blood cholesterol levels in rats fed the formulated diets are higher than those in rats fed the AT2 control diets. In addition, the LDL cholesterol levels are lower in rats fed the formulations compared to those in the AT1 and AT2 control diets. These results appear adapted within the framework of the fight against infantile malnutrition in the context of the local resources available.

KEYWORDS: Infant food; Sesamum indicum, Moringa oleifera, Nutritional quality, Plasma Biochemical Parameters, flours.

1 INTRODUCTION

From the age of 6 to 24 months, breast milk becomes insufficient to meet the nutritional needs of the infant. During this period, it is therefore necessary to give the child a liquid or semi-liquid food to supplement breast milk. These complementary foods should provide the child with key nutrients such as protein, fat and carbohydrates in a balanced proportion [1].

In developing countries, commercial weaning foods are available, but their cost remains high for people of low socio-economic status, particularly in rural areas [2]. As a result, nannies prefer cereal-based complementary foods [3], [4]. However, several studies have reported that porridges that traditional cereal-based porridges have insufficient energy, protein, lipid and essential mineral densities to meet the energy needs of infants in weaning [5]. In addition, the protein contained in cereals has a low nutritional value because it is deficient in lysine and tryptophan, which are essential amino acids for the proper development of the child [6]. Despite their low content of essential nutrients for children, cereal-based food supplements remain the most affordable for low-income households [7]. It is therefore necessary to improve the nutritional density of these food supplements, while using accessible and cost-effective technology.

In households, several simple and less expensive techniques are used to produce weaning foods adapted to children's needs [8]. Germination, fermentation and roasting of cereals are affordable and widely practiced processing techniques in Africa [9]. Fermentation is a process that improves the nutritional value of food by biosynthesis and bioavailability of vitamins and essential amino acids, reducing anti-anthinutritional factors. Germination increases nutrient bioavailability, energy density and food acceptability [10]. Roasting, on the other hand, reduces anti-nutritional factors, improves the taste and nutritional quality of the food product and reduces its moisture content, thus increasing its shelf life [9]. An integrated approach that combines a

variety of traditional food processing techniques in the preparation of weaning foods is more effective in eliminating anti-nutrients in cereals, thereby improving nutrient availability [8]. In addition, the exploration of local food resources is one of the sustainable food approaches to address the nutrition-related public health problems of vulnerable groups [11].

In Côte d'Ivoire, sesame (*Sesamum indicum*) and moringa (*Moringa oleifera*) are available, but adults consume them in traditional form. However, their nutritional potential could be an asset in the fight against malnutrition. Indeed, some studies have shown that sesame seeds have proven to be good sources of edible oil, protein and minerals such as potassium, phosphorus, magnesium and calcium [12]. In addition, sesame oil contains high levels of unsaturated fatty acids, particularly oleic and linoleic acids, which are suitable for the body and cholesterol-free [13]. Moringa leaves are used to prevent or treat protein-energy malnutrition and other nutritional diseases [14]. They contain little fat and carbohydrates, but are an excellent source of vitamins, various antioxidant compounds, proteins and amino acids with all essential amino acids [14], especially sulphur-containing amino acids (methionine and cystine) which are often in insufficient supply in cereals and other plant foods [15].

This study contributes to the exploration of the nutritional potential of under-exploited local resources in infant weaning feeding. More specifically, the study aims to develop nutritious weaning flours from local cereals (millet and maize) and under-exploited local resources (sesame and moringa) using traditional, simple and accessible processing techniques for disadvantaged households.

2 MATERIALS AND METHODS

2.1 MATERIALS

2.1.1 MATERIAL FOR THE FORMULATIONS

Millet (*Pennisetum glaucum*) and maize (*Zea mays*) seeds were purchased at the Abobo market (Abidjan, Côte d'Ivoire). The leaves of moringa (*Moringa oleifera*) have been obtained a producer in the locality of Abobo-Baoulé (Abidjan, Côte d'Ivoire), while sesame (*Sesamum indicum*) came from the Meagui family locality (south-western region of Côte d'Ivoire). Two commercial weaning food brand (AT1 and AT2) used as control was purchased from a local superstore.

2.1.2 ANIMAL MATERIAL

The wistar albino rats (Rattus norvegicus) were obtained from the animals' barn of the Ecole Normale Supérieur (ENS) (Abidjan, Côte d'Ivoire). The average temperature of the room was (27 ± 2 °C) and the percentage of humidity was in range from 70 to 80 %, with 12 hours of daylight and 12 hours of darkness.

2.2 SAMPLE PROCESSING

2.2.1 PROCESSING OF MILLET AND MAIZE SEED FLOUR FERMENTED

The millet and maize seeds were sorted to eliminate plant debris, defects and infested. Then sorted seeds were washed and one (1) Kg of seeds were soaked for 24 hours in 3 L of water separately. The soaked seeds were put again in water to start the fermentation for 3 days. The fermented seeds were washed with distilled water, dried in an oven at 45 °C for 2 days. Then, the dried seeds were milled and sieved through 0.25 mm wire mesh before packing in a sealed airtight plastic container and storage at 4 °C prior to formulation and analysis.

2.2.2 PROCESSING OF MILLET AND MAIZE SEED GERMINATED FLOUR

The millet and maize seeds were sorted, washed and soaked for 24 hours. The soaked seeds were kept on a cotton cloth and allowed to germinate in the dark at room temperature for 3 days for millet seeds and 5 days for maize seeds. Then the germinated seeds were dried in an oven at 45 °C for 2 days and degerminated by hand. The dried seeds were milled, sieved, packed and stored at 4 °C as before.

2.2.3 PROCESSING OF SESAME UNGERMINATED SEED FLOUR

The mature and dry sesame seeds were sorted to remove infested seeds and washed in clean tap water before draining at room temperature. Samples of seeds (200 g) were boiled in water (in stainless steel container) for 5 min, oven dried at 45 °C for 2 days. Then, the dried seeds were roasted (oven-cooking) for 10 min at a soft fire and cooled at room temperature. The

roasted seeds were ground into flour using a blender equipped with a 0.50 mm mesh sieve. The ground material obtained was stored at 4°C in a clean dry airtight sample bottle until required formulation and analysis.

2.2.4 PROCESSING OF SESAME GERMINATED SEED FLOUR

The mature and dry sesame seeds were sorted to remove infested seeds and washed in clean tap water before draining at room temperature. The drained seeds were soaked for 24 hours. The soaked seeds were kept on a cotton cloth and allowed to germinate in the dark at room temperature for 24 hours. Samples of germinated seeds (200 g) were boiled in water (in stainless steel container) for 5 min then drained and oven dried at 45 °C for 2 days. Then, the dried have been degerminated seeds by hand. The degerminated seeds were roasted (oven-cooking) for 10 min at a soft fire and cooled at room temperature. The roasted seeds were ground into flour using a blender equipped with a 0.50 mm mesh sieve. The ground material obtained was stored at 4°C in a clean dry airtight sample bottle until required formulation and analysis.

2.2.5 PROCESSING OF MORINGA LEAF POWDER

Moringa oleifera leaves were sorted and washed in clean tap water containing 1% NaClO. Then, they were dried at room temperature for 4 days, grounded into powder using a blender and sieved with a fine sieve of 0.25 mm. The resulting powder was packaged in black polyethene bags and stored in airtight plastic containers away in the dark until formulation and analysis.

2.3 WEANING FOOD BLEND FORMULATION

The weaning food blends containing millet or maize fermented, millet or maize fermented germinated, sesame ungerminated or germinated and moringa were formulated using different proportions of individual ingredients. The different composite flours, the reference commercial flours and their code as shown in Table 1.

Table 1. Composition of designed formulations based on millet and maize

	Formulations based on millet			
Ingredient (%)	**MiS**	**MiSMo5**	**MiSG**	**MiSGMo5**
Fermented millet flour	60	60	60	60
Germinated millet flour	10	10	10	10
Ungerminated Sesame flour	30	25	-	-
Germinated Sesame flour	-	-	30	25
Moringa powder	-	5	-	5
	Formulations based on maize			
Ingredient (%)	**MaS**	**MaSMo5**	**MaSG**	**MaSGMo5**
Fermented maize flour	60	60	60	60
Germinated maize flour	10	10	10	10
Ungerminated Sesame flour	30	25	-	-
Germinate Sesame flour	-	-	30	25
Moringa powder	-	5	-	5
	Reference commerciale flours			
AT1	Control diet 1			
AT2	Control diet 2			

2.4 METHODS OF PROXIMATE ANALYSIS

Nutrient (moisture, ash, protein, fat, fiber and carbohydrate) content was determined according to standard methods of [16]. Carbohydrate content was determined by the difference that is by deducing the mean values of other parameters that were determined from 100. Energy value was estimated using the Atwater's conversion factors [17].

2.5 BIOLOGICAL ASSESSMENT OF THE WEANING FOOD

2.5.1 DIETS PREPARATION

The porridges of the composite flours were cooked by introducing 100 g of flour into 100 mL of tap water. The cooking lasted 6 min over low heat. After 5 min of cooking, 10 % table sugar was added, then the cooking lasted 1 min. The resulting paste was reduced to a dumpling before being served to the rats.

For the control flours (AT1 and AT2), 100 g were reduced to a dumpling in 100 ml of boiled tap water.

2.5.2 RAT GROUPS CONSTITUTION AND EXPERIMENTAL PROCEDURE

A total of 50 growing rats were used and fed diets. The young rats were divided into groups of 5 rats with homogeneous weights (60 ± 2 g). Thus eigth (8) groups were fed with the different formulations selected and 2 batches were fed with control flours (AT1 and AT2).

The nutritional assessment was conducted according to the procedure described by [18]. It lasted 28 days and was divided into three (3) phases: an acclimatization phase, then a growth phase and a balance-sheet phase. During the acclimatization phase (72 h), the rats received water and granules from the SFACI society (Société de Fabrication d'Aliments Composés Ivoiriens), so that they would have the same diet at the beginning of the experiment. After this period, the animals were weighed and randomly divided into 10 groups with an average mass approximately the same (with a margin of ± 2 g) for the growth phase. The rats were housed individually in separate cabins in a metabolic cage with a facility to collect urine and faeces separately. Every morning, between 7 a.m. and 8:30 a.m., rats in the same batch were fed the same diet with 30 g of feed per rat to minimize waste. The water was distributed at will in bottles and renewed every 3 days. The quantities of fresh food are weighed before being served. The next day, the refusals (leftovers) are collected and weighed before being distributed again. The dry matter of fresh feed and refusals is also measured according to method of AOAC [16]. Also, the rats were weighed every three (3) days and the increase in animal mass was recorded. During the last seven (7) days of the experiment, faeces and urine with a few drops of dilute hydrochloric acid (0.1N) were collected daily, weighed and stored at -10°C for nitrogen determination [16].

2.5.3 DETERMINATION OF NUTRITIONAL PARAMETERS

The Feed intake, Protein intake, Feed efficiency ratio (FER), Protein efficiency ratio (PER), Apparent digestibility (AD), True digestibility (TD), Net protein retention (NPU), Biological value (BV) were estimated by the method of [18]. The body length and body mass index (BMI) were determine according to methods of [19].

2.5.4 COLLECT OF BLOOD SAMPLES

At the end of the 28 days experiment, the rats were fasting for 16 hours before the blood sample was taken. This sampling was performed after ether anesthesia, according to the procedure described by [20]. Blood samples were collected in hemolysis tubes and immediately stored in a cooler containing ice (+2 °C) before being sent for biochemical parameter analysis.

2.5.5 DETERMINATION OF SERUM BIOCHEMICAL PARAMETERS

Once in the laboratory, the tubes were centrifuged at 3000 rpm for 5 min to obtain the serum, which will be stored at -20 °C. These serum were stored in eppendorf tubes, on which biochemical analyses were performed using an automated Coulter ACT diff 2 system.

These parameters, built-in the automatic analyser, were tested according to the methods below: blood glucose was tested by method of [21]; total proteins were evaluated according to [22] methods; creatinine was evaluated according to the colorimetric method of [23]; urea was evaluated according to [24]; total cholesterol (TC) was determinated by method of [21]; triglycerides (TG) were determinated using method described by [25]; HDL-cholesterol (HDL-C) was determined following the [26]method and LDL-cholesterol (LDL-C) was calculated as per the method described by [27].

2.5.6 ORGAN SAMPLING AND WEIGHING

The organs were collected after the various blood samples were taken, the animals were dissected and the various organs (hearts, livers and kidneys) were collected quickly [1].

2.6 STATISTICAL ANALYSIS

The statistical analysis of data was done by one-way Analysis of Variance (ANOVA) using the STATISTICA Software version 7.1. Differences between means values were carried out using Duncan's Multiple Range Test ($P<0.05$).

3 RESULTS AND DISCUSSION

3.1 BIOCHEMICAL COMPOSITION

The mean values of proximate chemical composition and energy values of flours studied are given in Table 2.

The moisture content of the samples is 3,34 ± 1,36 and 5,92 ± 0,09 % for composite flours and that of the AT1 and AT2 control flours is 7.60 ± 0,05 and 5.68 ± 0.27 % respectively. These water content are significantly different ($p \leq 0.05$). However, the moisture content for all the diets studied are lower than the 10% recommended for long storage of flour [28]. Aslo, the low moisture content of complementary foods increase the nutrient composition and inhibits microorganism activities [29].

The protein content in composite flour was in range from 13.08 ± 0.76 to 15.29 ± 0.01 % DW. The commerciale flours use control AT1 and AT2 content respectively 8.46 ± 0.58 and 15.67 ± 0.18 % DW of protein contents. The results indicate that formulate flours are significantly different ($p \leq 0.05$) and included between than commercial ET1 and AT2 flours. The variations in the crude protein content may be due to the ingredients used in their formulations [30]. The protein contents that all composite flours have higher than commercial AT1 flour. The presence in composite flour of moringa leaf powder and/or sesame germined seed flour are inscreases the protein content of formulated diets. This might be due to the protein content of the incorporated moringa leaf powder [31]. Aslo, the increase in protein content could be due alterations of other components (starch, lipids) which might have altered the proportion of the protein on dry weight basis during soaking and germination [32]. However, except for control diet AT1, the protein content of the studies diets within the recommended range (11-21%) [33]. Proteins play a role in the body defending and cover nitrogen expenditure caused by the renewal of tissues and the synthesis of some compounds involved in the proper body functioning (enzymes, hormones) [34].

The addition of moringa leaf powder and sesame seed flours improved the ash content of formulated diets. The value content of the weaning food samples ranged between AT1 (0.33 ± 0.01 % DW) to MaSMo5 (2.52 ± 0.04 % DW). The commercial reference flour AT2 has 2.28 ± 0.03 % DW. However, the value of all the formulated studies were within the recommended norms for weaning food (≤ 3 %) [35]. The values obtained in this study indicate that diets contain appreciable amount of important minerals for best development of children.

The fat content in the formulated (18.17 ± 0.04 – 21.56 ± 0.06 %DW) was higher ($P < 0.05$) as compared to references flours AT1 (1.77 ± 0.30 % DW) and AT2 (9.53 ± 0.09 % DW). This could be attribute to the inclusion of sesame seed in the different formulations. Indeed, the fat content of formulated diets decreases significantly ($P \leq 0.05$) with incorpored moringa leaf powder and subtitution of the sesame seed ungerminated flours (S) by the sesame seed germinated flours (SG). This decreasing could be attribute on the one hand to the weak contents in lipids of moringa leaf powder [31] and on the other hand of soaking and germination may be due to the action of lipolytic enzymes which utilized the fats present. However, the fat content obtained in this study fall within the recommended norms for infants (10 - 25 %) [35]. Fat is important in diets because it is a high-energy nutrient and promotes fat-soluble vitamins absorption [4]. In addition, the oil of sesame contains importante oleic acid, linoleic acid and antioxydant believed to promote cell integrity and healthy fonction of body tissues [13].

Concerning the fiber contents in studied flours, the lowest values statistically ($P \leq 0.05$) are obtained from the two commercial reference flours AT1 and AT2 with 1.52 ± 0.15 and 2.09 ± 0.03 % DW respectively. The formulated flours fiber contents varied statistically from 3.82 ± 0.04 (MaS) to 5.07 ± 0.09 (MiSGMo5) % DW. However, all formulated diets have values conform to that recommended (≤ 5%) [35]. The fibres contribute to the maintenance of the healthy intestinal flora [36]. In general, the health benefits of dietary fibre consumption include the prevention, reduction and treatment of nutritional diseases (constipation, colon cancer, diabetes, obesity and gallstones) [36].

The carbohydrates have an essentially energetic role, they are the energy source that can be rapidly used by the body and are involved in the anabolism of proteins [34]. The carbohydrate of the formulated flours ranged between 57.81 ± 0.14 and 60.97 ± 0.22 % DW. The control commercial flour AT1 (87.92 ± 1.26 % DW) and AT2 (70.44 ± 0.35 % DW) provides the highest value statistically ($P \leq 0.05$) compared to formulated flours. However, the carbohydrate of the formulated flours close to the recommended value (64 ± 4%) according [35].

The energy density of the samples depends on the values of fat, protein and carbohydrate of the diets. According the Table 2, the flours studied provide energy values that range 401.49 ± 0.90 to 483.50 ± 1.07 kcal/100 g DW. However, composite flours have statistically higher ($p > 0.05$) energy values (460.91 ± 0.03 - 483.50 ± 1.07), to those of the commercial reference flours

AT1 and AT2 (401.49 ± 0.90 and 430.23 ± 0.48 kcal/100 g DW respectively). All the diets studied have energy values close to those of the recommended (400-425 kcal/100 g) by [35]. This is desirable in infants and children, because low energy density foods tend to reduce total energy intake and the use of other nutrients [37].

Table 2. Proximate composition of formulated diets

		Parameter (% DW)					
Diets	**Moisture (%)**	**Protein**	**Ash**	**Fat**	**Fiber**	**Carbohydrate**	**Energy (Kcal/100g DW)**
MiS	3.77 ± 1.30 ^{e}	13.08 ± 0.76 ^{b}	1.79 ± 0.02 ^{b}	21.56 ± 0.06 ^{g}	4.30 ± 0.17 ^{e}	59.28 ± 0.64 ^{d}	483.50 ± 1.07^{j}
MiSMo5	3.54 ± 0.65 ^{a}	13.48 ± 0.07 ^{c}	2.04 ± 0.01 ^{d}	18.72 ± 0.05 ^{e}	4.80 ± 0.10 ^{h}	60.97 ± 0.22 ^{g}	466.23 ± 0.13^{f}
MiSG	3.35 ± 0.42 ^{a}	13.82 ± 0.07 ^{d}	1.93 ± 0.03 ^{c}	20.98 ± 0.16^{f}	4.43 ± 0.15 ^{f}	58.85 ± 0.35 ^{c}	479.47 ± 0.35^{h}
MiSGMo5	4.29 ± 0.91 ^{b}	14.99 ± 0.59 ^{g}	2.09 ± 0.05 ^{d}	18.39 ± 0.70^{d}	5.07 ± 0.09 ^{i}	59.48 ± 0.09 ^{e}	463.41 ± 3.60^{d}
MaS	3.34 ± 1.36 ^{a}	14.29 ±0.59 ^{c}	2.17 ±0.02 ^{e}	20.99 ± 0.13^{f}	3.82 ± 0.04 ^{c}	58.72 ± 0.69 ^{b}	480.95 ± 0.79^{i}
MaSMo5	4.57 ± 0.73 ^{c}	14.92 ± 0.36 ^{g}	2.42 ± 0.05 ^{g}	18.47 ± 0.05^{d}	4.50 ± 0.11 ^{g}	59.70 ± 0.47 ^{f}	464.70 ± 0.90^{e}
MaSG	4.22± 0.19 ^{b}	14.66 ± 0.01 ^{f}	2.27 ± 0.03 ^{f}	20.90 ± 0.20^{f}	4.37 ± 0.10 ^{f}	57.81 ± 0.14 ^{a}	478.01 ± 1.29^{g}
MaSGMo5	5.92 ± 0.09 ^{d}	15.29 ± 0.01 ^{h}	2.52 ± 0.04 ^{h}	18.17 ± 0.04 ^{c}	4.96 ± 0.10 ^{i}	59.06 ± 0.08 ^{d}	460.91 ± 0.03^{c}
AT1	7.60 ± 0.05 ^{e}	8.46 ± 0.58 ^{a}	0.33 ± 0.01 ^{a}	1.77 ± 0.30^{a}	1.52 ± 0.15^{a}	87.92 ± 1.26^{i}	401.49 ± 0.90^{a}
AT2	5.68 ± 0.27 ^{d}	15.67 ± 0.18 ^{i}	2.28 ± 0.03 ^{f}	9.53 ± 0.09^{b}	2.09 ± 0.03^{b}	70.44 ± 0.35^{h}	430.23 ± 0.48^{b}

Values are mean ± standard deviation of triplicate measurements and those bearing different letter within a columns are significantly different (P ≤ 0.05).

***MiS**: 60% Millet fermented, 10% Millet germinated and 30% Sesame; **MiSMo5**: 60% Millet fermented, 10% Millet germinated, 25% Sesame and 5% Moringa; **MiSG**: 60% Millet fermented, 10% Millet germinated and 30% Sesame germinated; **MiSGMo5**: 60% Millet fermented, 10% Millet germinated, 25% Sesame germinated and 5% Moringa; **MaS**: 60% Maize fermented, 10% Maize germinated and 30% Sesame; **MaSMo5**: 60% Maize fermented, 10% Maize germinated, 25% Sesame and 5% Moringa; **MaSG**: 60% Maize fermented, 10% Maize germinated and 30% Sesame germinated; **MaSGMo5**: 60% Maize fermented, 10% Maize germinated, 25% Sesame germinated and 5% Moringa; **AT1** :Control diet 1, **AT2** : Control diet 2*

3.2 BIOLOGICAL EVALUATION OF DIETS

3.2.1 GROWTH PERFORMANCE AND ANTHROPOMETRICAL PARAMETERS

Analysis of the results obtained shows a mass gain in rats fed formulated and commercial diets (AT2) (Figure 1; Table 3). In addition, the average mass of the batch of rats subjected to the AT2 control diet increased slightly compared to rats fed flours formulated with a markdown from day 6 of the experiment. Moreover, depending on the treatment applied to sesame seeds (S or SG) and the presence or absence of moringa leaf powder (Mo) in the diet administered to rats, a difference was observed in the evolution of the masses of the rat batches. The high growth of rats fed diets containing germinated sesame seed (SG) powder and moringa leaves would confirm the impact of leafy vegetables and seed germination on their nutritional value in food [38],[39]. Also, the growth of these rats could therefore indicate a regular development of the cellular metabolism of rats [40]. In addition, the diet of rats fed the AT1 control diet showed a loss of mass from day 6 until the end of the experiment. This loss of mass in rats fed the formulated and control AT2 diets could be explained by the high protein content of the flours (8.46 ± 0.58 % DW). According to [1] the protein requirement of growing rats varies from 9 to 18 %.

The body mass index (BMI) of rats fed the formulated diets ranges from 0.45 ± 0.02 to 0.51 ± 0.07 g/cm^2 (Table 3). Those of rats fed the AT2 control diets are 0.46 ± 0.06 g/cm^2. However, rats in the AT1 control diet (0.36 ± 0.03 g/cm^2) had the lowest BMI. In addition, the statistical analysis did not show any significant difference ($p \geq 0.05$) between the formulated and AT2 control regimes. They would indicate that rats exposed to the different formulated foods would not show signs of obesity. These values are within the range (0.38 to 0.68 g/cm^2) of normal rats described by [19]. Consequently, the formulated diets could have a health benefit on the child's body during weaning.

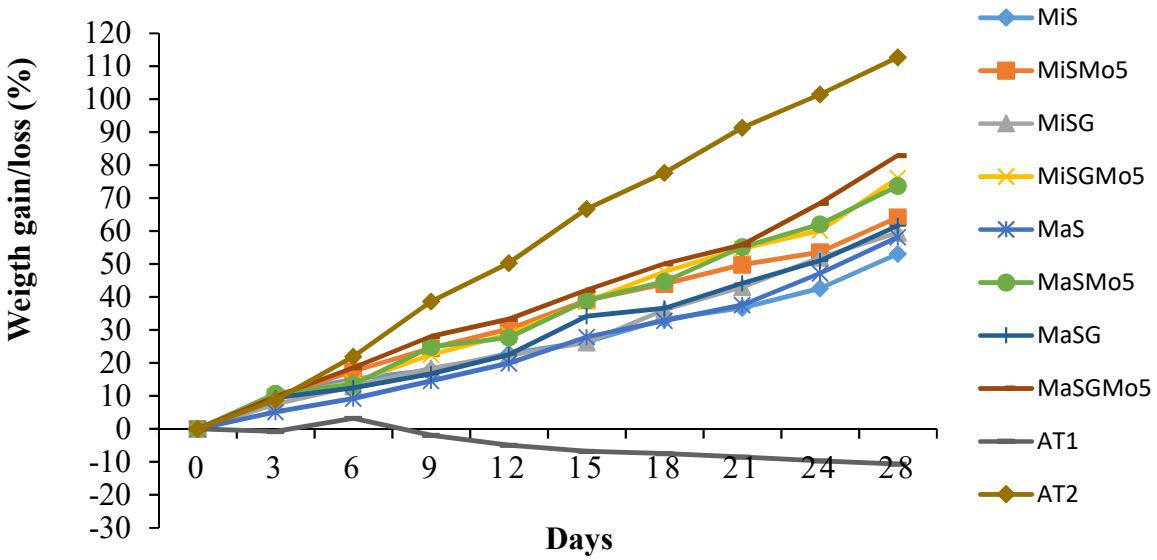

Fig. 1. Weight variation of rats fed composite and control flours

Table 3. Weight gain, body length and body mass index (BMI)

Experimental diets	Initial weight (g)	Final weight (g/d)	Weight gain (g/d)	Final length (cm)	BMI (g/cm²)
MiS	60.86 ± 7.62^{a}	93.13 ± 11.55^{b}	1.15 ± 0.17^{b}	13.60 ± 0.96^{b}	0.50 ± 0.01^{b}
MiSMo5	60.82 ± 7.53^{a}	99.70 ± 11.25^{c}	1.39 ± 0.17^{c}	14.50 ± 0.50^{d}	0.47 ± 0.03^{b}
MiSG	61.60 ± 7.50^{a}	98.16 ± 10.82^{c}	1.31 ± 0.15^{b}	14.50 ± 0.79^{d}	0.47 ± 0.00^{b}
MiSGMo5	60.31 ± 7.61^{a}	106.29 ± 14.74^{c}	1.64 ± 0.29^{e}	15.34 ± 1.25^{f}	0.45 ± 0.02^{b}
MaS	60.82 ± 7.34^{a}	98.15 ± 10.23^{c}	1.33 ± 0.12^{b}	13.88 ± 0.95^{b}	0.51 ± 0.07^{b}
MaSMo5	61.12 ± 7.35^{a}	106.05 ± 11.81^{c}	1.60 ± 0.20^{d}	14.70 ± 0.67^{d}	0.49 ± 0.06^{b}
MaSG	61.29 ± 7.44^{a}	96.89 ± 11.86^{c}	1.27 ± 0.19^{b}	14.00 ± 0.79^{c}	0.49 ± 0.03^{b}
MaSGMo5	60.51 ± 7.60^{a}	110.44 ± 11.85^{d}	1.78 ± 0.18^{e}	15.18 ± 0.73^{e}	0.48 ±0.06^{b}
AT1	60.88 ± 8.68^{a}	54.54 ± 8.98^{a}	-0.23 ± 0.02^{a}	12.28 ± 0.97^{a}	0.36 ± 0.03^{a}
AT2	59.82 ± 10.49^{a}	127.27 ± 10.19^{e}	2.40 ± 0.43^{f}	16.58 ± 0.76^{g}	0.46 ± 0.06^{b}

Values are mean ± standard deviation of triplicate measurements and those bearing different letter within a columns are significantly different (P ≤ 0.05).

3.2.2 FEED CONSUMPTION RATE AND PROTEIN QUALITY OF DIETS

The feed efficiency ratio (FER) of the formulated and control diets (AT1 and AT2) differs significantly at the 5% threshold (Table 4). The formulated and control AT2 diets were well assimilated by rats with FER of (0.18 ± 0.03 and 0.23 ± 0.03) and 0.26 ± 0.05 respectively. This could be explained by the high fat and protein content of flours that would improve the aroma, flavour and palatability of these diets [41]. However, the AT1 control diet (-0.05 ± 0.00) was poorly assimilated by rats. The protein efficiency ratio (PER) of the formulated diets ranges from 1.38 ± 0.20 to 1.64 ± 0.29. The AT2 control regime recorded a PER of 1.66 ± 0.30. However, the statistical analysis did not show any significant difference ($p \geq 0.05$) between the formulated diets and the AT2 control diets (Table 4). In addition, the protein efficiency coefficients of the composite flours and the AT2 control feed are within the range of 1.5 to 2 reflecting the good quality of a food protein. Indeed, the quality of a protein is poor if the PER is less than 1.5; good if it is between 1.5 and 2 [42]. The content of the PER obtained in this study demonstrates the advantage of using sesame seeds and moringa leaves in infant feeding. In addition, observation of the results showed that the rats' bodies used the proteins contained in the AT1 trade regime (-0.54 ± 0.04), which could justify the loss of mass in these rats.

Table 4. Feed intake, Protein intake, FER (Feed efficiency ratio) and PER (Protein efficiency ratio) of formulated diets and controls

Experimental diets	Feed intake (g/j)	Protein intake (g/j)	FER	PER
MiS	6.39 ± 1.40^{b}	0.84 ± 0.03^{b}	0.18 ± 0.03^{b}	1.38 ± 0.20^{b}
MiSMo5	6.50 ± 0.64^{b}	0.88 ± 0.00^{c}	0.21 ± 0.03^{c}	1.59 ± 0.20^{b}
MiSG	6.42 ± 0.86^{b}	0.89 ± 0.00^{c}	0.20 ± 0.02^{c}	1.47 ± 0.17^{b}
MiSGMo5	6.65 ± 1.05^{b}	1.00 ± 0.03^{e}	0.22 ± 0.05^{d}	1.64 ± 0.29^{b}
MaS	6.16 ± 1.26^{b}	0.88 ± 0.03^{c}	0.21 ± 0.03^{c}	1.45 ± 0.22^{b}
MaSMo5	7.05 ± 1.15^{c}	1.05 ± 0.02^{f}	0.23 ± 0.03^{d}	1.53 ± 0.19^{b}
MaSG	6.42 ± 1.41^{b}	0.94 ± 0.00^{d}	0.21 ± 0.02^{c}	1.42 ± 0.12^{b}
MaSGMo5	7.60 ± 1.65^{d}	1.16 ± 0.00^{g}	0.23 ± 0.02^{d}	1.53 ± 0.15^{b}
AT1	4.93 ± 1.41^{a}	0.42 ± 0.03^{a}	-0.05 ± 0.00^{a}	-0.54 ± 0.04^{a}
AT2	9.24 ± 1.09^{e}	1.45 ± 0.02^{h}	0.26 ± 0.05^{e}	1.66 ± 0.30^{b}

Values are mean ± standard deviation of triplicate measurements and those bearing different letter within a columns are significantly different (P ≤ 0.05).

3.2.3 DIGESTIBILITY, BIOLOGICAL VALUE (BV) AND NET PROTEIN UTILIZATION (NPU)

The apparent digestibility (AD) of the diets studied showed a significant difference at the 5% threshold (Table 5). Analysis of the results indicated that the highest level was obtained with the AT2 control regime (93.01 ± 0.12 %). The lowest was recorded with the MiS scheme (81.47 ± 0.31 %). Apart from the latter, the AD values recorded in the rats subjected to the diets studied are statistically identical or higher (p ≤ 0.05) than those of the commercial control flour AT1 (83.05 ± 0.04 %). In addition, diets containing 5% of moringa leaf powder (Mo) have high values compared to diets containing sesame seed powder treated under the same conditions. In addition, the true digestibility (TD) of the diets studied differs significantly (p ≤ 0.05) (Table 5). The TD of the formulated diets ranges from 85.18 ± 0.31 to 93.55 ± 0.02. The values for the AT1 and AT2 control regimes were 90.48 ± 0.04 % and 95.15 ± 0.12 %, respectively. However, more than 80% of the diet proteins were actually retained by rats. According to [43], an digestibility of more than 70 % is desired in foods intended for children of weaning age. These results are similar to those of [44] which obtained 87.82 - 97.57 % respectively. In addition, the relatively high digestibility values of diets containing germinated sesame seed powder (SG) and moringa leaves (Mo) would indicate the importance of raw material treatments and flour supplementation in improving the nutritional value of foods. Moroever, the actual digestibility values of the different diets are higher than the apparent digestibility. This observation was also made by [44].

The biological value (BV) of a food's protein reflects its bioavailability in the body [45]. The values recorded in this study oscillate between those of the AT1 (78.66 ± 1.62 %) and AT2 (95.57 ± 0.05 %) controls. The content of the formulations ranges from 83.51 ± 0.56 to 94.91 ± 0.00 %. The statistical analysis showed that there is a significant difference between control regimens (AT1 and AT2) and formulated regimens. In addition, the presence of sesame germinated seed (SG) and moringa leaf (Mo) powder increased the BV of the formulated diets tomore than 80%. Thus, 80% of the proteins contained in formulated foods would be assimilated by the body. In addition, the consumption of flours incorporated into the powder of germinated sesame seeds (SG) and moringa leaves (Mo) has a VB of more than 90%. This rate is similar to [46] which obtained by 88.31 - 100 respectively. In addition, the incorporation of germinated seeds and moringa leaves in infant flours improves the nutritional quality of the diet [8], [47].

Table 5. Digestibility (AD and TD), protein utilization (NPU), biological value (BV) and protein retention (PRE) of the formulated diets and controls

Experimental diets	Parameter (%)				
	AD	TD	NPU	BV	PRE (g/d)
MiS	81.47 ± 0.31^{a}	85.18 ± 0.31^{a}	73.79 ± 1.08^{b}	86.64 ± 0.65^{c}	0.62 ± 0.03^{b}
MiSMo5	85.18 ±0.15^{e}	88.72 ± 0.15^{d}	80.79 ± 0.07^{d}	91.06 ± 0.04^{e}	0.71 ± 0.00^{d}
MiSG	84.20 ± 0.11^{c}	87.69 ± 0.11^{c}	77.61 ± 0.08^{c}	88.51 ± 0.05^{d}	0.69 ± 0.00^{c}
MiSGMo5	89.02 ± 0.10^{g}	92.13 ± 0.10^{f}	86.69 ± 0.37^{f}	94.10 ± 0.18^{f}	0.86 ± 0.03^{f}
MaS	83.22 ± 0.10^{b}	86.75 ± 0.10^{b}	72.44 ± 0.81^{a}	83.51 ± 0.56^{b}	0.64 ± 0.03^{b}
MaSMo5	87.57 ± 0.21^{f}	90.52 ± 0.21^{e}	82.60 ± 0.30^{e}	91.26 ± 0.17^{e}	0.87 ± 0.02^{f}
MaSG	84.68 ± 0.17^{d}	87.97 ± 0.17^{c}	77.25 ± 0.01^{c}	87.81 ± 0.00^{d}	0.73 ± 0.00^{e}
MaSGMo5	90.89 ± 0.02^{h}	93.55 ± 0.02^{g}	88.79 ± 0.01^{g}	94.91 ± 0.00^{g}	1.03 ± 0.00^{g}
AT1	83.05 ± 0.04^{b}	90.48 ± 0.04^{e}	71.16 ± 1.98^{a}	78.66 ± 1.62^{a}	0.30 ± 0.03^{a}
AT2	93.01 ± 0.12^{i}	95.15 ± 0.12^{h}	90.94 ± 0.11^{h}	95.57 ± 0.05^{h}	1.32 ± 0.02^{h}

Values are mean ± standard deviation of triplicate measurements and those bearing different letter within a columns are significantly different (P ≤ 0.05).

3.2.4 BIOMETRIC VALUES OF RATS FED WITH DIETS

Biometrics of the organs (kidneys, liver and heart) of rats in the formulated and control diets (AT1 and AT2) are recorded in Table 6. One technique for assessing food quality is the measurement of organ biometrics [45]. Indeed, this measure makes it possible to detect anomalies in the organs implicated in nutritional metabolism [18]. The kidneys are extremely important and effective organs for the functioning of the body, but they are also extremely sensitive to various substances that can cause abnormalities. The kidney weights of rats on the formulated diets range from 0.70 ± 0.08 to 0.79 ± 0.09 g and those of rats on the AT2 diet from 0.76 ± 0.03 g. The analysis of the results did not show any significant difference ($p \geq 0.05$) between the formulated and control AT2 diets. These results are in the range of 0.77 - 0.90 g of rats fed with dockounou obtained by [48]. This observation would attest to the safety of diets formulated on normal kidney function. In addition, the low kidney mass obtained with rats in the AT1 control diet (0.49 ± 0.04 g) may be due to low dietary intake by rats. Similar observations have been reported by [49], on fed rats with a dietary restriction.

The liver is an organ involved in the metabolism of nutrients. The liver performs three vital functions such as purification function (cholesterol elimination, transformation of ammonia into urea, etc.), synthesis function (synthesis of coagulation factors and cholesterol synthesis, etc.) and storage function [48]. However, liver enlargement is an indicator of a treatment-related abnormality [45]. The liver mass of rats fed the formulated and control diets (AT1 and AT2) differs significantly at the 5% threshold. The lowest mass was recorded with rats in the AT1 control diet (2.18 ± 0.26 g) and the highest mass with those in the AT2 control diet (4.04 ± 0.20 g). The liver masses of ras subjected to the formulated diets range from 3.43 ± 0.21 to 3.87 ± 0.39 g. However, with the exception of rats fed the MaSMo5 diet (3.43 ± 0.21 g), the liver weights of rats fed the formulated diets are statistically identical ($p \geq 0.05$) to each other. However, the liver weights of rats fed the formulated diets are similar to (3.13 - 3.70 g) obtained by [48]. Thus, the consumption of the formulated diets may not have a negative impact on the functioning of this organ. In addition, the low liver mass in rats on the AT1 control diet (2.18 g) is believed to be due to the dietary reduction observed by rats. Such results have been reported by [49].

Table 6. Organs weight of rats fed with formulated diets and controls

Experimental diets	Weight (g)		
	Kidneys	Liver	Heart
MiS	$0,74 \pm 0,05^{b}$	$3,63 \pm 0,43^{c}$	$0,42 \pm 0,05^{c}$
MiSMo5	$0,76 \pm 0,03^{b}$	$3,43 \pm 0,21^{b}$	$0,40 \pm 0,03^{b}$
MiSG	$0,74 \pm 0,06^{b}$	$3,73 \pm 0,36^{c}$	$0,42 \pm 0,03^{b}$
MiSGMo5	$0,70 \pm 0,08^{b}$	$3,60 \pm 0,49^{c}$	$0,41 \pm 0,04^{b}$
MaS	$0,75 \pm 0,08^{b}$	$3,87 \pm 0,39^{c}$	$0,42 \pm 0,03^{b}$
MaSMo5	$0,76 \pm 0,06^{b}$	$3,81 \pm 0,31^{c}$	$0,45 \pm 0,05^{c}$
MaSG	$0,73 \pm 0,09^{b}$	$3,86 \pm 0,44^{c}$	$0,43 \pm 0,03^{c}$
MaSGMo5	$0,79 \pm 0,09^{b}$	$3,57 \pm 0,26^{c}$	$0,40 \pm 0,03^{b}$
AT1	$0,49 \pm 0,04^{a}$	$2,18 \pm 0,26^{a}$	$0,29 \pm 0,04^{a}$
AT2	$0,76 \pm 0,03^{b}$	$4,04 \pm 0,20^{d}$	$0,48 \pm 0,05^{d}$

Values are mean ± standard deviation of triplicate measurements and those bearing different letter within a columns are significantly different ($P \leq 0.05$).

3.2.5 Biochemical Parameters Studies

The levels of glucose, total protein, urea and creatinine in young rats subjected to the selected formulations and commercial control flours are recorded in Table 7.

The variation in blood glucose levels is one of the first approaches to detecting possible kidney dysfunction and diabetes in an individual [50]. This study, blood glucose levels in rats fed food preparations ranged from 55.10 ± 7.54 to 68.05 ± 2.55 mg/dL. These values range from 50 to 135 mg/dL recommended by [51] in normal rats. In addition, these values did not vary significantly from the controls in lot AT2. As a result, the consumption of the different diets formulated had no effect on the blood sugar levels of young rats. However, the hypoglycemia observed in rats subjected to the AT1 (41.00 ± 4.41mg/dL) control diet is explained by a state of protein-energy malnutrition leading to Kwashiorkor [52]. These results are consistent with those of [49] in rats with dietary restrictions.

The serum total protein levels are between those of rats on the AT1 (4.53 ± 0.21 g/dl) and AT2 (7.38 ± 0.86 g/dl) control diets. In addition, rats fed formulations containing germinated sesame seed powder (SG) and moringa leaf powder (Mo) significantly increased ($p \leq 0.05$) the serum total protein level in rats. Indeed, serum protein level is a parameter strongly influenced by the protein content of the diet [53]. Their importance results from the beneficial effect on health by maintaining

osmotic pressure, transporting molecules, purifying plasma, strengthening the immune system and coagulating blood [48]. Serum protein levels in rats on the elaborate diets are relatively low compared to the AT2 control lot. However, these values are consistent with the range (5.5 and 7.7 mg/dL) described by [54] in normal rats. In addition, the hypoproteinemia observed in rats fed the AT1 control diet is thought to result from insufficient protein intake, leading to protein malnutrition in the subjects [49]. As a result, consumption of these formulated foods would be able to meet the body's protein needs and maintain a healthy infant during weaning.

Creatinine and urea are excellent markers of kidney function, their increasing reflects kidney dysfunction [55]. However, an increase in plasma urea does not specifically indicate kidney impairment. Indeed, plasma urea concentration depends not only on kidney function but also on diuresis, dietary nitrogen intakes and endogenous protein catabolism [55]. Creatinine currently remains the most commonly used test for assessing kidney function, as it is essentially eliminated by the kidney route by glomerular filtration [56]. Creatinine highest value was recorded with rats on the AT1 diet (0.69 ± 0.02 mg/dL), followed by those on the AT2 control diet (0.60 ± 0.05 mg/dL). Moreover, a significant decrease in creatinine content is observed when diets are enriched with sesame germinated (SG) and moringa (Mo) seed powder. [57] showed that the presence of antioxidant compounds in plants conferred them a nephroprotective activity. In addition, the serum creatinine concentration (0.48 - 0.64 mg/dL) of rats in the formulated diets is consistent with that of [54] which is 0.2-0.6 mg/dL required in young growing rats. Furthermore, the results obtained in this study are low compared to those (1.51-1.71 mg/dL) of [58]. These observations demonstrate the safety of the various foods formulated on kidney function.

Table 7. Glucose, total protein, urea and creatinine of rats fed with food formulations and controls

Experimental diets	Glucose (mg/dL)	Total protein (g/dL)	Urea (mg/dL)	Creatinine (mg/dL)
MiS	62.18 ± 5.56^{c}	5.16 ± 0.10^{b}	4.40 ± 0.60^{b}	0.56 ± 0.05^{c}
MiSMo5	55.10 ± 7.54^{b}	5.68 ± 0.56^{c}	3.94 ± 0.69^{a}	0.51 ± 0.01^{b}
MiSG	68.05 ± 2.55^{d}	5.44 ± 0.44^{c}	5.08 ± 0.84^{f}	0.57 ± 0.06^{d}
MiSGMo5	56.40 ± 6.92^{b}	6.25 ± 0.22^{d}	4.91 ± 0.65^{e}	0.48 ± 0.04^{a}
MaS	63.75 ± 10.40^{c}	4.98 ± 0.60^{b}	4.82 ± 0.28^{d}	0.64 ± 0.02^{f}
MaSMo5	61.05 ± 4.82^{c}	5.32 ± 0.61^{b}	4.53 ± 0.48^{c}	0.58 ± 0.03^{d}
MaSG	64.30 ± 9.67^{c}	5.38 ± 0.73^{c}	5.97 ± 0.31^{i}	0.57 ± 0.05^{d}
MaSGMo5	61.63 ± 4.83^{c}	6.44 ± 0.10^{d}	5.19 ± 0.43^{f}	0.51 ± 0.04^{b}
AT1	41.00 ± 4.41^{a}	4.53 ± 0.21^{a}	5.92 ± 0.73^{h}	0.69 ± 0.02^{g}
AT2	63.53 ± 1.45^{c}	7.38 ± 0.86^{e}	5.62 ± 0.76^{g}	0.60 ± 0.05^{e}

Values are mean ± standard deviation of triplicate measurements and those bearing different letter within a columns are significantly different (P ≤ 0.05).

In order to explore the value of a diet composed of a mixture of cereal (millet and maize), sesame and moringa on the health status of the animals tested, the levels of total cholesterol, HDL cholesterol, LDL cholesterol and triglycerides were determined (Table 8).

For total serum cholesterol, the analysis of variance indicates that the lowest value is recorded in rats on the AT1 control diet (0.69 ± 0.04 g/L), while the highest value is observed in the blood of rats on the AT2 control diet (0.90 ± 0.06 g/l). In addition, in rats fed the formulated diets, the total cholesterol content (0.80 ± 0.04 - 0.85 ± 0.06 g/L) is lower compared to that of rats fed the AT2 control diet. This could be due to the fact that plant-based foods would have little or no cholesterol. Also, the presence of fibres and tannins in diets would promote the reduction of cholesterol in the blood by its faecal excretion or by decreasing its synthesis by the liver [59]. In addition, the HDL cholesterol (good cholesterol) (0.41 ± 0.01- 0.60 ± 0.05 g/L) and LDL cholesterol (0.09 ± 0.02 - 0.19 ± 0.04 g/L) content in rats fed the formulated diets are comparable to those reported by [58] which are approximately 0.55 g/L and 0.15 g/L respectively for Wistar rats. This would suggest that the consumption of elaborate formulations would not pose a risk of hyperlipidemia or cardiovascular disease in children. In addition, the low total cholesterol/HDL-cholesterol ratio (1.39 - 2.04) compared to the maximum limit of 3 in animals that ingested the formulations would confirm the health benefits of consuming these flours [60].

Table 8. Lipid profile and atherogenic indices of rats fed with formulated diets and controls

Experimental diets	Parameter (g/L)					
	TG	CT	HDL-C	LDL-C	CT / HDL-C	LDL-C/HDL-C
MiS	1.18 ± 0.10^{h}	0.84 ± 0.07^{c}	0.42 ± 0.01^{d}	0.18 ± 0.06^{c}	1.98	0.42
MiSMo5	0.97 ± 0.11^{f}	0.83 ± 0.05^{c}	0.50 ± 0.01^{h}	0.14 ± 0.03^{b}	1.67	0.28
MiSG	1.08 ± 0.06^{g}	0.85 ± 0.06^{c}	0.45 ± 0.03^{e}	0.18 ± 0.03^{c}	1.86	0.39
MiSGMo5	0.90 ± 0.09^{d}	0.80 ± 0.04^{b}	0.51 ± 0.02^{h}	0.11 ± 0.05^{b}	1.56	0.21
MaS	1.18 ± 0.09^{h}	0.83 ± 0.06^{c}	0.41 ± 0.01^{c}	0.19 ± 0.05^{c}	2.04	0.46
MaSMo5	0.97 ± 0.03^{f}	0.84 ± 0.03^{c}	0.48 ± 0.06^{g}	0.16 ± 0.08^{b}	1.75	0.34
MaSG	0.93 ± 0.06^{e}	0.84 ± 0.03^{c}	0.46 ± 0.04^{f}	0.19 ± 0.04^{c}	1.83	0.43
MaSGMo5	0.72 ± 0.04^{b}	0.83 ± 0.03^{c}	0.60 ± 0.05^{i}	0.09 ± 0.02^{a}	1.39	0.15
AT1	0.53 ± 0.04^{a}	0.69 ± 0.04^{a}	0.24 ± 0.02^{a}	0.35 ± 0.03^{d}	2.87	1.43
AT2	0.80 ± 0.06^{c}	0.90 ± 0.06^{d}	0.40 ± 0.07^{b}	0.34 ± 0.05^{d}	2.27	0.87

Values are mean ± standard deviation of triplicate measurements and those bearing different letter within a columns are significantly different (P ≤ 0.05).

4 CONCLUSION

The formulated flours have a high content of protein, fat, ash, fibre and an energy value that complies with the standards for complementary food. As well, the incorporation of sesame germinated seed (SG) powder into flours to optimize these parameters. Nutrition tests of enriched formulated flours (sesame and moringa) and the AT2 control diet in growing rats showed better dry matter intake. Also, the food and protein efficiency coefficient of the formulated diets is similar to that of the control diet AT2. This finding resulted in weight gain in rats fed these diets as opposed to rats fed the AT1 control diets. In addition, no obesity was detected in rats on the formulated diets. Moreover, the analysis of the results showed that the consumption of diets formulated by rats did not induce an abnormality on the organs (kidneys, liver and heart). Blood biochemical parameters (glucose, urea, total protein and creatinine) generally showed good functioning of rat organs. Consumption of the formulated diets showed good accumulation of blood lipids (total cholesterol, HDL-cholesterol, LDL-cholesterol and triglycerides) in rats. These formulations could therefore be offered to mothers in rural areas and those on low incomes.

REFERENCES

[1] K. Bouafou, K. Kouamé, et A. Offoumou, "Bilan azoté chez le rat en croissance de la farine d'asticots séchés," *Tropicultura*, vol. 25, no. 2, pp. 70-74, 2007.

[2] A. Yewelsew, J. S. Barbara, J. H. Margaret, and E. G. Gail, "Nutritive value and sensory acceptability of corn and Kocho-Based foods supplemented with legumes for infant feeding in southern Ethiopia," *Afri. J. of Food Agri. Nutri. and Dev*., Vol. 6, no. 1, pp. 1684-5376, 2006.

[3] A. Lartey, A. Manu, K. H. Brown, J. M. Peerson, and K. G. Dewey, "A randomized, community-based trial of the effects of improved, centrally processed complementary foods on growth and micronutrient status of Ghanaian infants from 6 to 12mo of age," *American Journal of Clinical Nutrition*, vol. 70, pp. 391–404, 1999.

[4] M. W. Tenagashaw, J. N. Kinyuru, G. M. Kenji, E. T. Melaku, and H. K. Susanne, "Nutrient density of complementary foods formulated from a blend of teff, soybean and orange-fleshed sweet potato," *International Journal of Food Science and Nutrition Engineering*, vol 7, no. 4, pp. 61-69, 2017.

[5] L. Songré-Ouattara, C. Mouquet-Rivier, C. Icard-Vernière, I. Rochette, B. Diawara, J. P. Guyot, "Potential of amylolytic lactic acid bacteria to replace the use of malt for partial starch hydrolysis to produce African fermented pearl millet gruel fortified with groundnut," *Int. J. Food Microbiol*., vol. 130, pp. 258-264, 2009.

[6] M. Solomon, "Nutritive value of three potential complementary foods based on cereals and legumes," *Afri. J. Food Agri. Nutri. Dev.*, vol. 5, pp. 1–14, 2005.

[7] F. K. Amagloh, A. Hardacre, A. N. Utukumira, J. L. Weber, L. Brough, and J. Coad, "A household-level sweet potato-based infant food to complement vitamin A supplementation initiatives," *Maternal and Child Nutrition*, vol. 8, no. 4, pp. 512-521, 2012.

[8] K. K. A. Amoin, E. A. Agbo, A. G. Dago, A. G. Gbogouri, D. K. Brou and G. Dago, "Comparaison des caractéristiques nutritionnelles et rhéologiques des bouillies infantiles préparées par les techniques de germination et de fermentation," *International Journal of Biological and Chemical Sciences*, vol. 9, no. 2, pp. 944-953, 2015.

[9] C. F. Ajibola, T. N. Fagbemi, and O. F. Osundahunsi, "Nutritional Quality of Weaning Foods Formulated from Maize Gruel "Ogi" and Crayfish Using Combined Traditional Processing Technology," *Advances in Research*, vol. 6, no. 4, pp. 1–11, 2016.

[10] O. A. Adeoti, A. O. Alabi, S. O. Adedokun, K. O. Jimoh, O. O. Elutilo, and L. A. Azeez, "Influence of Processing Methods on the Nutrient, Anti-Nutrient, Mineral Compositions and Functional Properties of Akee Apple (Blighia Sapida Konig) Seed and Aril Flour," *J. Hum. Nutr. Food Sci*, vol. 5, no. 1, pp. 1101, 2017.

[11] N. F. Fogny, E. Y. Madode, F. F. Laleye, Y. Amoussou-Lokossou, and A. P. Kayode, "Formulation de farine de fonio enrichie en ressources alimentaires locales pour l'alimentation complémentaire des jeunes enfants au Bénin," *International Journal of Biological and Chemical Sciences*, vol. 11, no. 6, pp. 2745-2755, 2017.

[12] J. M. Nzikou, L. Mate, G. Bouanga-kalou, C. B. Ndangui, N. P. G. Pambou-Tobi, A. Kimbonguila, T. Silo, M. Linder, and S. Desobry, "Chemical composition of the seeds and oil of sesame (Sesamun indicum L.) grown in Congo- Brazzaville," *Advance Journal of food Science and Technology*, vol. 1, no. 1, pp. 6-11, 2009.

[13] I. D. A. Kouamé, M. B. Faulet, G. S. E. Ekissi, B. J. Fagbohoun and P. L. Kouamé, "Effects of sprouting time on physicochemical and biochemical parameters of oil extracted from sesame (Sesamum indicum)," Journal of Current Research, vol. 10, no. 6, pp. 70358-70364, 2018.

[14] F. Anwar, S. Latif, M. Ashraf and A.H. Gilani, "Moringa oleifera: A Food Plant with Multiple Medicinal Uses," Phytotherapy Research, vol. 21, pp. 17–25, 2007.

[15] O. I. Steve and O. I. Babatunde, "Chemical compositions and nutritional properties of popcorn-based complementary foods supplemented with Moringa oleifera leaves flour," J. Food Res., vol. 2, no. 6, pp. 117-132, 2013.

[16] AOAC, Official Methods of Analysis of Association of Official Analytical Chemists, 17th Ed, Gaithersburg, Maryland, USA, 2000.

[17] W. O. Atwater and F. G. Benedict, "A new respiratory calorimeter and experiments on the conservation of energy in human body II," Physical Review vol. 9, pp. 214-251, 1902.

[18] Adrian, J., Rabache, M., and Fragne, R., Technique d'analyse nutritionnelle In Lavoisier Tec et Doc (Eds). Principes de techniques d'analyse, Paris, pp. 451-478, 1991.

[19] E. L. B. Novelli, Y. S. Diniz, C. M. Galhardi, G. M. X. Ebaid, H. G. Rodrigues, F. Mani, A. A. H. Fernandes, A. C. Cicogna and J. L. V. B. N. Filho, "Anthropometrical parameters and markers of obesity in rats," Lab Anim; vol. 41, pp. 111–119, 2007.

[20] Descat, F., Hématologie du rat: hémogramme et myélogramme, Thèse médecine vétérinaire Toulouse, pp. 109, 2002.

[21] P. Trinder, "Determination of glucose in blood using Glucose Oxidase with an alternative oxygen acceptor," Ann clinBiochem, vol. 6, pp. 24-27, 1969.

[22] Spinreact. Total protein Biuret. Colorimetric; Quantitative determination of total protein. SPINREACT, S.A./S.A.U. Ctra.Santa Coloma, 7 E-17176 SANT ESTEVE DE BAS (GI) Espagne. 2015.

[23] M. Rasha and M. Ahmed, "Formulation of Reduced Calorie and Trans-free Fat Biscuits Using Palm Oil and Sucralose: Study of Their Hypoglycemic Activity on Albino Rats," Ame. J. Food Nutr., Vol. 3, No. 6, pp. 131-140, 2015.

[24] Spinreact. UREA – B. Berthelot. Enzymatique colorimétrique. Détermination quantitative d'urée. SPINREACT, S.A./S.A.U. Ctra.Santa Coloma, 7 E-17176 SANT ESTEVE DE BAS (GI) Espagne, 2015.

[25] Tietz N. W., Clinical Guide to Laboratory Tests, Second Edition W.B. Saunders Company, Philadelphia, USA. pp 554-556, 1990.

[26] C. C. Allain, L. S. Poom, C. S. Chan, W. S. Richmonal and P.C. Fu, "Enzymatic determination of total serum cholesterol," Clin. Chem., vol. 20, pp. 470-475, 1974.

[27] T. W. Friedwald, D. S. Fredrickson and L. J. Levy, "LDL cholesterol estimation," Clin. Chem., Vol. 18, pp. 499-501, 1972.

[28] A. V. Ikujenlola and E. A. Adurotoye, "Evaluation of Quality Characteristics of High Nutrient Dense Complementary Food from Mixtures of Malted Quality Protein Maize (Zea mays L.) Steamed Cowpea (Vigna unguiculata)," J. Food Proc. Technol., vol. 5, pp. 291, 2014.

[29] A. U. Achidi, B. Tiencheu, N. Tenyang, H. M. Womeni, M. N. Moyeh, L. T. Ebini and F. Tatsinkou, "Quality evaluation of nine instant weaning foods formulated from cereal, legume, tuber, vegetable and crayfish," Int. J. Food Sci. Nutr. Eng., vol. 6, no. 2, pp.21-31, 2016.

[30] N. S. Dlamini and W. K. Solomon, "Effect of Ingredients Ratio on Physicochemical and Sensory Properties of Sorghum, Maize and Soya Protein Concentrate Blend Extrudates," *International Journal of Food Science and Nutrition Engineering*, vol. *6, no.* 5, pp. 112-120, 2016.

[31] M. R. Mahan, N. Y. Konan, D. Sidibé, A. Coulibaly, P. Ezoua, K. O. Chatigre and G. H. M. Biego, "Nutritive compounds from leaves of *Moringa oleifera* L. and beans of *Vigna unguiculata* W. for improvement of the meal deriving with new shoots of *Borassus aethiopum* M. *Côte d'Ivoire," International Journal of Environmental & Agriculture Research*, vol. 2, no. 6, pp. 64-74, 2016.

[32] O. B. Ocheme and C. E. Chinma, "Effects of Soaking and Germination on Some Physicochemical Properties of Millet Flour for Porridge Production," Journal of Food Technology, vol. 6 no. 5, pp. 185-188, 2008.

[33] FAO/OMS. Programme mixte FAO/OMS sur les normes alimentaires. Commission du Codex Alimentarius : Rapport de la 30ème session du comité du codex sur la nutrition et les aliments diététiques ou de régime. Rome, Italie, French, pp. 1-223, 2008.

[34] R. Ponka, E. L. T. Nankap, S. T. Tambe and E. Fokou, "Composition nutritionnelle de quelques farines infantiles artisanales du Cameroun," *International Journal of Innovation and Applied Studies,* vol. 16, no. 2, pp. 280-292, 2016.

[35] FAO/WHO, CODEX CAC/GL 08, 1991. Codex Alimentarius: Guidelines on Formulated Supplementary Foods for Older Infants and Young Children, 4, pp 144, 1991.

[36] P. A. Dakia, M. M. A. Combo, B. M. Yapo, D. K. Brou and M. Paquot, "Dietary fibre content in carob (ceratonia siliqua l) seed husk," *International Journal of Current Research International Journal of Current Research*, vol. 9, no. 12, pp. 62190-62196, 2017.

[37] Brown, K. Dewey, K., and Allen L., Complementary feeding of young children in developing countries: A review of current scientific knowledge, World Health Organization, Geneva WHO/NUT/98.1; 1998.

[38] V. Kumar, A. K. Sinha, H. P. S. Makkar and K. Becker, "Dietary roles of phytate and phytase in human nutrition: A review," Food Chem.,vol. 120, pp. 945–959, 2010.

[39] B. D. Beruk, "Effect of Soaking and Germination on Proximate Composition, Mineral Bioavailability and Functional Properties of Chickpea Flour," Food and Public Health, vol.5, no. 4, pp. 108-113, 2015.

[40] T. Dally, A. Meite, K. G. Kouame, K. G. M. Bouafou and S. Kati–Coulibali, "Efficacité nutritionnelle de trois mets Ivoiriens : cabatoh à la sauce dah au nord; foutou igname à la sauce gouagouassou au centre; riz cuit à la sauce graine à l'ouest," Journal of Applied Biosciences, vol. 33, pp. 2084-2090, 2010.

[41] P. Singh, R Kumar, S. N. Sabapathy and A. S. Bawa, "Functional and edible uses of soy protein products," CRFSFS, vol. 7, pp. 14-28, 2008.

[42] M. Friedman, "Nutritional Value of Proteins from Different Food Sources. A Review," J. Agric. Food Chem. Vol. 44, pp. 6-29, 1996.

[43] FAO/WHO, Protein quality evaluation, Report of the joint FAO/WHO Expert consultation Bethesda, MD., USA, pp. 58-66, 1989.

[44] E. H. Kamau, C. A. Serrem and F. W. Wamunga, "Rat Bioassay for Evaluation of Protein Quality of Soy-Fortified Complementary Foods," Journal of Food Research, vol. 6, no. 6, pp. 35-44, 2017.

[45] K. Bouafou, B. A. Konan, A. Meite, G. Kouame, S. Kati-Coulibally, "Substitution de la farine de poisson par la farine d'asticots séchés dans le régime du rat en croissance : risques pathologiques?," Journal of Applied Biosciences, vol. 48, pp. 3279– 3283, 2011.

[46] A. O. Akinsola, M. A. Idowu, E. K. Oke, O. A. Idowu and A. M. Laniran, "Nutritional evaluation of maize-millet based complementary foods fortified with soybean," Annals. Food Science and Technology, vol. 18, no. 2, pp. 173-182. 2017.

[47] D. Shiriki, M. A. Igyor and D. I. Gernah, "Nutritional evaluation of complementary food formulations from maize, soybean and peanut fortified with *Moringa oleifera* leaf powder," Food Nutr. Sci., vol. 6, no. 494-500, 2015.

[48] N. J. Kouadio, K. A. S. Kra and L. S. Niamké, "Nutritional Effect of Boiled and Baked Soybean Dockounou on the Wistar Rats Health Conditions," International Journal of Biochemistry and Biophysics, vol. 5, no. 1, pp. 1-8, 2017.

[49] T. Moriyama, S. Tsujioka, T. Ohira, S. Nonaka, H. Ikeda, H. Sugiura, M. Tomohiro, K. Samura and M. Nishikibe, "Effects of reduced food intake on toxicity study parameters in rats," The Journal of Toxicological Sciences, vol. 33, no.5, pp. 537-547, 2008.

[50] M. Janghorbani, A. Aminorroaya and M. Amini, "Hypertension in Non-Type 2 Diabetes in Isfahan, Iran: Incidence and Risk Factors," *International journal of hypertension*, Article ID 3132729, pp. 7, 2017.

[51] Johnson-Delaney C., Exotic Companion Medicine Handbook for Veterinarians (2 Vol. Set). Lake Worth, FL: Zoological Education Network, pp. 500, 1996.

[52] E. K. V. Kouakou, K. G. M. Bouafou, A. Meite, K. G. Kouame and S. Kati-Coulibaly, "Farine de sevrage commerciale ANAGOBAKA: quels risques pathologiques dans le régime du rat en croissance?". Int. J. Biol. Chem. Sci., vol. 10, no. 1, pp. 167-174, 2016.

[53] B. Backlund, D. L. Zoran, M. B. Nabity, B. Norby and J. E. Bauer, "Effects of dietary protein content on renal parameters in normal cats," Journal of Feline Medicine and Surgery, vol. 13, pp. 698 – 704, 2011.

[54] Giknis, M. L. A., and Clifford C. B., Clinical laboratory parameters for Crl: WI (Han), *Charles River Laboratories*, pp. 14, 2008.

[55] Schmitt F., Pathologie rénale. In: Biochimie Hématologie. Edited by Vaubourdolle M, édition le moniteur, tome 2, Paris, pp 543-558, 2007.

[56] S. A. Gbakon, T. S. Ubwa, U.J. Ahile, O. G. Obochi, I. A. Nwannadi and M. I. Yusufu, "Studies on Changes in Some Haematological and Plasma Biochemical Parameters in Wistar Rats Fed on Diets Containing Calcium Carbide Ripened Mango Fruits," International Journal of Food Science and Nutrition Engineering, vol. 8, no. 2, pp. 27-36, 2018.

[57] M. Nandave, S. K. Ojha, S. Joshi, S. Kumari and D. S. Arya, "Moringa oleifera leaf extract prevents isoproterenol-induced myocardial damage in rats: Evidence for an antioxidant, antiperoxidative, and cardioprotective intervention" Journal of adequately Medicinal Food, vol. 12, no. 1, pp. 47-55, 2009.

[58] G. Goutianos, A. Tzioura, A. Kyparos, V. Paschalis, N. V. Margaritelis, A. S. Veskoukis, A. Zafeiridis, K. Dipla, and I. S. Vrabas, "The rat reflects human responses to exercise in blood biochemical profile: a comparative study," *Physiological reports*, vol. *3, no* 2, e12293, 2015.

[59] L. A. Brown, C. J. Kerr, P. Whiting, N. Finer, J. Mc Eneny and T. Ashton, "Oxidant stress in Healthy? Normal-weight, Overweight, and Obese Individuals," Obesity, vol. 17, pp. 460-466, 2009.

[60] J. M. Njinkoue, J. C. Manz-Koule, F. Tchoumbougnang, C. S. Milong Melong, N. C. Tchintchui, C. R. Fowe, F. J. Schweigert and I. Gouado, "Evaluation des effets hypolipidémiants de l'huile extraite du poisson *pseudotolithus senegalensis* chez des rattes ayant subi une dyslipidémie," Int. J. Biol. Chem. Sci., Vol.11, no. 6, pp. 2952-2961, 2017.