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Effect of GANIME form and it's efficacy on Lee index and albumin levels in rats with energy-protein deficiency (PED)

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ABSTRAK

Latar Belakang: *Prevalensi Kekurangan Energi Protein (KEP) meningkat selama dekade terakhir. Penyebab utama KEP yaitu asupan makanan tidak adekuat dan penyakit infeksi. Pengaturan klinis balita KEP menggunakan makanan komersil yang harganya mahal. Ganyong, ikan patin, dan kacang merah sebagai bahan pangan lokal dengan kandungan gizi tinggi berpotensi menjadi makanan tambahan bagi anak KEP.*
Tujuan: *Penelitian ini bertujuan untuk menguji pengaruh bentuk formula GANIME dan efikasinya terhadap indeks massa tubuh (BMI) dan kadar albumin pada tikus model dengan PED.*
Metode: *Penelitian terdiri dari dua tahap yaitu menganalisis kandungan proksimat GANIME dan melakukan penelitian in vivo pada sepuluh ekor tikus Wistar jantan berumur 3 minggu (50-100 gram). Tikus dibagi secara acak menjadi dua kelompok yaitu G1 (pelet GANIME) dan G2 (bubur GANIME) dan diamati selama 14 hari. Berat badan (BB), BMI, dan albumin diukur sebelum dan sesudah perlakuan. Uji t-berpasangan dilakukan untuk membandingkan hasil sebelum dan sesudah pengobatan, sedangkan perbedaan antar kelompok dinilai menggunakan uji One-way Analysis of Variance (ANOVA).*
Hasil: *Formula GANIME yang optimal diidentifikasi pada P3, dengan kandungan protein tertinggi (24,55%). Tikus G1 menunjukkan berat rata-rata 78,00 ± 15,52 g, tidak berbeda nyata dengan G2 (70,50 ± 2,12 g) (p = 0,565). Peningkatan bobot badan lebih besar pada tikus G1 dibandingkan G2 (12,67 g). Rata-rata BMI tikus G1 adalah 256,16 ± 25,57, tidak berbeda nyata dengan G2 (258,18 ± 2,59) (p = 0,923). Tikus G1 juga menunjukkan peningkatan BMI yang lebih besar dibandingkan dengan P2 (14,28). Rerata kadar albumin pada tikus G1 adalah 3,15 ± 0,56 g/dL, serupa dengan G2 (2,95 ± 0,36 g/dL) (p = 0,683). Tikus G1 mengalami penurunan albumin lebih kecil dibandingkan tikus G2, dengan selisih 0,08 g/dL.*
Kesimpulan: *Pemberian pelet formula GANIME lebih efektif meningkatkan berat badan dan IMT serta penurunan albumin yang lebih kecil pada tikus model KEP.*

KATA KUNCI*:* *kekurangan energi protein (KEP); albumin; indeks massa tubuh (IMT),; makanan local; GANIME*

ABSTRACT

Background: *The prevalence of Protein Energy Deficiency (PED) has increased over the past decade. Inadequate food intake and infectious diseases are the primary causes of PED. Clinical management of toddlers with PED often involves costly commercial foods. Ganyong, catfish, and red beans as local food ingredients with high nutritional content have the potential to be additional food for children with PED.*

Objectives: *This study aims to examine the effect of GANIME formula form and it's efficacy on body mass index (BMI) and albumin levels in the rats model with PED.*

Methods: *The study consisted of two phases: analyzing the proximate content of GANIME and conducting in vivo research using ten male Wistar rats aged 3 weeks (50-100 grams). The rats were randomly divided into two groups, G1 (GANIME pellets) and G2 (GANIME porridge), and were observed for 14 days. Body weight (BW), BMI, and albumin were measured before and after treatment. Paired t-tests were conducted to compare pre-and post-treatment results, while inter-group differences were assessed using One-Way Analysis of Variance (ANOVA) tests.*

Results: *The results showed that the optimal GANIME formula was identified at P3, with the highest protein and energy content. The G1 group of rats experienced a greater increase in body weight and BMI than the G2 group of rats but the increase was not significant (p > 0.05). Each group did not differ statistically significantly (0.644). Albumin in each group experienced a non-significant decrease (p > 0.05) and the two were not statistically different (0.690).*

Conclusions: *Administering the GANIME formula in pellet form exhibited superior efficacy because it's consumed more so it can increase body weight and BMI, and produce a lower decrease in albumin levels in rats model with PED.*

KEYWORD*:* *protein-energy deficiency (PED), albumin, body mass index (BMI), local food, GANIME formula*

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INTRODUCTION

In the past decade, the number of cases involving toddlers with Protein-Energy Deficiency (PED) has surged by 59 million cases (1). PED, characterized by unintentional weight (BW) loss and muscle mass reduction due to inadequate food intake, is responsible for a staggering 45% of under-five mortality worldwide (2). In Indonesia, the prevalence of undernourished children under five stands at 13.8%, with 3.9% of them experiencing malnutrition (3). PED during toddlerhood can significantly impede future growth and development, with malnutrition leading to diminished physical and cognitive functions (4).

Physical manifestations of PED in toddlers encompass parched and wrinkled skin, fragile hair and nails, an appearance of weakness and lethargy, and a gaunt physique (5). Children with PED also experience a decline in serum proteins like albumin and prealbumin (6). Albumin, the principal constituent (60%) of total plasma protein, is produced by the liver and normally ranges from 3.8 to 4.8 g/dL (7). Over decades, albumin has been utilized as a key biomarker for PED. A decrease in albumin levels can be attributed to inflammation (8). Elevated pro-inflammatory mediators like tumor necrosis factor-alpha (TNF-α) and interleukin-6 (IL-6) lead to reduced m-RNA albumin levels (9). The repercussions of PED on albumin intake are twofold, impacting both weight and muscle mass (10). Decreased muscle mass accompanies reduced nutrient absorption (11). The criteria for malnutrition, as established by ASPEN, encompass insufficient energy intake, reduced body weight and muscle mass, loss of subcutaneous fat, reduced fluid retention, and weakened grip strength. The diagnosis of PED is confirmed when two of these six conditions are met (12).

The ongoing government program aimed at addressing PED in toddlers involves providing supplementary food (PMT) in the form of biscuits (13). This program constitutes a targeted nutritional intervention directly delivered to toddlers (14). However, the PMT provision has yet to effectively combat this issue. New cases of PED are emerging at an alarming rate, indicating that the response's effectiveness is limited. Consequently, the prevalence of PED among children under five remains relatively unchanged (7). Alternative interventions are imperative to supplement this initiative. Modifying the PMT approach has proven effective in ameliorating the nutritional status of toddlers afflicted by PED (15). Indonesia, an agricultural nation, boasts abundant natural resources, including ganyong. Ganyong (Canna edulis Ker.), a tropical plant with high carbohydrate content (18.4%), holds potential as an alternative food source to replace rice (16). Carbohydrates serve as the primar energy source for metabolic systems. The country's fishing potential is substantial, reaching 12.54 million tons annually, with catfish (Pangasius sp.) being one of the notable varieties (17). Indonesia's waters teem with catfish, which are rich in protein (17%). This protein content is comparable to catfish (17.7%) and surpasses that of carp (16%) (16). Proteins function as energy sources, supplying amino acids essential for synthesizing cell proteins, hormones, and metabolic enzymes (18). Amino acids also contribute to the repair of damaged tissues in children with PED. The nation's legume potential is vast, with legumes constituting a prominent agricultural output (19). Despite the copious red bean (Phaseolus vulgaris) production, utilization remains suboptimal, necessitating optimization efforts. Red beans, boasting high protein content (22.1%), are rich in arginine, an activator of the growth hormone (Human Growth Hormone) and a guardian of immunity (16).

The direct administration of the GANIME formula to toddlers with PED is unfeasible due to its novelty and lack of prior utilization. Establishing rats as a toddler model for PED serves to offer a comprehensive portrayal of the interventions' impact during the clinical research phase (20). With this background in mind, the primary objective of this study is twofold: to assess the nutritional composition of the GANIME formula and to evaluate its efficacy when presented as pellets and porridge on various parameters, including body weight, Body Mass Index (BMI), albumin levels, physical-clinical attributes, and feed intake in the rats model with PED.

MATERIALS AND METHODS

Design, location, and time

The GANIME formulation consists of three distinct formulas, each containing a specific ratio of canna flour, catfish flour, and red bean flour—namely, P1 (40, 20, and 40)%, P2 (45, 25, and 30)%, and P3 (50, 30, and 20)% respectively. This formulation is developed considering the nutritional content of each ingredient, referencing the 2018 Indonesian Food Composition Table. The estimated nutritional content calculations for the GANIME formula are tailored to rat requirements. Nutritional content analysis for the GANIME formula was conducted in February 2023, under test number 02/LHA/LA/02/2023, at the Food Chemistry and Biochemistry Laboratory, Food Technology Study Program, Faculty of Agriculture, Universitas Sebelas Maret.

This study serves as a preliminary exploration into the effects of GANIME porridge consumption on amylase activity, albumin levels, and body weight in a rats model with PED. The care and treatment of experimental animals occurred at the Unit Pelayanan Teknis Laboratorium Terpadu Hewan Coba, Universitas Sebelas Maret, from February to April 2023. This research adopts an experimental laboratory approach, aiming to assess the efficacy of both GANIME pellets and porridge. The sample size was determined using the Festing formula, resulting in 5 rats for each treatment group (21). The entire research process obtained ethical approval from the Komisi Etik Penelitian, Faculty of Medicine, Universitas Sebelas Maret, under the designation 33/UN27.06.11/KEP/EC/2023.

Materials and tools

The core constituents of the GANIME formula encompass canna flour, catfish flour, and red bean flour. Canna flour and red bean flour were procured from online retailers, namely Riveroshop (Surabaya City, East Java) and

Nefababystore (Semarang City). Meanwhile, researchers manually prepared catfish flour using fresh catfish sourced from the Balekambang Fish Market in Surakarta City.

Preparatioan Rats Model with PED

The subjects enlisted for this study were male Wistar strain white rats, approximately three weeks old, and weighing between 50-100 grams. Rats exhibiting symptoms of diarrhea or illness were excluded based on predetermined criteria. The cages used in the experiment were made of plastic measuring 47 cm x 33 cm x 15 cm equipped with a water bottle and a standard feed container. The study commenced with seven days of acclimatization for the rats. The rat model used for PED was adapted from Agustina (2020) research, involving standard feed restrictions and modifications to the duration of modeling to 14 days (22).

Intervention

The allocation of subjects to groups was conducted randomly, forming treatment groups G1 (intervention involving GANIME pellets) and G2 (intervention involving GANIME porridge). The quantity of GANIME formula provided to rats was calculated at 10% of their body weight. Rearing cages were cleansed every three days to maintain a sanitary environment. The initial stage of modeling encompassed feed restrictions of 30% and 40% over four days, followed by 50% and 60% feed restrictions over three days in the subsequent stage.

Procedure

The methodology for fish meal production draws inspiration from Ningrum et al., (2017), with temperature and baking time modifications, specifically setting them at 125°C for approximately 5 hours (23). The determination of water, mineral, carbohydrate, protein, and fat content involves several distinct methods: thermogravimetry, dry method, difference method, kjeldahl method, and soxhletation.

Antropometry Measure

The observational aspect of the study encompasses multiple facets, including anthropometry, biochemistry, physical clinical assessments, and feed intake evaluation. BW and Body Mass Index (BMI), collected twice for each measurement (before treatment and after). Weights are recorded using a digital scale (Joil), while naso-anal length is measured with a measuring tape. BMI calculations are executed using the Lee Index formula (24).

$$\text{Lee Inde} = \left\{\frac{body\ weight\ (g)^{1/3}}{naso - anal\ length\ (cm)}\right\}\ x\ 10^3$$

Albumin Levels

Albumin levels was conducted before and post-treatment. Blood samples for albumin testing were collected via the retroorbital plexus, with a volume of two mL per rat. Analysis of albumin levels in the rats model with PED measured by at the Labolatorium Penelitian dan Pengujian Terpadu, Univerisitas Gajah Mada with photometric method using bromocresol blue (25).

The Physical-clinical Attributes

The physical-clinical attributes that were selected as PED biomarkers for this study encompassed skin condition, fur quality, ocular state, and behavioral traits (26). Regular daily observations were made regarding the physical and clinical aspects of the rats (27). An evaluation of feed intake centered on administration, consumption levels, and remaining feed was performed both pre-and post-treatment. Rats experiencing a 10% reduction in body weight along with albumin levels below 3.8 mg/dL and displaying passive movement were included as research subjects (26) (7) (28).

Data analysis

The nutritional content data for the GANIME formula, biomarkers, and physical observations of the rats model with PED are presented as percentages, means and standard deviations, as well as data categories. Data processing was executed using Statistical Program. The assessment of data normality was conducted through the Shapiro-Wilk test ($n \le 30$). Statistical analysis of the BW, BMI, and albumin levels for the rats model with PED encompassed paired t-tests for pre-post comparisons, and One-Way ANOVA tests were utilized ($p < 0.05$).

RESULTS AND DISCUSSIONS

The GANIME formulation boasts elevated protein levels, positioning it as a viable supplementary food option for PED sufferers. Nutritional composition of GANIME formula is presented in **Table 1**. There is no significant different on nutritional composition on GANIME formula (p > 0.05). The formula 3 GANIME (P3) tend to highest on protein (24.55%) and energy (361.35 kcal) than other formula. The GANIME formula aligns with Indonesian National Standard (SNI) 01-7111.1-2005 for instant baby food, meeting numerous SNI criteria including ash, fat, protein, and carbohydrate content, except moisture. GANIME formula's moisture content stands at 10.70%, exceendingly recommended of SNI threshold of < 4% (29). The protein content surpasses the Ministry of Health's PMT (8-12%) but fat and carbohydrate content falls below, with GANIME formula registering an average protein content of 22.52% (30)

Table 1. GANIME Formula Nutrition Content per 100 gram

Parameters	Formulas			*p-value**
	P1	P2	P3	
Moisture (%)	10.66	10.72	10.71	0.357
Ash (%)	2,45	2.29	2.16	0.102
Fat (%)	2.55	2.35	2.57	0.165
Protein (%)	21.14	21.87	24.55	0.156
Carbohydrate (%)	63.20	62.77	60.01	0.180
Energy (kcal)	360.29	359.78	361.35	0.003

*Data are presented as mean (n=2). Kruskal-Wallis (α=5%)

This phenomenon is likely attributed to amylopectin's water-binding capability when subjected to heat, leading to an increase in moisture content. The primary source of amylopectin in the formula is canna flour, which contains a substantial proportion of amylopectin (76%). Regrettably, the heightened water content introduces an elevated risk of quicker spoilage. Persistent biological activity is fostered by the sustained presence of moisture, enabling the accelerated spoilage of products (31). The GANIME formula's ash content conformed to the normal parameters stipulated by SNI (≤ 3.5%) (29). It is conjectured that a considerable portion of the ash content emanates from red beans. Consequently, the inclusion of red beans in the formula is presumed to influence the ash content. This finding is congruent with the previous research of which elucidated that the introduction of turi bean flour can escalate ash content (32). The ash content is intricately connected to the product's mineral composition. Given that minerals play a pivotal role in averting mineral deficiencies among PED patients, their presence is of paramount importance.

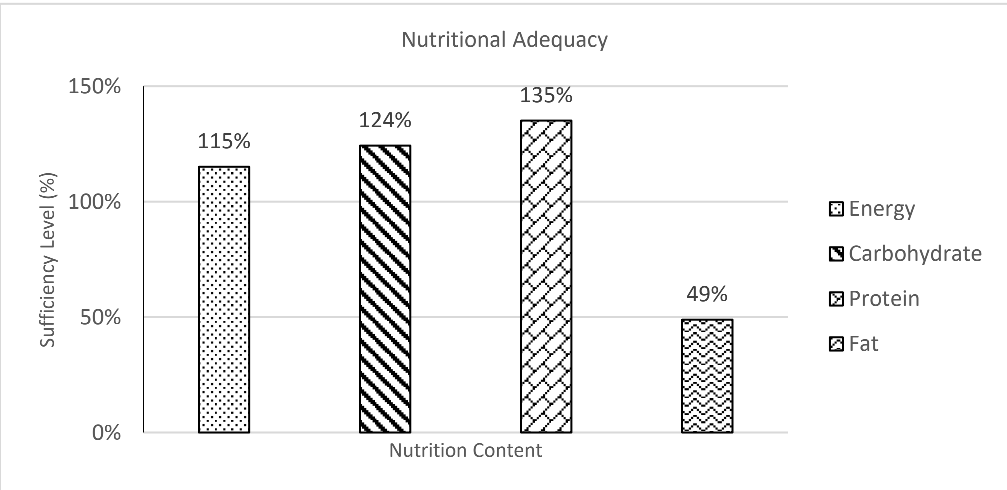

Figure 1. Nutrition Adequacy of Rats Model with PED fed the GANIME Formula. Determination of the amount of feed based on 10% BW of Rats.

Figure 1 demonstrates the extent of nutritional fulfillment within the PED rat model when fed with the GANIME formula at 10% of body weight. The preliminary research focused on the utilization of Formula 1, or P1 GANIME, due to its elevated energy and protein content. Although a majority of the nutritional constituents within GANIME Formula 1 align with the rats' nutritional requirements, the fat content only satisfies 49% of their needs.

The primary contributor to the fat content within the GANIME formula is believed to be catfish meal, given that catfish flour possesses a higher fat content (6.6%) (16). The fat content across all three GANIME formula variations surpasses the parameters stipulated by the Indonesian National Standard (SNI) of 1.5% (29). The high fat content in the ingredients can trigger adverse effects, because its changes during storage can endanger the health and longevity of the product. Protein content of GANIME formula adheres to the requisites outlined by SNI 2005 (minimum 8%) (29). This protein originates predominantly from catfish flour and red beans. Catfish is a source of animal protein (17%), while red beans are a vegetable source, (22.1%) (16). Protein plays an important role in new tissue formation, growth, maintenance, and various physiological functions of the human body. The carbohydrate content within the GANIME formula aligns with SNI standards for instant baby food (minimum 30%) (29). The components responsible for carbohydrate supply within the formula are ganyong and red beans. Ganyong boasts a relatively high carbohydrate content of 18.4%, while red beans offer an even higher carbohydrate content of 56.2% (16). It is noteworthy that the carbohydrate content's increase runs inversely proportional to the inclusion of canna flour but directly proportional to the addition of red beans. A diet enriched with high-carbohydrate foods proves beneficial for individuals grappling with PED as these foods provide essential glucose support for bodily functions and activities. Given that carbohydrates stand as the primary energy source, any curtailment in their intake can potentially impact the growth and development of children (11).

Characteristics of Rats

Indications of PED in rats encompassed a decline in both BW and BMI, sub-optimal of albumin levels, atypical physical-clinical states, and inadequate Intake The outcomes of the analysis of study rats characteristics post-14 days are illustrated in **Table 2.**

Table 2. Characteristics of Rats Model with PED

Biomarkers	**(Mean ± SD)**		***p-value****
	G1	**G2**	
Body weight (g)	52.60 ± 2.07	51.40 ± 5.77	0.673
BMI	243.43 ± 6.17	247.59 ± 9.37	0.432
Albumin (g/dL)	3.26 ± 0,18	3.12 ± 0.30	0.419

*Data are presented as mean ± standar deviatin (s.d) (n=10). G1 (fed with GANIME pellets), G2 (fed with GANIME porridge), BMI (Body Mass Index) using the Lee Index. *Paired t-test (α=5%)

Statistically, variables such as BW, BMI, and albumin levels of the research rats exhibited homogeneity ($p > 0.05$). The mean weight and albumin levels within the G1 group surpassed those of the G2 group, yet the G1 group's BMI was tent to inferior to that of G2.

Table 3.Physical Observation of Rats Model with PED

Physical Observation	**Observation Treatment**	**Observation Day-**		
		1	**2-7**	**8-14**
Hair	G1	N	NN	NN
	G2	N	NN	NN
Skin	G1	N	N	N
	G2	N	N	N
Eye	G1	N	N	N
	G2	N	N	N

Physical Observation	Observation Treatment	Observation Day- 1	2-7	8-14
Behavior	G1	N	N	NN
	G2	N	N	NN

N (Normal), TN (Not Normal).

Table 3 showcases the results of physical observations conducted on the research rats' condition, inclusive of hair, skin, eyes, and behavior, after the 14-day modeling period. Initial physical observations of the study rats exhibited normal conditions across all groups on the first day. However, by the seventh day, physical assessments disclosed aberrant conditions, characterized by disheveled and shedding fur, while the state of skin, eyes, and behavior still appeared normal. The behavioral aspect of the study rats appeared to be passive after the 14-day modeling period, as they exhibited a propensity for tranquility, tending to occupy corners within their cages.

After food restriction treatment, the rats prominently exhibited signs indicative of PED. Several PED criteria were conspicuous, such as, dwindling BW along with BMI, suboptimal albumin levels and manifestly irregular physical conditions. A 7% reduction in rat weight materialized on the 9th day of the modeling phase. As the modeling extended to the 14th day, the rats encountered a pronounced BW reduction, with the maximum decrease reaching 23%. This conspicuous dip in BW serves as a clear indication of PED manifestation in the rodents. Furthermore, the BMI calculation performed on the 14th day of modeling across both groups yielded an average of 248.57, thus establishing a reference for rat models experiencing PED. Biochemical scrutiny unveiled that albumin levels among the groups were as follows: G1 (3.26 ± 0.18 g/dL) and G2 (3.12 ± 0.30 g/dL), both falling beneath the standard threshold (3.8 g/dL). The rats' physical condition presented a visibly emaciated appearance, complemented by subdued movements, signifying a passive demeanor. Given these observations, the researchers confidently concluded that the rats had indeed developed PED following the 14-day modeling period.

Table 4. Changes in albumin, body weight, and BMI of Rats Model with PED Before and After Treatment

Variabel	(Mean ± SD) G1	G2	*p-value**
BW (gram)			
Before	65.33 ± 4.50	63.00 ± 5.65	0.639
After	78.00 ± 15.52	70.50 ± 2.12	0.565
Δ BW	12.67 ± 13.32	7.50 ± 3.54	0.644
*p-value***	(p=0.241)	(p=0.205)	
BMI			
Before	241.88 ± 13.82	248.58 ± 7.45	0.586
After	256.16 ± 25.57	258.18 ± 2.59	0.923
Δ BMI	14.28 ± 15.02	9.60 ± 4.86	0.711
*p-value***	(p=0.241)	(p=0.219)	
Albumin (g/dL)			
Before	3.23 ± 0.21	3.22 ± 0.32	0.963
After	3.15 ± 0.56	2.95 ± 0.36	0.683
Δ Albumin	-0.08 ± 0,34	-0.27 ± 0.67	0.690
*p-value***	(p=0.736)	(p=0.674)	

*: One-way ANOVA test, **: Paired T-Test, Significance ($p < 0.05$).

The average BW and BMI of the rats model with PED Analyzing Table 4, it becomes apparent that there existed an inconsequential increase in BW and BMI ($p > 0.05$) after treatment. The most substantial BW and BMI augmentation was observed within Group G1, each of 12.67 grams and 14.28. The inter group distinctions on all phases, encompassing pre, during and post-treatment remained statistically insignificant ($p > 0.05$).

Rats consume approximately 15.6 g/day of feed, which equates to roughly 10% of their overall BW. This amount content about of 72 kcal of energy which is able to meet the calorie needs of rats (62.56 kcal/day) (33). The BW of rats experiences an uptick when calorie intake surpasses expenditure. Furthermore, the complete amino acid profile in the GANIME formula significantly contributes to the increase in BW. This synergistic amalgamation of amino acids sourced from catfish and red beans engenders a complementary interplay within the product (34).

Increases in BMI typically correlate with food intake (35). BMI serves as a metric to gauge healthy weight levels. To calculate the rats' BMI, their length and body weight were factored in drawing upon the Lee Index (24). Evidently, the rats' BMI surged, presumably due to their consumption of the GANIME formula, which exceeded their caloric requirements. Various additional factors contribute to fluctuations in BMI, encompassing physical activity, genetic predisposition, medical conditions, and lifestyle habits (36).

Average Albumin of the rats model with PED

Table 4 showcases an insubstantial decline in albumin levels within both groups ($p > 0.05$) during the intervention. Intriguingly, the most minimal albumin reduction surfaced within Group G1, registering at -0.08 g/dL. Across the treatment groups, statistically insignificant disparities persisted ($p > 0.05$) throughout all stages encompassing pre, during and post-treatment.

After treatment, rats model with PED exhibited a discernible decrease in albumin levels. This dip in albumin is not consistent with earlier research that entailed administering mocaf to rats models of PED (37). The suboptimal albumin levels detected in the PED rat models can be attributed to insufficient feed intake and prevailing infectious diseases. PED sufferers often endure concurrent infections due to their association with child malnutrition. The albumin decline post-treatment is conjectured to be a consequence of pathological disturbances within the rats models with PED. The mitigation of low albumin levels cannot solely be achieved by augmenting protein intake; it necessitates a comprehensive approach addressing the underlying pathological condition (38). This albumin decrease is likely attributable to the utilization of protein from the GANIME formula for the repair of muscle tissue damaged by the prevailing PED conditions (39). Figure 2 illustrates the outcomes of assessing GANIME formula consumption in rats modeling PED throughout the treatment period. In the initial week, all groups displayed a 100% consumption rate of the GANIME formula feed, indicating full consumption. As the second week progressed, the G1 group showcased the most substantial feed intake, equivalent to 77.7%. In the first week, no leftover feed remained within any treatment group in the first week, signifying complete consumption. However, in the second week, the G1 group exhibited the lowest remaining feed, tallying at 5.2 grams.

The nutritional composition of the GANIME formula appears to adequately fulfill the nutritional requisites of the rats model with PED. The decline in feed consumption witnessed during the intervention can be attributed to the rats' intrinsic tendency to curtail their food intake upon meeting their energy demands (40). It is postulated that the GANIME formula feed encompasses elevated sugar levels, potentially influencing the satiety center within the hypothalamus. The notable sugar content in the feed might impact the entromedial sensor, consequently inducing a reduction in appetite and subsequently leading to diminished food intake (33).

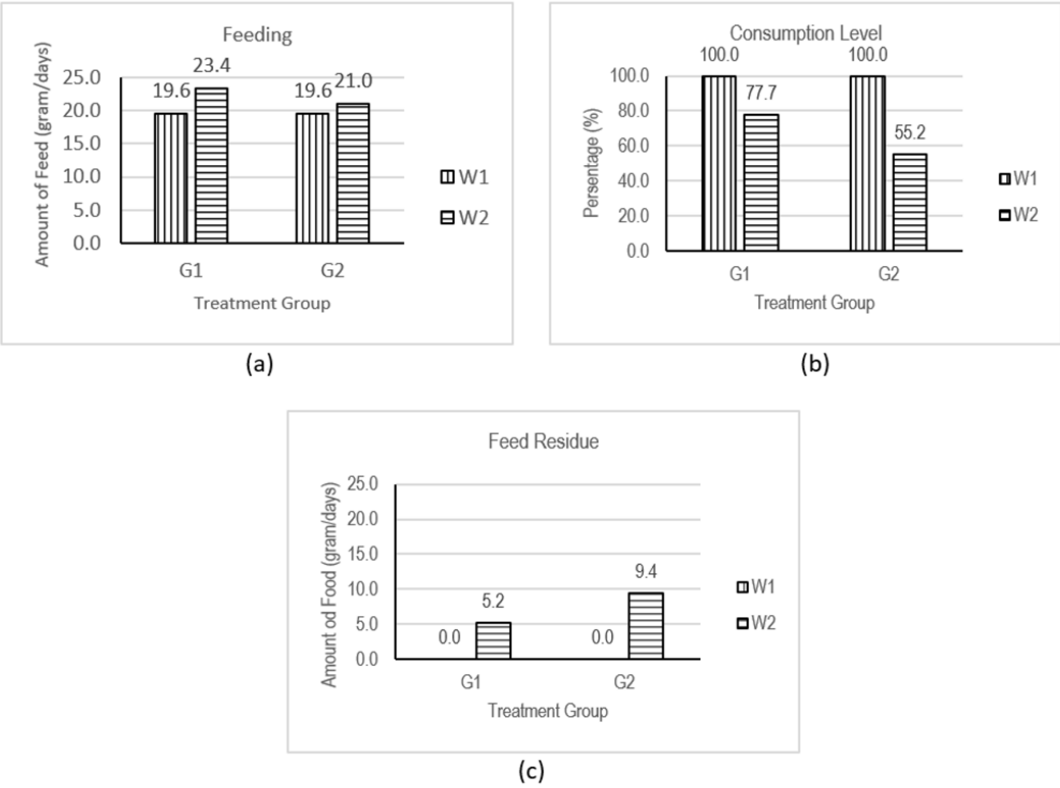

Figure 2. GANIME Intervention Feed Intake. (a) feeding, (b) feed consumed, and (c) remaining food that is not consumed by given to the rats model with PED, M1 (first week), M2 (second week).

CONCLUSIONS AND RECOMMENDATIONS

The GANIME formula, with a composition ratio of 50:30:20, emerges as the optimal formulation due to its high protein (24.55%) and carbohydrate (60.01%) content that fulfills the daily requirements. Administering the GANIME formula in pellet form exhibited superior efficacy because it's consumed more so it can increase body weight and BMI, as well as produce a lower decrease in albumin levels in rats model with PED. Further research on the GANIME formula needs to be carried out to reduce the water content, increase the fat and carbohydrate content.

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