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EFFECT OF 75% *IRVINGIA GABONENSIS* FLOUR ON ANTHROPOMETRIC PARAMETERS IN RATS RENDERED OBESE BY CRUDE PALM OIL

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ABSTRACT

Obesity is currently one of the major global public health issues. It is characterized by an excessive accumulation of body fat resulting from a prolonged imbalance between energy intake and expenditure. *Irvingia gabonensis* is a non-timber forest product widely utilized in West and Central Africa for both food and medicinal purposes. This study aimed to evaluate the effect of supplementation with 75% *Irvingia gabonensis* flour on obesity induced by a diet enriched with 15% red palm oil in Wistar rats. Fifteen (15) rats were randomly assigned to three homogeneous experimental groups of five animals each. Two diets were formulated for the experiment: a standard diet, used to feed the control group; and an obesity-inducing diet, created by supplementing the standard diet with 15% crude palm oil. A second group (the obese control group) received this latter diet. Finally, a third group received a diet consisting of 25% of the obesity-inducing diet and 75% *Irvingia gabonensis* flour; this constituted the treated group. Body weight in the rats of Groups 1 and 2 increased significantly during the obesity induction phase (week 3) compared to the control group. However, the body weight of the rats in Group 2 (LIg75%) decreased significantly ($p < 0.05$) starting from the fourth week following the introduction of the 75% *Irvingia gabonensis* flour into the diet. Food intake among rats in Group 2 (LIg75%) during the treatment weeks did not differ significantly from that of the control group and Group 1. The quantity of feces produced by rats in Group 2 was higher than that of Group 1. The feed conversion ratio (FCR) for Group 2 (LIg75%) gradually normalized over the course of the treatment weeks. Protein efficiency (PE) followed the same trend, showing a gradual recovery in Group 2 during weeks 4 and 5. In conclusion, the diet consisting of 75% *Irvingia gabonensis* flour and 25% high-fat diet (15% crude palm oil added to the standard diet) exerts significant biological and metabolic effects.

Keywords: *Irvingia gabonensis*, Anthropometric, Rats, Obesity-inducing diet, Consumption

1 INTRODUCTION

Obesity is currently one of the world's major public health issues. It is characterized by an excessive accumulation of body fat resulting from a prolonged imbalance between energy intake and expenditure. This condition is recognized as

a significant risk factor for numerous non-communicable diseases, such as type 2 diabetes, cardiovascular disease, hypertension, and certain cancers [1]. Its incidence continues to rise in both developed and developing countries. According to the World Health Organization, the prevalence of overweight rose from 26% to 34% over a decade, making the prevention and management of obesity a public health priority [2]. Among the nutritional factors involved in the development of obesity, excessive fat consumption plays a significant role. In West Africa, crude palm oil or red oil is a primary source of dietary lipids. Several studies have shown that a diet containing more than 15% red palm oil induces significant weight gain and metabolic disturbances in Wistar rats [3; 4]. These effects are primarily attributed to its high saturated fatty acid content specifically palmitic acid which promotes adipose tissue accumulation and the onset of lipid disorders [5]. However, an observation frequently made in the Tonkpi region of western Côte d'Ivoire raises a scientific question. Populations in this region traditionally and regularly consume red palm oil as part of their daily diet. Based on current knowledge, this dietary habit would be expected to lead to a high prevalence of obesity; yet, this does not appear to be consistently the case among these populations. Analyse of local dietary habits reveals that populations in the Tonkpi region frequently incorporate flour derived from the kernels of *Irvingia gabonensis* commonly known as wild mango or kplé in the Yacouba language into their diet. This flour is widely used as a thickening agent in traditional sauces. An abundant and accessible natural resource, *Irvingia gabonensis* is a non-timber forest product widely utilized in West and Central Africa for both culinary and medicinal purposes [6]. Its kernels are recognized for their high content of dietary fiber, protein, and bioactive compounds capable of exerting beneficial effects on lipid and carbohydrate metabolism [7]. Previous studies have shown that the soluble fibers found in *Irvingia gabonensis* can reduce intestinal lipid absorption, improve blood lipid profiles, and contribute to weight loss [7; 8]. Regular consumption of this flour could mitigate the obesogenic effects associated with a diet high in red palm oil. Consequently, it is reasonable to ask whether the regular consumption of *Irvingia gabonensis* flour might be the dietary factor capable of limiting or counteracting the obesogenic effects of red palm oil among the populations of the Tonkpi region. Thus, the hypothesis of this study is that *Irvingia gabonensis* flour could act as a protective factor against obesity induced by red palm oil. Verifying this hypothesis would not only provide a better understanding of the mechanisms involved in this nutritional interaction but also promote the value of a local forest resource in the prevention and management of obesity. The central question of this study is, therefore, whether supplementation with 75% *Irvingia gabonensis* flour can prevent or reduce obesity induced by a diet enriched with 15% red palm oil in Wistar rats. The aim of this study is thus to evaluate the effect of 75% *Irvingia gabonensis* flour supplementation on obesity induced by a diet enriched with 15% red palm oil in Wistar rats.

2 MATERIALS AND METHODS

2.1 Plant material

The plant material used in this study consists of seeds from *Irvingia gabonensis* (Irvingiaceae) commonly known as wild mango or African mango purchased at the local market in the town of Man, in western Côte d'Ivoire, and then shade-dried (in an air-conditioned room) for 72 hours before being processed into flour.

2.2 Animal material

The animal material consists of fifteen (15) growing albino rats (*Rattus norvegicus*) both male and female of the Wistar strain, weighing between 36 g and 42 g and aged approximately 3 to 4 weeks. The animals were obtained from the Central Laboratory of the University of Man (LCA-UMAN). They had free access to food and water under standardized conditions, including a 12-hour light/dark cycle and ambient temperature. All protocols were conducted in accordance with European legislation regarding the welfare of laboratory animals [9].

2.3 Ethical considerations

All animal procedures were performed in accordance with ethical guidelines regarding the use of laboratory animals and animal welfare, in compliance with the protocols of European Council Directive 2010/707 [9].

2.4 Dietary materials

Five food ingredients were used to formulate the experimental diets: palm oil, maize, fish meal, water, and mineral salt. Palm oil, which is rich in saturated fatty acids, was used as the primary lipid source to induce experimental obesity in rats [3; 4]. In this study, palm oil was incorporated at a level of 15% in the diets for the obese group and the group treated with *Irvingia gabonensis*, compared to 2% in the control group's diet. The diet for the obese group consisted of palm oil, maize, fish meal, mineral salt (sodium chloride, NaCl), and water, mixed in proportions of 15 g, 52.14 g, 18.86 g, 2.4 g, and 11.6 g, respectively, to make a total of 100 g. The control group received a standard diet composed of 2 g of palm oil, 57 g of maize, 25 g of fish meal, 13 g of water, and 3 g of mineral salt, totaling 100 g.

2.5 Laboratory equipment

A variety of equipment was used to carry out this study. Individual cages were used to house the animals. An electronic scale was used to weigh the feed and the rats.

2.6 Methods

2.6.1 Preparation methods of *Irvingia gabonensis* flour

The process of preparing *Irvingia gabonensis* flour involves harvesting, cracking, drying the kernels, and processing them into flour. Once harvesting is complete, the fruit must be cracked open to extract the kernels. The kernels were spread in a thin layer on a clean surface for 72 hours at room temperature. The dried kernels were then stored in airtight containers until use. The powder was obtained by grinding the *Irvingia gabonensis* seeds in a blender to produce a fine powder.

2.6.2 Method for experimental induction of obesity

Experimental obesity was induced in the rats of the obesity group (LO) by administering a diet enriched with 15% red palm oil for three (3) weeks. This proportion represents the 15% reference threshold in dietary conditions [3] that generates a lipid surplus, promoting the accumulation of adipose mass and metabolic disturbances characteristic of obesity. Significant weight gain compared to the control group was used as the criterion to validate the induction of obesity [10].

2.6.3 Formation of experimental groups and diet formulation

After a five-day (5) acclimatization period under standard animal facility conditions, the fifteen (15) rats were randomly assigned to three homogeneous experimental groups of five animals each. Three distinct diets were formulated based on the experimental objectives of each group. Rations were prepared daily using individually weighed ingredients, which were then manually mixed until a homogeneous blend was obtained. The oil content in the standard diet (LT) was set at 2%. The obese group (LO) received a diet enriched with 15% crude palm oil, serving as a reference for rats rendered obese after 3 weeks of feeding [3]. A group of obese rats was treated with a diet consisting of 25% of the obesity-inducing diet and 75% *Irvingia gabonensis* flour. The detailed composition of the three diets is presented in Table 1. The experiment lasted 5 weeks, comprising a 3-week obesity induction phase using the obesity-inducing diet and a 2-week treatment phase involving the incorporation of 75% *Irvingia gabonensis* flour. Rations were distributed once daily. Water was provided *ad libitum* throughout the experiment. Feed residues were collected and weighed daily to calculate the food intake of each group.

Table 1: Composition of experimental diets (in g per 100 g of ration)

Ingrédients	LT (g/100g)	LO (g/100g)	LIg75% (g/100g)	
			Obesity diet	reatment diet
Corn	57	52.14	52.14	25 (One portion of the obesity diet) +75 <i>Irvingia gabonensis flour</i>
Fish powder	25	18.86	18.86	
Red palm oil	2	15	15	
Mineral salt	3	2.4	2.4	
Water	13	11.6	11.6	
Total	100	100	100	100

2.6.4 Measurement of anthropometric parameters

At the end of the experimental period, the following anthropometric parameters were measured or calculated for each animal, following the methodology described in [3; 11]:

Weight gain (WG): The body weight of each rat was measured individually once a week using a previously calibrated precision electronic scale. Weight gain (WG) was calculated using the formula from [3]:

$$WG (g) = Pf - P0$$

Pf = final weight (g); P0 = initial weight (g)

Feed conversion ratio (FCR): ratio of the amount of food consumed to the mass gain over the same period.

$$(\text{FCR}) = \frac{\text{Quantity of feed consumed during a given period}}{\text{Weight gain during the same period}}$$

Protein efficiency (PE): ratio of the amount of protein consumed to the mass gained over the same period [11].

$$(\text{EP}) = \frac{\text{Protein consumed (g)}}{\text{Weight gain during the same period}}$$

Energy efficiency (EE): ratio of the amount of energy consumed to the mass gain over the same period [11].

$$(\text{EE}) = \frac{\text{amount of energy consumed during a given period}}{\text{weight gain during the same period}}$$

Digestibility coefficient (DC): determined by daily collection of excreta between 9:00 and 10:00 a.m., dried at 20°C for 24 h on a ventilated bed, and then weighed [3].

$$(\text{ID}) = \frac{(\text{Amount of feed consumed} - \text{mass of droppings produced during a given period})}{\text{weight gain during the same period}}$$

2.7 Statistical analyses

Results were expressed as the mean followed by the standard error of the mean ($M \pm \text{SEM}$). Comparisons between experimental groups (LT, LO, LIg75%) were performed using a one-way analysis of variance (ANOVA1) followed by the Tukey-Kramer test. The significance thresholds used were: $p < 0.05$ (significant), $p < 0.01$ (very significant), $p < 0.001$ (highly significant), and $p < 0.0001$ (extremely significant).

3 RESULTS

3.1 Changes in rat weight following supplementation with 75% *Irvingia gabonensis* flour after palm oil-induced obesity

Prior to obesity induction, the mean initial weight of the rats did not differ significantly ($p > 0.05$), ranging from 52.0 ± 2.08 g to 54.0 ± 2.52 g. During the third week marking the end of the obesity induction phase using a high-fat diet the weight of rats in Group 1 (LO) increased significantly ($p < 0.001$) by 51.0%, and that of Group 2 (LIg75%) by 47.9%, compared to the control group ($p < 0.001$) (Table 2). During the fourth week of treatment, following the introduction of 75% *Irvingia gabonensis* flour into the diet of Group 2 (LIg75%), the weight of these rats (115 ± 6.12 g) decreased significantly ($p < 0.05$) by 14.8% compared to Group 1 (135 ± 3.93 g), approaching the control group's weight with a difference of only 4.5%. By week 5, this trend was confirmed: Group 2 (120 ± 5.24 g) showed a difference of only 2.6% relative to the control group, compared to 25.6% for Group 1 ($p < 0.01$).

Table 2: Changes in rat weight (g) following supplementation with 75% *Irvingia gabonensis* flour after palm oil-induced obesity

Groups	Variation in animal weight			
	Obesity induction period		Treatment period	
	Initial weight	Week 3	Week 4	Week 5
Control	52.0 ± 2.08	92.7 ± 4.41	110 ± 1.45	117 ± 2.89
Lot 1 (LO)	52.7 ± 1.86	140 ± 3.06 a***	135 ± 3.93 a*	147 ± 2.08 a**
Lot 2 (LIg75%)	54 ± 2.52	137 ± 3.76 a***	115 ± 6.12 b*	120 ± 5.24 b**

a*** ($P < 0.001$): significant difference compared to the control group. b* ($P < 0.05$); b** ($P < 0.01$): significant difference between Group 1 and Group 2.

3.2 Weight gain in rats following supplementation with 75% *Irvingia gabonensis* flour after palm oil-induced obesity

Weight gain provides an objective measure of the magnitude of weight increase during the experiment. At week 3, the weight gain of Group 1 (LO) was 87.3 g, an increase of 114.5% compared to the control group (40.7 g). That of Group 2 (LIg75%) was 83.0 g, an increase of 103.9% compared to the control group during the same induction period. After treatment in week 4, the weight gain of Group 2 (61.0 g) decreased by 25.9% compared to Group 1 (82.3 g), differing by only 5.2% from the control (58.0 g). In week 5, Group 2 (66.0 g) recorded a 30.0% reduction compared to Group 1 (94.3 g), with a difference of only 1.5% compared to the control (65.0 g) (Table 3).

Table 3: Weight gain of rats (g) following supplementation with 75% *Irvingia gabonensis* flour after palm oil-induced obesity

	Weight gain		
Groups	Week 3	Week 4	Week 5
Témoin	40,7	58,0	65,0
Lot 1 (LO)	87.3 (+114.5%)	82.3 (+41.9%)	94.3 (+45.1%)
Lot 2 (LIg75%)	83.0 (+103.9%)	61.0 (–25.9%)	66.0 (–30.0%)

Weight gain (g) derived from body weight changes. n = 5, mean ± SEM.

3.3 Average feed intake following supplementation with 75% *Irvingia gabonensis* flour after palm oil-induced obesity

Feed intake for the control group was 61.0 ± 7.00 g, 57.7 ± 6.64 g, and 55.7 ± 8.51 g in weeks 3, 4, and 5, respectively. For rats in Group 1 (LO), feed intake decreased by 4.3%, 5.7%, and 13.1% in weeks 3, 4, and 5 compared to the control. For rats in Group 2 (LIg75%), feed intake decreased by 8.5%, 11.8%, and 8.3% in weeks 3, 4, and 5 compared to the control (Table 4).

Table 4: Average feed intake (g) following supplementation with 75% *Irvingia gabonensis* flour after palm oil-induced obesity

	Quantity of food		
Lot	Obesity induction period (Week 3)	Treatment period	
		Week 4	Week 5
Témoin	$61,0 \pm 7$	$57,7 \pm 6,64$	$55,7 \pm 8,51$
Lot 1(LO)	$58,4 \pm 5,3$	$54,4 \pm 5,81$	$48,4 \pm 7,5$
Lot2 (LIg75%)	$55,8 \pm 6,1$	$50,9 \pm 7,21$	$51,1 \pm 6,2$

(P > 0.05): no significant difference in the amount of food consumed compared to the control group rats. FIg75%: *Irvingia gabonensis* flour 75%; LO: Obese Group; n = 5, m ± SEM.

3.4 Daily fecal output for each rat group following supplementation with *Irvingia gabonensis* flour

Table 5: Daily fecal output (g) for each rat group following supplementation with *Irvingia gabonensis* flour

	Amount of feces produced		
Groups	Obesity induction period (Week 3)	Treatment period	
		Week 2	Week 3
Control	50	43	40
Lot 1 (LO)	48,0 (–4,0%)	41,0 (–4,7%)	33,0 (–17,5%)
Lot 2 (LIg75%)	45,0 (–10,0%)	42,0 (–2,3%)	37,0 (–7,5%)

Quantity of feces measured during the experiments. FIg75%: *Irvingia gabonensis* flour 75%; LO: Obese Group; n = 5, m ± SEM.

Fecal output for the control group was 50.0 g, 43.0 g, and 40.0 g during the obesity induction week (week 3) and the treatment weeks (weeks 2 and 3). In Group 1 (LO) rats, fecal output decreased by 4.0%, 4.7%, and 17.5% compared to the control during the induction week (week 3) and the treatment weeks (weeks 2 and 3). For Group 2 (LIg75%) rats, a

decrease of 10.0%, 2.3%, and 7.5% was observed compared to the control. The more pronounced reduction in fecal output in Group 2 (Llg75%) during week 3 reflects improved intestinal nutrient absorption due to the fibers in the *Irvingia gabonensis* flour (Table 5).

3.5 Digestibility index (DI) after supplementation with *Irvingia gabonensis* flour

The digestibility index was calculated for the three groups over the three-week period. In the control group, the digestibility index was 0.270, 0.253, and 0.242 in weeks 3, 4, and 5, respectively. In the rats of Group 1 (LO), DI values decreased by 55.9%, 35.6%, and 32.6% in weeks 3, 4, and 5 compared to the control group. As for the rats in Group 2 (Llg75%), the DI also decreased by 51.9%, 42.3%, and 11.6% compared to the control group (Table 6).

Table 6: Digestibility index (DI) after supplementation with *Irvingia gabonensis* flour

	Digestibility index		
Goups	Obesity induction period (Week 3)	Treatment period	
		Week 4	Week 5
Control	0.270	0.253	0.242
Lot 1(LO)	0.119 (-55.9%)	0.163 (-35.6%)	0.163 (-32.6%)
Lot2 (Llg75%)	0.130 (-51.9%)	0.146 (-42.3%)	0.214 (-11.6%)

Digestibility index determined based on food consumed, fecal mass, and weight gain. Flg75%: *Irvingia gabonensis* flour; LO: Obese Group; n = 5, m ± SEM.

3.6 Feed Conversion Ratio (FCR) after supplementation with *Irvingia gabonensis* flour

In the control group, FCR values were 1.499, 0.995, and 0.857 in weeks 3, 4, and 5, respectively. In Group 1 (LO) rats, the FCR decreased by 55.4%, 33.6%, and 40.1% compared to the control group in weeks 3, 4, and 5; this reflects better feed conversion linked to the high energy density of the obesogenic diet. In Group 2 (Llg75%) rats, an FCR decrease of 55.2%, 16.2%, and 9.7% was observed compared to the control group (Table 7).

Table 7: Feed Conversion Ratio (FCR) after supplementation with *Irvingia gabonensis* flour

	Feed conversion ratio		
Lot	Obesity induction period (Week 3)	Treatment period	
		Semaine 4	Semaine 5
Témoin	1.499	0.995	0.857
Lot 1(LO)	0.669 (-55.4%)	0.661 (-33.6%)	0.513 (-40.1%)
Lot2 (Llg75%)	0.672 (-55.2%)	0.834 (-16.2%)	0.774 (-9.7%)

Feed conversion ratio determined based on feed consumed and weight gain. Flg75%: *Irvingia gabonensis* flour 75%; LO: Obese group; n = 5, m ± SEM.

3.7 Protein efficiency (PE) after supplementation with *Irvingia gabonensis* flour

Table 8: Protein efficiency (PE) after supplementation with *Irvingia gabonensis* flour

	Protein efficiency		
Groups	Obesity induction period (Week 3)	Période de traitement	
		Semaine 2	Semaine 3
Control	0.283	0.188	0.162
Lot 1(LO)	0.126 (-55.5%)	0.125 (-33.5%)	0.097 (-40.1%)
Lot2(Llg75%)	0.127 (-55.1%)	0.157 (-16.5%)	0.146 (-9.9%)

Protein efficiency (%) determined based on the amount of protein consumed and weight gain. Flg75%: *Irvingia gabonensis* flour 75%; LO: Obese group; n = 5, m ± SEM.

In the control group, PE values were 0.283, 0.188, and 0.162 in weeks 3, 2, and 3, respectively. In rats from Group 1 (LO), PE decreased by 55.5%, 33.5%, and 40.1% compared to the control group. In rats from Group 2 (Llg75%), PE decreased by 55.1% in week 3, then progressively increased by 16.5% in week 2 and 9.9% in week 3 compared to the control group (Table 8).

3.8 Energy efficiency (EE) following supplementation with *Irvingia gabonensis* flour

The energy value of the LT diet was estimated at 2.955 kcal/g, and that of the LO and Llg75 diets at 4.305 kcal/g (due to the addition of 15% palm oil). In the control group, EE values were 4.429, 2.940, and 2.532 kcal/g in weeks 3, 4, and 5, respectively. In Group 1 (LO) rats, EE decreased by 35.0% in week 3 and remained stable between weeks 2 and 3. In Group 2 (Llg75%) rats, EE increased by 22.2% in week 4 and by 31.6% in week 5 compared to the control group, indicating greater energy mobilization for metabolic processes associated with the incorporation of *Irvingia gabonensis* fibers into the diet (Table 9).

Table 9: Energy efficiency (EE) following supplementation with *Irvingia gabonensis* flour

Groups	Energy efficiency		
	Obesity induction period (Week 3)	Treatment period	
		Week 4	Week 5
Control	4.429 kcal/g	2.940 kcal/g	2.532 kcal/g
Lot 1(LO)	2.880 (–35.0%)	2.846 (–3.2%)	2.210 (–12.7%)
Lot2(Llg75%)	2.894 (–34.7%)	3.592 (+22.2%)	3.333 (+31.6%)

Energy efficiency (EE) determined based on energy intake and weight gain. Flg75%: *Irvingia gabonensis* flour 75%; LO: Obese group; n = 5, mean ± SEM.

4 DISCUSSION

The body weight of rats in Groups 1 and 2 increased significantly during the obesity induction phase (week 3) compared to the control group. This excessive weight gain is attributable to the high energy density of the saturated fatty acids in red palm oil (9 kcal/g versus 4 kcal/g for carbohydrates), which promotes a positive energy balance leading to the accumulation of adipose mass [4; 12]. These results align with those of [3], who demonstrated that a high-fat diet containing more than 15% red palm oil induces significant weight gain in Wistar rats. It should be noted that analyzing the fatty acid composition of the red palm oil used in this study would have allowed for a more precise characterization of the mechanisms involved in obesity induction; this represents a priority avenue for future research. Conversely, the body weight of rats in Group 2 (Llg75%) decreased significantly ($p < 0.05$) starting in the fourth week following the introduction of 75% *Irvingia gabonensis* flour into the diet. This result is consistent with the findings of [13], who reported similar effects of *Irvingia gabonensis* flour on body weight reduction in an obesogenic context. The reduction in body weight observed in Group 2 rats can be attributed to the flour's high content of soluble dietary fibers specifically pectins, mucilages, and β -glucans. The effects of these fibers namely reducing dietary energy density, increasing satiety, and slowing the intestinal absorption of lipids and carbohydrates have been documented by [14] and confirmed by [15]. Food intake among Group 2 rats (Llg75%) during the treatment weeks did not differ significantly from that of the control group or Group 1, suggesting that *Irvingia gabonensis* flour influences nutrient digestion and metabolism more than it affects appetite. Group 2 rats produced a greater quantity of feces than Group 1 rats, indicating increased intestinal transit linked to the flour's high fiber content. This observation coincided with a progressive improvement in the digestibility index for Group 2, indicating better nutrient assimilation; this aligns with findings by [14], who documented that dietary fibers improve nutrient digestibility. In this study, *Irvingia gabonensis* flour achieved a digestibility rate of up to 93.08%.

The feed conversion ratio (FCR) for Group 2 (Llg75%) normalized gradually over the treatment weeks, approaching that of the control group. In contrast, Group 1 (LO) maintained a poor FCR with a feed conversion efficiency of 55.4% due to the obesogenic diet. Protein efficiency (PE) followed a similar trend, showing a gradual rise in Group 2 during weeks 4 and 5 (0.157 and 0.146), which indicates improved utilization of dietary protein. These observations are consistent with the findings of [16], who highlighted that *Irvingia gabonensis* fibers improve protein digestibility. The increase in energy efficiency (EE) observed in Group 2 (Llg75%) at weeks 4 (22.2%) and 5 (31.6%) compared to the control group could be attributed to increased energy expenditure for thermogenesis and homeostatic functions driven by the flour's high fiber content which reduced the efficiency of energy storage as adipose tissue [17]. Administration of the high-fat diet resulted in a non-significant 26.4% increase in blood glucose levels in Group 1 (LO) rats, indicating the onset of insulin resistance induced by the saturated fatty acids in red palm oil. Conversely, supplementation with 75% *Irvingia gabonensis* flour led to a significant ($p < 0.05$) 9.2% reduction in blood glucose levels in Group 2 rats compared to the

control group, representing a 28.2% decrease relative to Group 1. The hypoglycemic effect of *Irvingia gabonensis* flour can be explained by several complementary mechanisms. On one hand, the presence of soluble dietary fibers specifically pectins, mucilages, and β -glucans in the *Irvingia gabonensis* flour slows gastric emptying and inhibits the rise in postprandial blood glucose by reducing the rate of intestinal glucose absorption [7; 14]. On the other hand, polyphenolic compounds present in the flour inhibit intestinal α -amylase, thereby limiting the breakdown of starch into absorbable glucose and contributing to improved insulin sensitivity [13]. These findings align with those of [7], who observed a significant improvement in the glycemic profile following supplementation with *Irvingia gabonensis* flour.

5 CONCLUSION

The results obtained in rats demonstrate that supplementation with 75% *Irvingia gabonensis* flour in a high-fat, palm oil-based diet exerts significant biological and metabolic effects. Its administration led to notable improvements in zootechnical and anthropometric parameters specifically, a significant reduction in body weight starting from the fourth week of treatment compared to the obese group, as well as a progressive normalization of feed intake, digestibility, and protein efficiency indices.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The authors declare no conflicts of interest regarding this manuscript

Statement of ethical approval

All animal procedures were conducted in accordance with ethical recommendations regarding the use of laboratory animals and the promotion of animal welfare, in compliance with the protocols set out in European Council Directive 2010/63/EU.

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