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Evaluation of the physicochemical profile and effects of papaya seeds (*Carica papaya L.*) on glycaemia, triglyceridaemia and cholesterolaemia in Swiss albino mice

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Abstract

The objective of this study is to evaluate the physicochemical properties and the effect of papaya seeds (*Carica papaya L.*) on glycaemia, triglyceridaemia and cholesterolaemia in mice with a view to their valorization in health nutrition. To do this, the papaya seeds were dried at different temperatures (50 °C/72h; 75 °C/48h and 105 °C/24h) in an oven and then ground with a blender to obtain a flour. Five (5) experimental rations were formulated from the papaya seeds dried at 75 °C in the oven for 48 hours. The rations were LT, L1, L2, L3 and L4, with papaya seed incorporation rates of 0%, 25%, 40%, 50% and 57% respectively. Consumed by Swiss albino mice. On the 60th day of the study, the blood of the mice was collected in heparinised tubes which were then centrifuged at 3000 rpm for 5 min. The plasma obtained was assayed for biochemical parameters including glucose, triglycerides and cholesterol at a private clinical biochemistry laboratory. The results revealed that for the physicochemical parameters, the seeds dried at 50°C had a better pH (6.67) which tends towards neutrality, a low fat content (5%), the highest protein content (32%) and a higher fibre content (17.9%). It could therefore be said that 50°C is the appropriate temperature for parameters such as pH, fibre, protein and fat. On the other hand, the temperature of 105 °C would be the most suitable for parameters such as dry matter (92.17%), carbohydrate content (41.12%) and energy value (334.6 Kcal). On the other hand, the temperature of 75 °C gave the highest ash content (7.80%). Furthermore, the results relating to the biochemical blood parameters of the mice showed that blood sugar levels varied from 1.38 to 1.90 g/L while triglyceride levels varied from 1.10 to 2.82 g/L. Cholesterol levels ranged from 1.41 to 1.85 g/L for total cholesterol, from 0.46 to 1.47 g/L for HDL and from 1.48 to 11.44 g/L for LDL. We could deduce from this work that papaya seeds have a hyperglycemic action. These seeds would increase total, HDL and LDL cholesterol levels when incorporated into the diets of mice at increasing rates. On the other hand, papaya seeds decreased the triglyceride levels of mice that consumed them.

Keywords: *Carica papaya L.*; Papaya seeds; Blood sugar; Triglyceride; Cholesterol

1. Introduction

Papaya, from the Caricaceae family, is a tropical tree plant; native to Central and South America [1], [2]. In 2012, the world production of papaya was around 12.4 million tonnes [3]. Mexico is the leading exporting country in the world with 74,000 tonnes per year, followed by Malaysia with 54,000 tonnes per year. Côte d'Ivoire is the 5th largest African producer after Ghana. It exports 1163 tonnes annually to the European Union [4] . In Côte d'Ivoire, the main cultivation area is in the south, more precisely in the Azaguié area, where former banana growers have now converted to papaya production [4] . Papaya is a well-known agricultural commodity in several African countries and worldwide. The pulp (flesh) of the papaya has a delicate and sweet aroma [5]. Papaya is an ingredient in many cuisines around the world.

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Thai and Vietnamese people use the unripe fruit as a vegetable in cooking [6]. Papaya has many qualities. Indeed, this fruit offers a wide range of consumer products. It is commonly used for dessert or processed into jam or drinks [7]. Emeruwa [8] demonstrated the pronounced efficacy of papaya fruit and seed extracts against the bacteria *Staphylococcus aureus, Bacillus cereus, Escherichia coli, Pseudomonas aeruginosa*, and *Shigella flexneri* that cause many infections. The Dutch and Malays use leaf and young fruit extracts to eradicate intestinal worms and treat boils [9]. Traditional African medicine also uses papaya organs in its treatments. In Ghana, infusion of the dry leaves, administered as a purge, treats gastric disorders. The decoction of the same leaves is used for genitourinary problems in Côte d'Ivoire [9]. The processing of this fruit, as well as its direct consumption, results in large quantities of waste, such as the skin and seeds. In contrast to the pulp, which is totally consumed, the seeds and pericarp are totally rejected, as they are of unknown interest to everyone. With the exception of some farmers who use papaya pericarp for livestock feed, the seeds are part of the co-products whose technological applications and nutritional potential are still little known by the agri-food sector.

The objective of this work is therefore to valorise papaya seeds in health nutrition. Specifically, the aim is to (1) determine the physicochemical properties of papaya seeds; (2) evaluate the effect of papaya seeds on glycaemia, triglyceridaemia and cholesterolaemia in Swiss albino mice.

2. Material and methods

2.1. Biological material

The biological material used in this study consists of pawpaw (*Carica papaya L.*) fruit seeds. These fruits come from the markets of the city of Daloa, in the Haut Sassandra region of Côte d'Ivoire (Figure 1).

Figure 1 Papaya (*Carica papaya L.*) seeds

2.2. Methods

2.2.1. Sampling and production of pawpaw seed flour

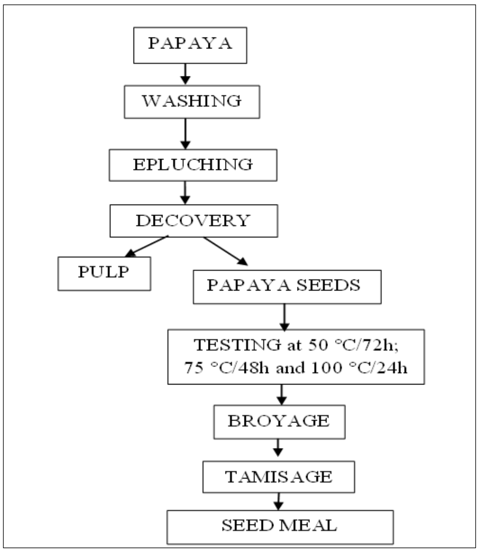

Figure 2 Manufacturing diagram of papaya seed flour

The pawpaw fruits were purchased, at the mature stage, at the markets of the city of Daloa, in the Haut Sassandra region, Côte d'Ivoire. At the Laboratoire d'Agro valorisation de l'UFR Agroforesterie, Université Jean Lorougnon Guédé, Daloa (Côte d'Ivoire), the seeds were extracted from the fruits and then placed in an oven at different temperatures (50° C for 72 hours, 75° C for 48 hours and 105° C for 24 hours). The dried seeds were crushed with a blender and then sieved with a sieve (300 µm). The flours obtained were each kept in a glass jar that had been previously washed and dried for the determination of physicochemical and functional parameters (Figure 2).

2.3. Determination of the physico-chemical properties of papaya seeds

The dry matter was determined by oven-drying the pawpaw seeds at 105°C for 24 hours [10]. The pH of the sample was measured with a digital pH meter (Consort PI07, Belgium). The titratable acidity was carried out by neutralising the total free acidity with a sodium hydroxide solution (NaOH 0.1 N). The ash content was determined after the destruction of the organic substance by incineration. The fibre content is determined according to the AOAC method [10]. The crude protein content is determined from the nitrogen content according to the Kjeldhall method. Lipids are extracted according to the Soxhlet method [10].

2.3.1. Available carbohydrates

The available carbohydrate content was determined according to the difference method described by FAO [11]. This content is obtained by the following mathematical formula:

$$\text{Carbohydrate (\% DM)} = 100 - [\text{Protein} + \text{Fat} + \text{Fibre} + \text{Ash}].$$

2.3.2. Energy value

The energy value was determined according to the difference method described by Atwater and Rosa [12]. This content is obtained by the following mathematical formula:

$$\text{EV (Kcal/l00g DM)} = 4 \times \text{Protein} + 9 \times \text{Fat} + 4 \times \text{Carbohydrate}$$

2.4. Formulation of Rations

Five (5) experimental rations were formulated from papaya seeds dried at 75°C in an oven for 48 hours. The rations were LT, L1, L2, L3 and L4, with a 0%, 25%, 40%, 50% and 57% incorporation rate of pawpaw seed meal respectively. Maize and fish meal were progressively replaced by papaya seed meal in these rations. The other ingredients were shellfish and salt (Table 1). Sixty (60) mice were divided into the five batches at a rate of 12 mice per batch, and these mice were then fed ad'libitum with the rations for two months .

Table 1 Formulation of the experimental food rations

Ingredients	**LT**	**L1**	**L2**	**L3**	**L4**
Corn flour (g)	60.58	44.60	35.82	28.08	25.50
Fish meal (g)	32.62	23.60	17.38	15.12	10.70
Shellfish (g)	4	4	4	4	4
Salt (g)	2.8	2.8	2.8	2.8	2.8
Papaya seed flour (g)	*0*	*25*	*40*	*50*	*57*
Total (g)	100	100	100	100	100
Number of mice per batch	12	12	12	12	12

LT: 0% papaya seed meal in mouse ration (control); L1: 25% papaya seed meal in mouse ration; L2: 40% papaya seed meal in mouse ration; L3: 50% papaya seed meal in mouse ration; L4: 57% papaya seed meal in mouse ration;

2.5. Determination of blood parameters

On day 60 of the study, blood samples were collected according to good laboratory practice. The heparinised tubes were centrifuged at 3000 rpm for 5 minutes. The plasma obtained was assayed for biochemical parameters including glucose, triglycerides and cholesterols in a private clinical biochemistry laboratory using a STETHO URIT-810 automatic analyser.

2.6. Statistical analysis of the data

The data collected after the physicochemical and functional characterisation of the flour samples were subjected to statistical analysis. Thus, a multivariate analysis of variance was carried out in order to assess the existence of differences between the samples studied. Multiple comparison tests (Tukey HSD) were conducted when the difference was found to be significant ($p < 0.05$) in order to separate the different samples. These statistical treatments were carried out using STATISTICA 7.1 software.

3. Results

3.1. Physicochemical characteristics of papaya seeds

The analysis of the physicochemical composition of papaya seeds dried at different temperatures shows a variability and illustrated on the graphs. Indeed, the pH of papaya seeds differs according to

the drying temperature. The seeds dried at 75 °C (6.21 ± 0.03) show a significant difference with the seeds dried at 50 °C (6.67 ± 0.06) and 105 °C (6.60 ± 0.01) (Table 2). The titratable acidity content of the seeds showed a significant difference. The seeds dried at 105 °C (0.32 ± 0.02%) have a higher titratable acidity content than the seeds dried at 50 °C (0.25 ± 0.02%) and 75 °C (0.24 ± 0.02%) (Table 2). The fat content of seed flours dried at 50 °C, 75 °C and 105 °C also differed significantly from each other with values of (5 ± 0.00%), (7 ± 0.00%) and (6 ± 0.00%) respectively (Table 2). The protein content of the seed flours dried at different temperatures are significantly different. In particular, the protein content of seed flours dried at 50 °C (32 ± 0.01%) is higher than those of seed flours dried at 75 °C (28 ± 0.01%) and 105 °C (29 ± 0.01%) (Table 2). In addition, the dry matter, fibre, ash, carbohydrate and energy content of the seed flours dried at the different temperatures did not differ significantly ($p > 0.05$). Indeed, the dry matter content of seeds dried at 50 °C is 45.10±0.051%, those at 75 °C and 105 °C are respectively 47.40±1.11% and 48.8± 0.42% (Table 2). The values recorded for the fibre content are 17.9 ± 0.04% for the pips dried at 50 °C, which is the highest, 17.6 ± 0.06% for the pips dried at 75 °C and 16.2 ± 0.24% for the pips dried at 105 °C, which has the lowest content (Table 2). The highest ash content is recorded for the 75 °C drying temperature (7.80 ± 0.26%) and the lowest for the 50°C temperature (7.40 ± 0.42%) (Table 2). The value recorded for carbohydrate levels in papaya seeds dried at 105 °C (41.12%) is higher than that at 50 °C (37.7%) and 75 °C (39.6%). The pips dried at 105 °C (334.48 Kcal) also recorded the highest energy value compared to those at 50 °C (323.80 Kcal) and 75 °C (334.40 Kcal) (Table 2).

3.2. Effects of papaya seeds on mouse mass

The masses of the mice varied from 17g to 33g from week 1 to week 7 of the experiment. We note that the masses of the mice of the test batches (L1 to L4) are lower than those of the control batch (LT) from the 1st week to the 3rd week. On the other hand, the masses of the mice in the test batches (L1 to L4) were greater than those of the control batch (LT) from week 3 to week 7 (Figure 3).

Table 2 Physicochemical characteristics and energy value of papaya seeds according to drying temperature

Temperature and drying time	Dry matter (%)	pH	Titratable acidity (eq.g/100g)	Ash content (%)	Fibre content (%)	Fat (%)	Protein (%)	Carbohydrate (%)	Energy value (Kcal)
50 ° C / 72h	91.20±1.11^{a}	6.67 ± 0.06^{a}	0.25 ± 0.02^{a}	7.40 ± 0.42^{a}	17.9 ± 0.04^{a}	5.1 ± 0.30^{a}	32. 6± 0.81^{c}	37.7 ± 0.11^{a}	323.80 ± 0.22^{a}
75 °C / 48h	91.27±0.51^{a}	6.21 ± 0.03^{b}	0.24 ± 0.02^{a}	7.80 ± 0.26^{a}	17.6 ± 0.06^{a}	7.3 ± 0.55^{c}	28.7 ± 1.01^{a}	39.6 ± 0.43^{a}	333.40 ± 0.86^{a}
105 °C / 24h	92.17 ± 0.42^{a}	6.60 ± 0.01^{a}	0.32 ± 0.02^{b}	7.68 ± 0.36^{a}	16.2 ± 0.24^{a}	6.8 ± 0.28^{b}	29.9 ± 0.99^{ab}	41.12 ± 0.46^{a}	334.48 ± 0.86^{a}

50 °C / 72h: seeds dried at 50 °C for 72h; 75 °C / 48h: seeds dried at 75 °C for 48h; 105°C / 24h: seeds dried at 105 °C for 24h; Values are expressed as Mean ± Standard Deviation; Values in the same column with the same letter are not significantly different from each other according to Tukey's comparison test at the 5% threshold (P>0.05).

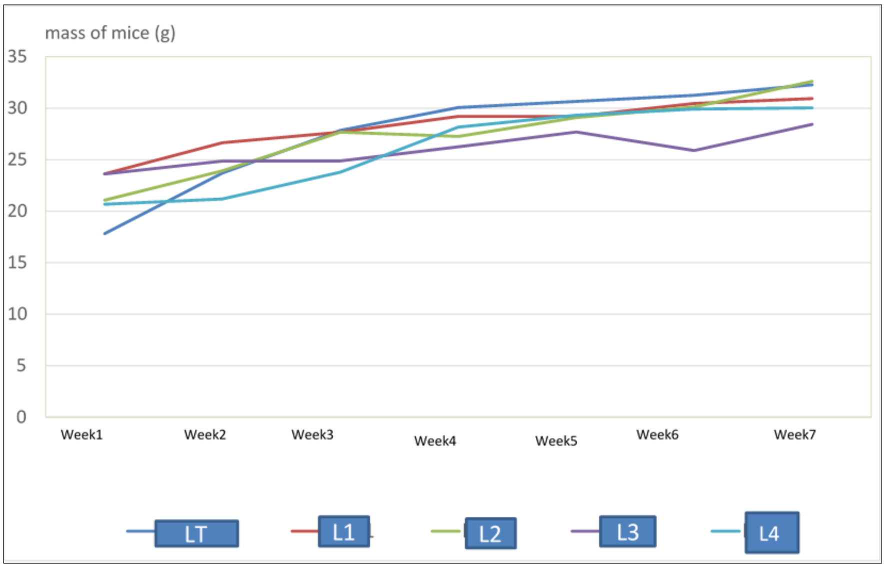

Figure 3 Variation in body weight of the different batches during the experiment

3.3. Effects of papaya seeds on blood glucose and triglyceride levels in mice

The glucose content of the batches of mice varied from 1.38 to 1.90 g/L. The blood glucose levels of the test mice are higher than the control and normal blood glucose levels (0.70-1.1 g/L) (Table 3). Triglycaemia levels in the mice ranged from 1.10 g/L to 2.82 g/L. There was a significant decrease in triglycerides in the trials (1.10-1.4 g/L) compared to the control (2.82 g/L). These TG levels are in line with the standards (0.5-1.5 g/L) (Table 3).

Table 3 Glucose content of mice as a function of increasing levels of pein formation in the diet

	LT	**L1**	**L2**	**L3**	**L4**	**standard**
Blood glucose (g/L)	1.38±0.15^{a}	1.91±0.32^{b}	1.67±0.21^{c}	1.90±0.26^{b}	1.85±0.19^{b}	0.70-1.1
Triglyceridemia (g/L)	2.82±0.41^{a}	1.4±0.87^{b}	1.17±0.26^{c}	1.12±0.17^{c}	1.10±0.12^{c}	0.5-1.5

LT: 0% papaya seed meal in mouse ration (control); L1: 25% papaya seed meal in mouse ration; L2: 40% papaya seed meal in mouse ration; L3: 50% papaya seed meal in mouse ration; L4: 57% papaya seed meal in mouse ration; values assigned different letters on the same line are statistically different at the 5% threshold (p≤0.05) after Turkey test.

3.4. Effects of papaya seeds on cholesterol levels in mice

Total cholesterol levels varied from 1.41 g/L to 1.85 g/L. The highest value was found for batch L4 (1.85 g/L) while the lowest was found for batches LT and L1 (1.41 g/L). There was a progressive increase in total cholesterol levels as papaya seed meal levels increased in the mice diets (Table 4). However, these values are within the recommended range (1.5-2.2 g/L). As for HDL, the L2 batch has the highest value (1.47 g/L). Beyond lot L2, the HDL levels drop (from 0.46 to 0.48 g/L) for lot L3 and L4 respectively. Finally, LDL levels increase as papaya seed meal levels increase in the mice's diets (1.48 to 11.44 g/L) (Table 4).

Table 4 Cholesterol content of mice with increasing levels of pawpaw seed meal in the diet

	LT	**L1**	**L2**	**L3**	**L4**	**Standard**
THC (g/L)	1.42±0.10	1.41±0.15	1.58±0.22	1.66±0018	1.85±0.25	1.5-2.2
HDL (g/L)	0.71±0.02	0.81±0.06	1.47±0.09	0.46±0.04	0.48±0.05	0.4-0.8
LDL (g/L)	1.48±0.17	3.27±0.12	5.96±0.13	7.89±0.44	11.44±0.56	1.3-2.2

LT: 0% papaya seed meal in mouse ration (control); L1: 25% papaya seed meal in mouse ration; L2: 40% papaya seed meal in mouse ration; L3: 50% papaya seed meal in mouse ration; L4: 57% papaya seed meal in mouse ration; THC: total cholesterol; HDL: high density lipoproteins; LDL: low density lipoproteins; values assigned different letters on the same line are statistically different at the 5% threshold (p≤0.05) after the Turkey test.

4. Discussion

4.1. Physicochemical profile of papaya seed flours

The physicochemical parameters of the papaya seed meal samples were determined. This study indicated that the titratable acidity of papaya seed flours dried at 105°C (0.32 ± 0.02%) is higher than those at 75°C (0.24 ± 0.02%) and 50°C (0.25 ± 0.02%). These results are higher than those of N'da and *al.* [13]. (0.04%) in their work on the biochemical characterisation and antioxidant activity of papaya pericarp. The relative decrease in acidity in papaya pulp could be the result of the use of organic acids (citric acid and malic acid) in the pericarp as respiration substrates for the fruit [14]. The pH of the different papaya seed meals ranged from 6.21 to 6.67. These results are higher than those of N'da and *al.* [13]. in their work on papaya pericarp, which is around 5.80. This increase in the pH of the pips would explain the beginning of the natural degradation of the pulp towards the pips of the fruit during its conservation. The fat content of papaya seeds dried at different temperatures ranged from 5% to 7%. These results are higher than those of N'da and *al.* [13]. in their work on papaya pericarp (2.51 ± 0.13%). On the other hand, our results remain lower than those of Dossou and *al.* [15]. and Oloyede [16]. In their work on the nutritional properties of papaya pulp which are respectively 56.66 ± 0.27% and 51.58 ± 0.04%. Fat is important in the diet because it is believed to contain fat-soluble vitamins and is also a source of energy. The protein content of papaya seeds dried at different temperatures, namely 50°C (32 ± 0.01), 75°C (28 ± 0.01) and 105°C (29 ± 0.01), is higher than those obtained by Dossou and *al.* [15] on aril harvested in Ghana and Meite et *al.* [17] on wheat, whose values are 11.67 ± 0.37% and 10.09 ± 0.09% respectively. This difference would be due to the effect of temperature which could denature the proteins. The dry matter content of papaya seed flour dried at different temperatures ranged from 91.20% to 92.17%. These rates are similar to those of Muhamad [18] and Meite et *al.* [17] in their respective work on solo papaya pulp 8 (90.18%) and wheat flour dried at 100°C (92.67 ± 0.20 g/100 g). This dry matter content is higher than that of wheat flour which is 86.2 ± 0.6% and lower than that of Blighia sapida flour harvested in Nigeria (96.05 ± 0.01%), according to Oloyede [16] and in Ghana (95.17± 0.02%) according to Dossou and *al.* [15].

These results suggest that the nutrients in the pulp are also present in the pawpaw seeds. The difference in material content can be explained by the fact that 105°C is the highest temperature compared to other temperatures. The higher the temperature, the greater the chance of extracting the maximum amount of water from the sample. The fibre content of papaya seeds dried at different temperatures 50°C, 75°C and 105°C ranged between 16.2g and 17.9g. These results are lower than those of N'da and *al.* [13] in their analysis of papaya pericarp, which is 32.5 g. However, these values are higher than the values found in papaya pulp according to the work of Muhamad [18] and Nwofia and *al.* [19] which is 0.5g. These results suggested that papaya seeds could be recommended for people with digestive disorders. The ash content of papaya seeds dried at 75°C (7.80±0.26%) is higher than those at 50°C (7.42±0.42%) and 105°C (7.68±0.36%). These values are higher than the ash levels of *Blighia sapida* aril flour (5.49 ± 2%) analysed by Dossou and *al.* [15].

On the other hand, these results are still lower than those of Oloyede [16], which is 8.68 ± 0.42%. This high ash content of papaya seeds would mean that they are richer in minerals than the papaya pulp. The carbohydrate content of papaya seeds dried at different temperatures ranged from 45.10 ±0.46% to 48.8±0.11%. These results are still lower than those of N'da and *al.* [13] and Oloyede [16] on papaya pericarp, respectively 52.33% and 54.5%. On the other hand, the carbohydrate content of papaya seeds in the present study was higher than those of Dossou and *al.* [15] during these analyses on Blighia sapida flour harvested in Nigeria (6.86 ± 0.06%). This flour, a carbohydrate source, would find its application in diets. The energy value of papaya seeds dried at 105 °C (334.48 ± 0.86 Kcal/100 g) is higher than at 75 °C (333.40 ± 0.86 Kcal/100 g) and 50 °C (323.80 ± 0.22 Kcal/100 g). These results are higher than those of N'da et al [13] on papaya pericarp with an energy value of 278.59 Kcal/100 g and 35 Kcal/100 g for the pulp reported by Mubumad [18]. On the other hand the energy value of papaya seed meal is lower than that of Blighia sapida from Ghana (590.67 Kcal/100 g) according to Dossou and *al.* [15], and Nigeria 571.16 kcal/100 g according to Oloyede [16]. Papaya seeds provide more energy than papaya pulp and pericarp. For carbohydrate and energy intake, it would be better to consume the seeds of the papaya.

4.2. Body weight and blood parameters of mice

The results obtained show a progressive increase in the body weight of the mice during the experiment. The weights observed before the experiment ranged from 17.82g to 20.68g and after two months of experimentation we observed body weights above 28g in each batch of mice. These results are similar to those obtained by Oloyede [16]. and Zambou and *al.* [20] during work on rats fed a yolk-enriched diet, which shows a result ranging from 140 to 150g after 70 days of treatment. This increase in body weight could be due to the nutrient composition of the rations.

Glucose is an essential energy substrate; the sources of glucose are dietary carbohydrates and endogenous (mainly hepatic) production through glycogenolysis (release of stored glucose as glycogen) and gluconeogenesis (synthesis of glucose from e.g. lactate, glycerol and most amino acids). The blood concentration, or blood glucose level, depends on the relative proportions of glucose entering the circulation and glucose used [21]. The blood glucose values in the present study range from 1.38 to 1.91 g/L. These values are higher than those of Amara and Djerroud [22] who used the methanoic extract of Nigella damascena seed on swiss albino mice (1.22 to 1.38 g/L). These results show that papaya seeds would have a hyperglycemic effect on the diets of mice.

Triglycerides and cholesterol are products of lipid breakdown. The blood concentration of these products constitutes the lipemia. Triglyceride levels are relatively low (1.10-1.40 g/L) compared to the control (2.82 g/L). These levels are higher than those found in the work of Françoise and *al.* [23] These levels are still in line with those recommended (0.5-1.5 g/L). The decrease in triglyceride level was observed by Françoise and *al.* [23] before and after alloxane injection in rats (0.80 g/l) and (0.70 g/l) respectively. The incorporation of papaya seed meal in the diet of mice decreases the triglyceride level in mice. These results are consistent with the work of Mattar and Obeid [24]; Boukhari and *al.* [25] and Bouchard and *al.* [26] who showed that fish oil supplementation decreased high plasma triglyceride levels. On the other hand, in the sub-chronic toxicity study by Tahraoui and *al.* [27] it was found that administration of aqueous extract of Centaurium erytherea at doses of 100, 600 and 1200 mg/kg/day for 90 days, resulted in a significant decrease in serum glucose and triglyceride concentrations.

In addition, total cholesterol levels in the present study ranged from 1.41 to 1.85 g/L. These values increased with increasing levels of papaya seed meal in the diets of mice. These results are higher than those of Amara and Djerroud [22] on the methanoic extract of *Nigella damascena* seed (0.72 to 0.70g/L). The observed variations could be due to the relatively high lipid composition of papaya seeds. The HDL and LDL contents also increase. The HDL levels remain within the norms except for the L2 batch (1.42 g/L). The LDL content is two to three times higher than the recommended values. These results show that papaya seeds promote lipid metabolism in mice. Nirankush and *al.* [28] after administration of a dose of 200 mg/kg/day of Coco nucifera extract for 28 days, found no significant difference in cholesterol concentrations compared to the control group.

5. Conclusion

The objective of this study was to evaluate the physicochemical properties and effect of papaya seeds on blood glucose, triglyceride and cholesterol levels in mice.

The results revealed that for physicochemical parameters, seeds dried at 50°C had a better pH (6.67) which tends to neutrality, a low fat content (5%), the highest protein content (32%) and a higher fibre content (17.9%). It could therefore be said that 50°C is the appropriate temperature for parameters such as pH, fibre, protein and fat. On the other hand, the temperature of 105°C would be the most suitable for parameters such as dry matter (92.17%), carbohydrate content (41.12%) and energy value (334.60 Kcal). On the other hand, the temperature of 75°C gave the highest ash content (7.80%).

Furthermore, the results relating to the biochemical blood parameters of the mice showed that blood sugar levels varied from 1.38 to 1.90 g/L while triglyceride levels varied from 1.10 to 2.82 g/L. Cholesterol levels ranged from 1.41 to 1.85 g/L for total cholesterol, from 0.46 to 1.47 g/L for HDL and from 1.48 to 11.44 g/L for LDL.

We could deduce from this work that papaya seeds have a hyperglycemic action. These seeds would increase total, HDL and LDL cholesterol levels when incorporated into the diets of mice at increasing rates. On the other hand, papaya seeds reduce the triglyceride levels of mice that have consumed them.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

Statement of ethical approval

The experimental protocol and animal handling procedures were conducted according to good laboratory practice (29).

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