

Original article

Organic Composition and Fatty Acid Profile of Macadamia Nut Oil and Its Impact on the Body Weight of Male Rabbits

Tahani Faraj^{1*}, Fayrouz Khaled²

¹Chemistry Department, Faculty of Science, Al Qubba / Derna University, Libya

²Chemistry Department, Faculty of Science, Omar Al-Mokhtar University, El-Beida, Libya

*Corresponding Email. tahanibensaleh@gmail.com

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ABSTRACT

This study investigated the organic composition and biological effects of macadamia nut oil using GC-MS analysis and an in vivo experimental model. The GC-MS results revealed that macadamia oil is predominantly composed of fatty acid derivatives, with a marked dominance of monounsaturated fatty acids. The principal compound identified was 9-octadecenoic acid (Z)-, methyl ester (26.86%), followed by oleic acid (18.83%) and hexadecanoic acid, ethyl ester (13.32%). Moderate levels of E-9-octadecenoic acid ethyl ester (7.00%) and 8,9,12-octadecatrienoic acid, methyl ester (3.12%) were also detected, indicating the presence of both mono- and polyunsaturated fatty acids. Minor constituents, including eicosapentaenoic acid (1.70%) and other long-chain unsaturated fatty acids ($\leq 1.71\%$), suggest a diverse lipid profile with potential antioxidant and anti-inflammatory properties. Chromatographic analysis showed well-resolved peaks, with the most abundant compounds eluting between 29 and 31 minutes, confirming the predominance of long-chain fatty acids. Biologically, the results demonstrated a progressive increase in body weight in both control and treated groups. At baseline, no significant difference was observed between the control (1250 ± 45 g) and macadamia group (1245 ± 42 g) ($P = \text{NS}$). After two weeks, body weight increased to 1320 ± 38 g in the control group and 1355 ± 40 g in the treated group, with no significant difference ($P > 0.05$). However, by week 4, a significant increase ($P < 0.05$) was recorded in the macadamia-treated group (1480 ± 48 g) compared to the control group (1410 ± 50 g). These findings indicate that prolonged administration of macadamia nut oil may enhance weight gain, potentially due to its high content of bioactive monounsaturated fatty acids. Overall, the study highlights the rich fatty acid composition of macadamia oil and its potential physiological impact on growth performance.

Introduction

The search for natural growth promoters and nutritional supplements has gained significant attention in recent years, particularly focusing on plant-derived organic compounds [1]. Macadamia nuts, primarily from the species *Macadamia integrifolia*, are renowned for their unique chemical profile, characterized by a high concentration of monounsaturated fatty acids and various bioactive secondary metabolites [2]. These organic constituents are not only vital for nutritional value but also play a crucial role in modulating metabolic processes and enhancing growth performance in animal models [3]. From an organic chemistry perspective, the therapeutic and nutritional efficiency of Macadamia is attributed to its complex mixture of long-chain fatty acids and esters. Analytical techniques, such as Gas Chromatography-Mass Spectrometry (GC-MS), are essential for identifying these bioactive molecules, including Oleic acid and Hexadecanoic acid derivatives, which are known to influence lipid metabolism and energy balance. Understanding the precise chemical composition is fundamental to elucidating how these compounds interact with biological systems to promote physiological development [4].

Rabbits (*Oryctolagus cuniculus*) serve as an ideal experimental model for nutritional studies due to their sensitive metabolic response to dietary changes. Monitoring body weight gain in male rabbits provides a clear indicator of the efficiency of organic supplements in stimulating growth and improving general health [5-20]. While previous studies have explored the general benefits of nuts, there is limited research specifically linking the GC-MS identified organic compounds of Macadamia to the incremental growth patterns in male rabbits over a controlled period [21]. Therefore, this study was designed to characterize the organic chemical constituents of Macadamia extract using GC-MS and to evaluate its impact on the body weight of male rabbits over a four-week experimental duration. By bridging the gap between organic analytical chemistry and animal physiology, this research aims to provide a comprehensive understanding of how Macadamia-derived compounds can be utilized as a natural alternative for enhancing growth performance.

Materials and Methods

The chemical constituents of the Macadamia extract were identified using Gas Chromatography-Mass Spectrometry (GC-MS). The analysis was performed to determine the profile of bioactive organic compounds, specifically fatty acids and esters, which are hypothesized to influence growth performance. Ten adult male rabbits (*Oryctolagus cuniculus*) were utilized in this study.

The animals were sourced from a local supplier and housed in a controlled environment with a consistent light/dark cycle. They were provided with a standard basal diet and water *ad libitum* throughout the experimental period. All procedures were conducted in accordance with ethical guidelines for animal research. After an initial acclimatization period, the rabbits were randomly divided into two equal groups (n=5 per group): Control Group: Received a standard diet without any additional supplements. Macadamia Group: Received the standard diet supplemented with Macadamia extract (2 mg/kg).

The experimental duration lasted for four consecutive weeks. To monitor the physiological impact of the Macadamia organic compounds, the body weight of each rabbit was measured at the beginning of the study (initial weight at Week 0) and subsequently recorded bi-weekly (Week 2 and Week 4). Weight gain was calculated as the difference between the final and initial body weights.

The data collected were expressed as Mean \pm Standard Deviation (SD). Statistical significance between the control and treatment groups was determined using an independent t-test (or one-way ANOVA where applicable). A P-value of less than 0.05 was considered statistically significant.

Results

The GC-MS analysis presented in Table 1 and Figure 1 revealed that macadamia nut oil is predominantly composed of fatty acid derivatives, with a clear dominance of monounsaturated fatty acids. The major compound identified was 9-octadecenoic acid (Z)-, methyl ester (26.86%), followed by oleic acid (18.83%) and hexadecanoic acid, ethyl ester (13.32%). This high proportion of oleic acid derivatives confirms that macadamia oil is rich in monounsaturated fatty acids, which are known for their beneficial metabolic and physiological effects.

In addition, moderate amounts of E-9-octadecenoic acid ethyl ester (7.00%) and 8,9,12-octadecatrienoic acid, methyl ester (3.12%) were detected, indicating the presence of both mono- and polyunsaturated fatty acids. Minor constituents such as eicosapentaenoic acid (EPA) (1.70%) and other long-chain unsaturated fatty acids were also identified, suggesting a diverse lipid profile with potential antioxidant and anti-inflammatory properties. The chromatogram in Figure 1 further supports these findings, showing well-resolved peaks corresponding to the identified compounds, with the most abundant components appearing at retention times between approximately 29 and 31 minutes. The distribution and intensity of peaks confirm the predominance of long-chain fatty acids in macadamia nut oil.

Table 1. "GC-MS Analysis of the Organic Composition and Fatty Acid Profile of Macadamia Nut Oil Used in the Experimental Study"

RT	Compound Name	Area %	Molecular Formula	Molecular Weight	CAS #
26.47	Hexadecanoic acid, ethyl ester	13.32	C ₁₈ H ₃₆ O ₂	284	628-97-7
29.51	9-Octadecenoic acid (Z)-, methyl ester	26.86	C ₁₉ H ₃₆ O ₂	296	112-62-9
29.65	Oleic Acid	18.83	C ₁₈ H ₃₄ O ₂	282	112-80-1
29.86	cis-5,8,11,14,17-Eicosapentaenoic acid	1.70	C ₂₀ H ₃₀ O ₂	302	10417-94-4
30.06	E-9-Octadecenoic acid ethyl ester	7.00	C ₂₀ H ₃₈ O ₂	310	6114-18-7
31.79	8,9,12-Octadecatrienoic acid, methyl ester	3.12	C ₁₉ H ₃₂ O ₂	292	2876-41-7
35.30	2,5-Octadecadienoic acid, methyl ester	1.06	C ₁₉ H ₃₀ O ₂	290	57156-91-9
39.43	12,15-Octadecadienoic acid, methyl ester	1.71	C ₁₉ H ₃₀ O ₂	290	57156-95-3

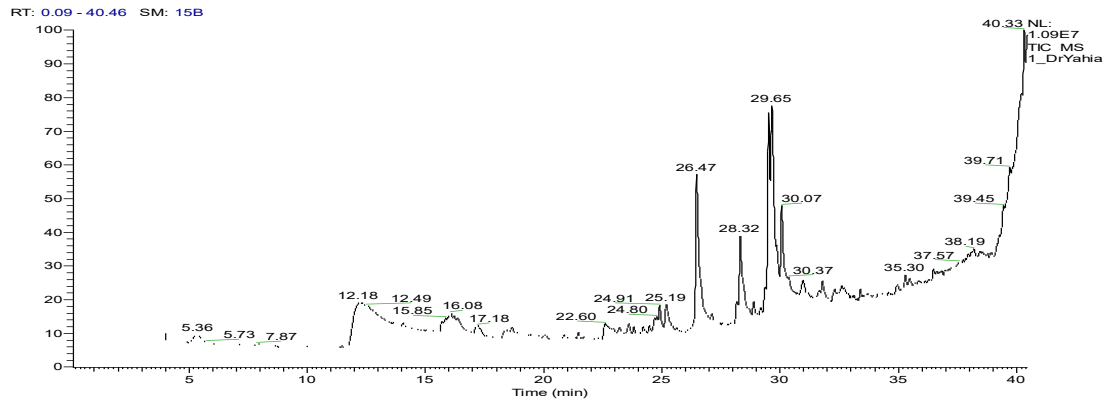


Figure 1. Representative GC-MS Chromatogram Illustrating the Organic Composition and Fatty Acid Profile of Macadamia Nut Oil

The results presented in Table 2 demonstrate a progressive increase in body weight in both the control and macadamia oil-treated groups over the experimental period. At baseline (Week 0), there was no significant difference between the two groups, as indicated by similar initial weights and a non-significant P-value (NS), confirming proper group matching at the start of the experiment. By Week 2, both groups showed an increase in body weight; however, the difference between the control group (1320 ± 38 g) and the macadamia oil-treated group (1355 ± 40 g) remained statistically non-significant ($P > 0.05$). This suggests that short-term administration of macadamia oil did not produce a marked effect on body weight. In contrast, by Week 4, a statistically significant increase ($P < 0.05$) was observed in the macadamia oil group (1480 ± 48 g) compared to the control group (1410 ± 50 g). This indicates that prolonged administration of macadamia nut oil may contribute to enhanced weight gain in male rabbits. The use of different superscript letters (a, b, c) within each group further confirms significant differences across time points, reflecting a consistent growth pattern throughout the study.

Table 2. “Comparative Analysis of Body Weight Changes in Control and Macadamia Oil-Treated Male Rabbits at Different Time Intervals”.

Group	Initial Weight (Week 0)	Week 2	Week 4
Control Group (n = 5)	1250 ± 45 ^a	1320 ± 38 ^b	1410 ± 50 ^c
Macadamia Group (n = 5)	1245 ± 42 ^a	1355 ± 40 ^b	1480 ± 48 ^c
P-value	NS	> 0.05	< 0.05*

Discussion

The present study investigated the organic composition and fatty acid profile of macadamia nut oil using GC-MS analysis, along with its impact on body weight in male rabbits. The findings revealed that macadamia oil is predominantly rich in monounsaturated fatty acids, particularly oleic acid and its derivatives, which constituted the major proportion of the identified compounds. The GC-MS results demonstrated that 9-octadecenoic acid (Z)-, methyl ester, and oleic acid were the most abundant constituents. This is consistent with previous reports indicating that macadamia oil is one of the richest natural sources of oleic acid, a monounsaturated fatty acid known for its role in improving lipid metabolism and energy utilization. Additionally, the presence of moderate levels of polyunsaturated fatty acids, such as eicosapentaenoic acid (EPA), suggests that macadamia oil may also possess anti-inflammatory and antioxidant properties [22]. These bioactive compounds contribute to improved metabolic efficiency and may influence physiological outcomes such as growth and weight gain [23].

The body weight results showed a gradual increase in both control and treated groups over time, which is expected under normal growth conditions. However, the macadamia oil-treated group exhibited a significantly higher body weight at Week 4 compared to the control group ($P < 0.05$), indicating a time-dependent effect of the oil. This delayed but significant increase suggests that the metabolic impact of macadamia oil requires prolonged exposure to manifest. The observed increase in body weight in the treated group can be explained by several mechanisms [24]. First, the high content of monounsaturated fatty acids, particularly oleic acid, enhances energy density and caloric intake, which can promote weight gain. Second, oleic acid has been shown to improve nutrient absorption and lipid metabolism, potentially leading to more efficient utilization of dietary energy. Furthermore, fatty acids present in macadamia oil may influence hormonal regulation and adipose tissue metabolism, thereby contributing to increased body mass. Interestingly, no significant difference was observed at Week 2, suggesting that short-term supplementation is insufficient to induce measurable physiological changes. This aligns with the concept

that dietary fatty acids exert cumulative effects over time, particularly in relation to growth and metabolic regulation. Overall, the results of this study indicate that macadamia nut oil, due to its rich composition of unsaturated fatty acids, especially oleic acid, can significantly influence body weight when administered over a longer period. These findings highlight the potential nutritional and metabolic importance of macadamia oil and support its role as a functional dietary component in animal nutrition [25-52].

Conclusion

Macadamia nut oil is rich in monounsaturated fatty acids, particularly oleic acid, as confirmed by GC-MS analysis, highlighting its significant nutritional value. Prolonged supplementation resulted in a significant increase in body weight in male rabbits, indicating a time-dependent metabolic effect.

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