# The amino acid and fatty acid composition and antioxidant activity of functional snack products

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**Abstract (150 - 450 words)**: Rising consumer awareness of the link between diet and health has increased interest in functional foods with enhanced nutritional profiles. In this study, two extruded snacks containing corn meal (80.7%), brewer's spent grain (14.8%), mechanically deboned poultry meat (3%), chicken liver (1%), and salt (0.5%), flavoured with pizza or cheese seasoning were developed, and evaluated by their amino acid profile, fatty acid composition, and antioxidant activity. One hundred grams of product could provide approximately one-third of the daily protein requirement for a 20 kg child, with lysine as the limiting amino acid. The fatty acid composition reflected the palm oil used in seasoning, showing a near-equal ratio of saturated and unsaturated fatty acids. Antioxidant activity was 34.25% and 34.19% for pizza- and cheese-flavoured snacks, respectively, exceeding values reported for similar extruded products in the literature. These results highlight the potential of combining extrusion technology with nutrient-rich raw materials to create functional snack products that meet both convenience and health-related demands of modern consumers.

**Keywords**: amino acid coposition, fatty acid composition, antioxidant activity, functional snacks

## 1. Introduction

Growing consumer awareness of the relationship between diet and health has driven demand for foods with improved nutritional quality. Functional foods, which provide essential nutrients and promote health, have become a focus of product development. Snack products, widely consumed especially among younger populations, are key targets for nutritional improvement. Two newly developed extruded snack products composed of corn meal (80.7%), brewer's spent grain (14.8%), mechanically deboned poultry meat (3%), chicken liver (1%) and salt (0.5%) with pizza and cheese flavor, were subjected to analisis of amino and fatty acid composition and antioxidant activity.

## 2. Methodlogy

Snacks were produced using co-rotating twin extruder [1] and coated with palm oil (15%) and clean label pizza and cheese flavour seasoning (8%).

Amino acid composition was determined by ion-exchange liquid chromatography (Biochrom 30+ Analyzer, UK) using a modified Spackman method [2]. Samples (~10 mg) were hydrolyzed with 6 M HCl (phenol, thioglycolic acid) or 4 M NaOH for tryptophan under nitrogen at 110 °C for 24 h. After dilution and filtration, amino acids were separated, detected post-ninhydrin reaction (570 nm; 440 nm for proline), identified by retention times of standards, and quantified via calibration curves.

Fats were extracted from samples using the Folch method [3] (chloroform–methanol, 2:1) and converted into fatty acid methyl esters (FAMEs) via transesterification with boron trifluoride. FAMEs were analyzed by gas chromatography (GC Agilent 7890A, FID detector, SP-2560 column), with helium as the carrier gas. The temperature program ranged from 140 °C to 240 °C. Fatty acids were identified using Supelco 37 FAME standards.

Antioxidant activity was determined using a modified DPPH spectrophotometric method [4]. Ground snack samples (1 g) were extracted with methanol. Extracts (100 μl) were mixed with $DPPH^{\cdot}$ solution and incubated in the dark for 60 min. Absorbance was measured at 515 nm (UV-1800, Shimadzu, Japan).

## 3. Results and Discussion

### *3.1 Amino Acid Composition*

In selected snack products, 18 amino acids were identified and quantified among which nine were classified as essential (Table 1). When compared with the recommended daily intake values, the amino acid content in 100 g of the analyzed samples was found to meet approximately one-third of the daily requirements for a child weighing 20 kg, with lysine identified as the limiting amino acid. Furthermore, the overall amino acid profile closely aligned with the WHO reference standard [5], with the exception of lysine, for which the standard recommends 4.5 g/100 g of protein, while the measured values in the products were 3.12 and 2.74 g/100 g of protein.

**Table 1.** Amino acid profile of analized snack products

| Amino acids | g/ 100g sample | | g/ 100 g protein | |
|---|---|---|---|---|
| | M3J1_pizza | M3J1_cheese | M3J1_pizza | M3J1_cheese |
| Aspartic acid | 0.55 | 0.48 | 7.18 | 6.52 |
| Threonine* | 0.25 | 0.22 | 3.23 | 2.99 |
| Tryptophan* | 0.06 | 0.06 | 0.84 | 0.85 |
| Serine | 0.30 | 0.27 | 3.90 | 3.67 |
| Glutamic acid | 1.26 | 1.15 | 16.58 | 15.80 |
| Proline | 0.55 | 0.54 | 7.19 | 7.34 |
| Glycine | 0.28 | 0.25 | 3.73 | 3.47 |
| Alanine | 0.49 | 0.46 | 6.51 | 6.27 |

| | | | | |
|---|---|---|---|---|
| Valine* | 0.37 | 0.36 | 4.87 | 4.93 |
| Cysteine | 0.10 | 0.11 | 1.32 | 1.48 |
| Methionine* | 0.12 | 0.15 | 1.58 | 2.05 |
| Isoleucine* | 0.29 | 0.30 | 3.86 | 4.09 |
| Leucine* | 0.65 | 0.67 | 8.54 | 9.14 |
| Tyrosine | 0.24 | 0.35 | 3.18 | 4.75 |
| Phenylalanine* | 0.63 | 0.65 | 8.30 | 8.91 |
| Histidine* | 0.20 | 0.21 | 2.63 | 2.82 |
| Lysine* | 0.24 | 0.20 | 3.12 | 2.74 |
| Arginine | 0.36 | 0.29 | 4.74 | 3.90 |

* essential amino acids

*3.2 Fatty Acid Composition*

To ensure that the spice mixtures adhered to the snack products, palm oil was applied to their surface. Therefore, the fatty acid profile of the samples (Table 2) corresponds to that of palm oil. From the results shown in Table 2, it can be seen that in the fatty acid composition of the snack products, the most abundant is monounsaturated oleic acid (43.0% and 42.5%), followed by saturated palmitic acid.

**Table 2**. Fatty acid composition of selected snack products and of palm oil

| Fatty acid (g/100 g) | M3J1_pizza | M3J1_cheese | Palm oil* |
|---|---|---|---|
| Lauric acid C12:0 | 0.2 | 0.2 | ND - 0.5 |
| Myristic acid C14:0 | 0.9 | 1.0 | 0.5 - 2 |
| Palmitic acid C16:0 | 37.5 | 38.6 | 39.3-47.5 |
| Palmitoleic acid C16:1 | 0.2 | 0.2 | ND -0.6 |
| Margaric acid C17:0 | 0.1 | 0.1 | ND - 0.2 |
| Stearic acid C18:0 | 4.2 | 4.2 | 3.6 - 6.0 |
| Oleic acid C18:1-cis-9 | 43.0 | 42.5 | 36.0 - 44.0 |
| Linoleic acid C18:2-cis-9,12 | 12.7 | 12.1 | 9.0 -12.0 |
| Arachidic acid C20:0 | 0.4 | 0.4 | ND - 1.0 |
| Eicosenoic acid C20:1-cis-11 | 0.2 | 0.2 | ND - 0.4 |
| Alpha-linolenic acid C18:3-cis-9,12,15 | 0.4 | 0.4 | ND - 0.5 |
| Behenic acid C22:0 | 0.1 | 0.1 | ND -0.2 |

* According to the Rulebook on the Quality and Other Requirements for Edible Vegetable Oils and Fats, Margarine and Other Fat Spreads, Mayonnaise and Related Products ("Official Gazette of SCG", No. 23/2006 and "Official Gazette of RS", No. 43/2013 – other rulebook)

*3.3 The antioxidant activity*

There were no major differences in antioxidant activity among the samples. Samples M3J1_pizza and M3J1_cheese exhibited antioxidant activity values of 34.25% and 34.19%, respectively. These values are significantly higher than those reported by Bhat et al., 2019 [6], whose enriched extruded whole-wheat snacks showed antioxidant activity

ranging from 13.9% to 17.6%. Similarly, extrudates developed by Wani and Kumar, 2019 [7], showed DPPH$^{\cdot}$ radical scavenging activity between 8.1% and 20.9%.

## 4. Conclusions

The snacks exhibited a palm oil–type fatty acid profile, balanced in saturated and unsaturated fatty acids, with oleic and palmitic acids predominating. They contained 18 amino acids (nine essential), while 100 g of snack could provide one-third of the daily protein requirement for a 20 kg child. Lysine was limiting amino acid. Antioxidant activity (~34%) exceeded literature values. These findings demonstrate that extrusion technology combined with nutrient-rich ingredients can produce functional snacks aligning with the health and convenience demands of modern consumers.

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