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COMPARATIVE EVALUATION OF FATTY ACID AND AMINO ACID COMPOSITIONS OF *PLEUROTUS OSTREATUS* (PLEUROTACEA) CULTIVATED BY SUBSTRATE ORGANIC SUPPLEMENTATION TECHNIQUES

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ABSTRACT

***Aim/Background**: Fatty acid and amino acid compositions of Pleurotus ostreatus (Pleurotacea) cultivated by various substrate organic supplementation techniques. **Methods**: Avocado seed supplementation (AVOS), whole wheat supplementation (WWS) and soyabean plus Avocado plus wheat plus corn supplementation (SAWCS) were comparatively evaluated in this study using standard methods. **Results**: Major fatty acids revealed by gas chromatography were polyunsaturated fatty acids (cis-linolec acid (18:2) making up 52.1% total fatty acids (TFA) in AVOS, 50.2% TFA in SAWCS and 29.5% TFA in WWS], Monounsaturated fatty acids (cis-oleic acid (16:1) making up 44.86% TFA in WWS, 21.71% TFA in AVOS and 17.68% TFA in SAWCS], and saturated fatty acid [palmitic acid (16:0) making up 14.8% TFA in AVOS, 11.2% TFA in SAAWCS, 10.21% TFA in WWS). Polyunsaturated fatty acid: saturated fatty acid ratio (PUFU: SFA) were SAWCS (3.10). AVOS (2.30) and WWS (1.40) respectively. Trans fatty acids observed in all the three samples were very low. Trans oleic acid was WWS (0.08%), AVOS (0.06%) and SAWCS (0.055%) in values and trans linoleic acid was AVOS (0.075%), SAWCS (0.04%) and WWS (0.025%) respectively. Total amino acids indicated in the three samples by high performance liquid chromatography (HPLC) were AVOS (219.7mg/g crude protein) with total essential amino acids of AVOS (103.5mg/g crude protein or 47.1%), WWS (101.3mg/kg crude protein or 40.6%) SAWCS (103.1mg/g crude protein or 50.5%) respectively. All the samples contain all the essential amino acids with Arginine predominating. Norvaline, an isomer of valine was also highlighted. **Conclusion:** These results indicated that the macrofungi cultivated by substrate organic supplementation techniques was rich in nutrients and suggest its use in food and feed formulations for humans and livestock.*

KEY WORDS: *Fatty acid composition; amino acid composition; macro fungi, organic substrate supplementation.*

INTRODUCTION

Our health, mental and physical state as well as nutritional status is mainly determined by the food we eat and how we eat it [1]. This statement is widely accepted, today because the capacity for human survival from generation to generation has always been via bioprospecting [2]. From age to age, people always value mushrooms as health foods [3]. Mushrooms make up the most rapidly new growing food that people that are health concerned currently cherish [4], hence, developing nations are encouraged to get involved in their massive production as a measure to addressing human health challenge. Miles and Chang [5] reported that about 1800 species of mushrooms are potentially medicinal, out of the 14,000-15,000 species that exist in the world. However, Guillamon *et al.* [6] highlighted that to distinguish between edible and medicinal mushrooms is difficult because numerous common edible mushrooms possess medicinal properties and several medicinal mushroom are also edible.

According to Kayode *et al.* [7] edible mushrooms such as *Pleurotus* make up a large population of the fungi family. Hall [8] reported that *Pleurotus* was cultivated as a subsistence measure during world war times but today, grown at commercial level around the world. The macrofungi may be used to prevent and treat diseases associated with high plasma cholesterol [9] because it is rich in dietary fiber, sterol, proteins and microelements.

Pleurotus mushroom has high nutritional value, hence, it is a good source of protein, carbohydrates, vitamins and minerals [10-12] indicated that the cultivation of macrofungi is an efficient, economic and viable biotechnology whereby lignocellulosic materials can be converted to protein foods of high quality. The current intellectual curiosity in nutritional research is to discover new ways of cultivating mushrooms so as to give them added value to improve the quality of human health. There is little information on the fatty acid and amino acid composition of *Pleurotus ostreatus* cultivated by organic substrate methods. This study is aimed at comparative evaluation of fatty acid and amino acid composition of *Pleurotus ostreatus* cultivated by substrate organic supplementation methods.

MATERIALS AND METHODS

Cultivation of *Pleurotus ostreatus*

The fungal culture used in this study was strain from ready mother spawn (grown on sorghum seeds) from a potato Dextrose Agar (PDA) tissue culture purchased from the mushroom research unit, Demonstration farm, Faculty of Agriculture, University of Port Harcourt, Port Harcourt, Rivers State, Nigeria.

Whole grains of wheat, seeds of Avocado pear, seeds of soyabean, maize seeds attached to the cob were sourced from local farms in Rivers State, South-South Nigeria. The materials were ground with electrical grinder and used as organic supplements for the basal substrate (saw dust) and these were mixed with different ratios to get three treatments in many replications.

Calcium trioxocarbonate (IV) and calcium tetraoxosulphate (VI) were added to the treatments followed by the addition of water until a humidity of 68% was obtained. Mixtures were packed into heat resistant polypropylene bags at 1kg per bag. A poly vinyl chloride pipe of 2.0cm thick and 2.5cm long was inserted at the neck of each bag to serve as bottle neck and extra propylene was pulled through the PVC pipe and held in place with rubber band and piece of cotton wool was plugged at the neck of the bags.

Substrate bags labeled AVOS, WWS and SAWCS were loaded in a drum for pasteurization by steam generated from boiling water at 100^0C for 5hrs. The drum was allowed to cool and the bags transferred to the inoculation room. Ethanol (70% v/v) was used to disinfect the hands, inoculation room, equipment and spawn bottles to prevent cross-contamination and the bags were inoculated by insertion (2 to 2.5cm deep) into the supplemented substrates. Inoculated bags were transferred into the incubation room (using disinfected plastic baskets) for spawn running under complete darkness at controlled temperature of 25^0C to 20^0C. Humidity of substrate bags was accomplished by spraying water two times, daily and incubation lasted for 40 days, the bags were colonized as mycelia thickening was observed and the bags were then opened for fruiting after transfer to the fruiting room. Fruiting occurred at optimal temperature of 24^0C in the presence of large circulation of air and enough light. Fruiting bodies matured within 48 hours and were harvested and kept in the refrigerator using loosely closed paper bags. They were later dried at 80^0C for 24 hours and stored in tightly sealed containers for further analysis.

Fatty Acid Composition

The fatty acid composition of the dried macrofungi samples was evaluated by employing gas-liquid chromatography in combination with flame ionization detection/capillary column as described by ISO 5509 [13] for trans esterified samples. A split-splitless injector, a flame ionization detector and a chrompack CP–90550 auto-sampler was used to equip the chrompack was used to equip the chrompack CP9001 and this system was employed in analyzing the fatty acid profiles.

Nitrogen was the carrier gas flown at the rate of 0.5ml/min at a temperature of 150^oC, while injection

was 1µL for a split ratio of 25:1, injector temperature, 250°C and detector temperature, 300°C. The column temperature was at 150°C (1min), 5°C/min to 230°C (5min), 15°C/min to 245°C (8min) and Runtime was 31 min. individual fatty acid composition was expressed as a percentage of the total fatty acids in the sample. Fatty acids were identified by comparing relative retention times of the fatty acid methyl esters peaks from the samples using standards. A 37 Fatty Acid Methyl Esters (FAMEs) supelco mixture (standard 47885-u) was employed and certain isomeric forms of fatty acids were identified by employing individual supelco (Bellefonte, PA) standards.

Amino Acid Composition

Amino acid composition of the macrofungi samples was evaluated by high performance liquid chromatographic method described by Maros *et al.* [14] Ten milliliter of 4N NaOH solution and ascorbic acid (200µg) was used in hydrolyzing 3g of dry samples under nitrogen gas in an autoclave at a temperature of 110°C and pH of 9.00 for 16hr followed by the filtration of the hydrolysate using cellulose acetate membrane filter (0.45µm). The amino acid existing on the hydrolysate were separated and quantified via the injection of hydiolysate into the HPLC system. A reverse HPLC and gradient elution using Agilent 1100 HPLC system (Agilent Technologies) equipped with auto-sampler, a Zorbox-Eclipse XDB – C18 column (4.6x150mm, 5pm) with a Zorbox Eclipse- AAA guard column (4.6x12.5mm, 5µm) and fluorescence detector was employed to carry out the amino acids analysis.

Statistical Analysis

Data presented are the means of the results of three replicates with a standard error of less than 5%. Coefficients of variation percent (CV %) was determined.

RESULTS

Fatty acid composition of lipid from fruiting bodies of *Pleurotus ostreatus* sample.

The fatty acid composition of the lipid from the fruiting bodies of the macrofungi samples (AVOS, WWS and SAWCS) are shown in Tables 1 and 2 respectively. Results indicated that 37 fatty acids were detected and the samples contained the highest polyunsaturated fatty acid (PUFA) in the order SAWCS (61.11%) AVOS (53.56%), WWS (30.67%) with cis-linoleic acid predominating in all the samples. This was followed by monounsaturated fatty acid (MUFA) in the order. WWS (46.82%) being the highest and SAWCS (19.07%), the lowest with cis-oleic acid predominating in all the samples.

Table 1 Fatty acid profile (%*) of the lipid from the fruiting bodies samples of *Pleurotus ostreatus*.

Fatty	Acids	AVOS	WWS	SAWCS	AOM	SD	CV%
$C_{4:0}$	Butyric acid	0.045	0.035	0.070	0.050	0.02	40.0
$C_{6:0}$	Caproic acid	0.050	0.090	0.025	0.055	0.03	54.5
$C_{8:0}$	Caprilic acid	0.130	0.105	0.925	0.387	0.47	121.4
$C_{10:0}$	Capric acid	1.050	0.140	0.110	0.433	0.53	123.3
$C_{11:0}$	Undecanoic acid	0.080	0.485	0.035	0.200	0.25	123.6
$C_{12:0}$	Lauric acid	0.155	0.050	0.215	0.140	0.08	59.7
$C_{13:0}$	Tridecanoic acid	0.050	0.020	0.020	0.030	0.02	66.7
$C_{14:0}$	Myristic acid	0.620	0.260	0.330	0.403	0.19	47.2
$C_{14:1}$	Myristolic acid	0.045	0.060	0.035	0.047	0.01	26.7
$C_{15:0}$	Pentadecanoic acid	1.440	0.360	0.555	0.785	0.58	73.3
$C_{15:1}$	Pentadesanoic acid	0.085	0.030	0.515	0.210	0.27	127.3
$C_{16:0}$	Palmitic acid	14.805	10.21	11.160	12.058	2.43	20.1
$C_{16:1}$	Palmitoleic acid	0.555	0.695	0.460	0.570	0.12	20.9
$C_{17:0}$	Margaric acid	0.345	0.180	0.145	0.223	0.11	48.5
$C_{17:1}$	Heptadesenoic acid	0.100	0.535	0.045	0.227	0.27	118.3
$C_{18:0}$	Stearic acid	3.495	9.400	5.415	6.103	3.01	49.4
$C_{18:1}$	Cis – oleic acid	21.54	44.86	17.68	28.03	14.70	52.4
$C_{18:1}$	Trans-oleic acid	0.060	0.080	0.055	0.065	0.01	20.4
$C_{18:2}$	Trans-linoleic acid	0.075	0.025	0.040	0.047	0.03	54.5
$C_{18:2}$	Cis-linoleic acid	52.10	29.50	50.16	43.920	12.53	28.5
$C_{18:3}$	Linolenic acid	0.090	0.025	0.040	0.052	0.02	43.4
$C_{18:3}$	Gamma	0.26	0.170	9.33	3.253	5.26	1.62
$C_{20:0}$	Arachidic acid	0.150	0.010	0.010	0.117	0.11	93.5
$C_{20:1}$	Eicosenoic acid	0.260	0.120	1.415	0.615	0.69	112.9

$C_{20:2}$	Eicosadienoic acid	0.215	0.395	0.320	0.310	0.016	5.16
$C_{21:0}$	Heneicosanoic acid	0.110	0.340	0.055	0.168	0.15	89.3
$C_{21:3}$	n=3, C_{15-11}-eicosatrienoic acid	0.175	0.195	0.115	0.162	0.04	25.7
$C_{20:4}$	Arachidonic acid	0.060	0.175	0.050	0.095	0.07	73.7
$C_{20:3}$	n=6,$C_{15-8,11,14}$-eicosatrienoic acid	0.010	0.040	0.030	0.027	0.02	56.6
$C_{22:0}$	Behenic acid	0.030	0.110	0.020	0.053	0.05	93.1
$C_{20:5}$	Eicosapentanoic acid	0.060	0.020	0.050	0.43	0.02	48.4
$C_{22:1}$	Erucic acid	0.270	0.060	0.090	0.140	0.11	81.1
$C_{22:2}$	Docosadienoic acid	0.250	0.345	0.355	0.317	0.08	26.2
$C_{23:0}$	Tricosanoic acid	0.200	0.250	0.160	0.203	0.05	22.2
$C_{24:0}$	Lignoseric acid	0.050	0.470	0.360	0.293	0.22	75.1
$C_{24:1}$	Nervonic acid	ND	ND	0.160	0.053	-	-
$C_{22:6}$	Docosahexaenoic acid	0.445	0.225	0.810	0.495	0.29	59.7

Where AVOS = Avocado seed supplementation, WWS = whole wheat supplementation, SAWCS = soyabean plus Avocado seed plus while wheat + corn/cob supplementation. AOM=average of mean, SD= standard deviation, CV%= percentage coefficient of variation.

Table 2: Total fatty acids, saturated fatty acids, monounsaturated fatty acids, Polyunsaturated fatty acids, PUFA: SFA ratio of the *Pleurotus ostreatus* samples

Parameters	AVOS	WWS	SAWCS	AOM	SD	CV%
Total fatty acids (TFA)	99.860	99.920	99.995	99.69	0.30	0.3
Saturated fatty acids (SFA)	23.480	22.430	19.815	21.91	1.89	8.6
Monounsaturated fatty acids (MUFA)	22.820	46.82	19.070	29.57	15.10	50.9
Polyunsaturated fatty acids (PUFA)	53.560	30.67	61.110	48.45	15.85	33.7
PUFA: SFA ratio	2.30	1.40	3.10	2.23	0.85	38.2

Where AVOS = Avocado seed supplementation, WWS = whole wheat supplementation, SAWCS = soyabean plus Avocado seed plus while wheat + corn/cob supplementation. AOM= average of mean, SD= standard deviation, CV% = percentage coefficient of variation.

Amino acid Profiles of the proteins from fruiting bodies of *Pleurotus ostreatus* samples

The amino acid composition of the macrofungi fruiting bodies samples: AVOS, WWS and SAWCS are shown in Table 3 The three samples showed a wide variation in the values of their amino acid composition as depicted by the high levels of percentage coefficient of variations (CV%). However, the amino acid values of leucine were close with CV% of 7.8. The highest concentrated amino acid in the three samples was glutamic acid (Glu) in the order WWS (78.0mg/g crude protein), AVOS (46.2mg/kg) SAWCS (21.0mg/kg crude protein), followed by aspartic acid (Asp) in the order: WWS (32.9mg/kg crude proten), AVOS (20.3mg/g crude protein) and SAWCS (17.0mg/g crude protein) respectively.

Table 3: Amino acid protein (mg/g crude protein*) of *Pleurotus ostreatus* samples

	Amino acids (mg/kg Crude protein)*					
Amino Acids	**AVOS**	**WWS**	**SAWCS**	**AOM**	**SD**	**CV%**
Alanine	18.5	6.21	14.5	13.07	6.30	48.3
*Arginine	28.9	11.8	10.5	17.10	10.10	59.1
Aspartic acid	20.3	32.9	17.0	23.40	8.40	35.9
Glutamic acid	46.2	78.0	21.0	48.40	28.60	59.1
Glycine	9.0	9.9	16.5	11.80	4.10	34.7
*Histidine	5.4	21.5	12.5	13.10	8.10	61.8
*Isoleucine	6.9	8.3	11.5	8.9	2.4	26.5
*Leucine	12.2	10.62	12.0	11.6	0.9	7.8
*Lysine	7.5	11.0	10.0	9.5	1.8	19.0
*Methionine	3.1	5.4	7.5	5.3	2.2	41.5
Norvaline	2.5	1.0	1.5	1.7	0.8	47.1
*Phenylalanine	8.0	10.0	11.0	9.7	1.5	15.5
Proline	3.1	7.1	8.5	6.2	2.8	45.2
Serine	10.4	6.1	10.0	8.8	2.4	27.3
*Threonine	10.0	9.2	10.1	9.8	0.5	5.1
*Tryptophan	12.0	11.2	7.5	10.2	2.4	23.5
Tyrosine	6.2	3.4	11.0	6.9	3.8	55.1
*Valine	9.5	6.2	11.5	9.1	2.7	29.7
Cystine	0.0	0.0	0.0	-	-	-

Where AVOS = Avocado seed supplementation, WWS = whole wheat supplementation, SAWCS = soyabean plus Avocado seed plus while wheat + corn/cob supplementation. AOM=average of mean, SD = standard deviation, CV% = percentage coefficient of variation, *Essential amino acids.

Table 4 is more informative on the components of the amino acids of the samples. The total amino acids (TAA) value was highest in WWS and lowest in SAWCS. The total essential amino acids (TEAA) with histidine was highest in SAWCS and lowest in AVOS. The total essential amino acid to total amino acid ratio in AVOS, WWS and SAWCS were 0.34, 0.36 and 0.45 respectively. WWS had the highest total acidic amino acid followed by AVOS and SAWCS had the lowest value. The total neutral amino acids were quite high in SAWCS and AVOS respectively but low in WWS. The samples had low total basic amino acid, total sulphur containing amino acid and total aromatic amino acid.

Table 4: Total Essential, non-essential, acidic, neutral and aromatic amino acids (mg/g crude protein*) of the *Pleurotus ostreatus* samples

Amino acids	AVOS	WWS	SAWCS	AOM	SD	CV%
Total amino acids (TAA)	219.7	249.8	204.1	224.5	23.2	10.3
Total non-essential amino acids (TNEAA)	145.1	160.3	111.5	139.0	25	18.0
Total essential amino acids (TEAA)						
Total essential with histidine	103.5	101.3	103.1	85.6	9.6	11.2
Total essential without histidine	98.1	79.8	90.6	72.4	6.7	9.3
% TNEAA	66.0	64.2	54.6	61.6	6.1	9.9
% TEAA	47.1	40.6	50.5	38.3	5.9	15.4
TEAA: TAA ratio	0.47	0.41	0.51	0.38	0.06	15.8
Total acidic amino acids (TAAA)	66.5	110.9	38.0	71.5	39.7	51.3
% TAAA	30.3	44.4	18.6	31.1	12.9	41.5
Total neutral amino acids (TNAA)	113.9	95.6	134.6	114.7	19.5	17.0
% TNAA	51.8	38.3	65.9	52.0	13.8	26.5
Total basic amino acids (TBAA)	41.8	44.3	33.0	39.7	25.9	41.9
% TBAA	19.0	17.7	16.2	17.6	1.4	8.0
Total sulphur amino acids (TSAA)	3.1	5.4	7.5	5.3	2.2	41.5
%TSAA	1.4	2.2	3.7	2.4	1.2	50.0
Total anomatic amino acids (TArAA)	14.2	13.4	22.0	16.5	4.8	29.1
% TARAA	6.5	5.4	10.8	7.6	2.9	38.2

Values are means ± standard deviations of triplicate determinations. Where AVOS = Avocado seed supplementation, WWS = whole wheat supplementation, SAWCS = soyabean plus Avocado seed plus while wheat + corn/cob supplementation. TEAA = total amino acid, TNEAA = total non-essential amino acid, TEAA = total essential amino acid, TAAA=total acidic amino acid, TNAA = total neutral amino acid, TBAA = Total basic amino acid, TSAA = Total sulphur amino acid, TArAA = total aromatic amino acid. AOM = average of mean, SD = standard deviation, CV% percentage coefficient of variation.

Table 5 shows the statistical comparism of the essential amino acids for the three samples. All the essential amino acids were found to be present with wide CV% in the three samples except leucine and threonine with low CV% of values 7.8% and 5.1% respectively. The highest varied parameter was histidine with a CV% of 61.8% followed by methionine with a CV% of 41.5% and valine with a CV% of 29.7.

Table 5: Total Essential amino acids of proteins from the fruiting bodies of *Pleurotus ostreatus* samples

ESSENTIAL AMINO ACIDS (Mg/g CRUDE Protein)*						
PARAMETER	**AVOS**	**WWS**	**SAWCS**	**AOM**	**SD**	**CV%**
Histidine	5.4	21.5	12.5	13.1	8.1	61.8
Argenine	28.9	11.8	10.5	17.10	10.10	59.1
Isolencine	6.9	8.3	11.5	8.9	2.4	26.9
Leucine	12.2	10.6	12.0	11.6	0.9	7.8
Lysine	7.5	11.0	10.0	9.5	1.8	19.0
Methionine	3.1	5.4	7.5	5.3	2.2	41.5
Phenylalanin	8.0	10.0	11.0	9.7	1.5	15.5
Threonine	10.0	9.2	10.1	9.8	0.5	5.1
Tryptophan	12.0	11.2	7.5	10.2	2.4	23.5
Valine	9.5	6.2	11.5	9.1	2.7	29.7

Where AVOS = Avocado seed supplementation, WWS = whole wheat supplementation, SAWCS = soyabean plus Avocado seed plus while wheat + corn/cob supplementation. AOM = average of mean, SD = standard deviation, CV% = percentage coefficient of variation.

Table 6 contain the amino acid scores for the three samples compared with the WHO reference protein pattern. The amino acid scores compared with the WHO reference protein pattern for human milk, adult and egg DRI and FAO [19,28] suggested a good comparism with most of the food sources. The highest chemical score obtained was 134.4% for histidine (compared to adult reference protein pattern) in WWS. This value is lower than a chemical score of 150% reported by Kang *et al.* [23] for threonine, which was the highest that they reported in their work.

Table 6: Comparism of Protein from the fruiting bodies of *Pleurotus ostreatus* samples with WHO Reference protein pattern. Amino acids reference adult patterns egg (mg/g protein) amino acid scores (%)

Amino acids	Reference Patterns (m/g protein)*			Amino acids (%)*								
	Human Milk	Adult	Egg	AVOS			WWS			SAWCS		
				X	Y	Z	X	Y	Z	X	Y	Z
Histidine	26	16	22	20.8	33.8	24.5	82.7	134.4	97.7	48.1	78.1	56.8
Isoleucine	46	16	54	15.0	53.1	12.8	18.0	63.8	15.4	25.0	88.5	21.3
Leucine	93	19	86	13.1	64.2	14.2	11.4	55.9	12.3	12.9	63.2	14.0
Lysine	66	16	70	11.4	46.9	10.7	16.7	68.8	15.79	15.2	62.5	14.3
Meth+ Cystine	42	17	57	7.4	18.2	5.6	12.9	31.8	9.5	17.9	44.1	13.2
Phenylala. + Tyr	72	19	93	17.7	74.7	15.3	18.6	70.5	14.4	30.6	116.8	23.7
Threonine	43	9	47	23.3	111.1	21.3	21.4	102.2	19.6	23.5	112.2	21.5
Valine	55	13	68	17.3	73.1	14.0	11.3	88.5	9.1	20.9	88.5	9.1

Where AVOS = Avocado seed supplementation, WWS = whole wheat supplementation, SAWCS = soyabean plus Avocado seed plus while wheat + corn/cob supplementation. X= compared to human milk protein pattern, Y= compared to adult reference protein pattern, Z = compared to egg protein pattern.

DISCUSSION

The saturated fatty acids were the lowest in the three samples in the order: AVOS (23.48%), WWS (22.43%) and SAWCS (19.82%) respectively, with palmitic acid predominating. Ergonul *et al.* [15] investigation on fatty acid composition of mushrooms also highlighted unsaturated fatty acid levels being higher than the saturated fatty acid counterparts.

Barros *et al.* [16] indicated in their studies a result in consonant with our report in this study that linoleic acid and oleic acid were predominant fatty acids followed by palmitic acid. Longvah and Deosthale [17] highlighted similar results for *schizophyllium commune* and *L.edodes* in which linoleic acid, palmitic and oleic acids accounted for almost the whole fatty acids. Essential fatty acids cannot be made by humans; hence they are ingested for good health [18].

Polyunsaturated fatty acids [19] help in the body's proper functioning and taking them in reasonable amount may protect the body from diseases associated with the heart and its vessels as well as diabetes mellitus. Glew *et al.* [20] also reported that linoleic acid is an essential component of membrane phospholipids and serves as a precursor for arachidonic acid, an essential fatty acid found in tissue membranes of humans. Arachidonic acid can also be metabolized to prostaglandins [21]. Prostaglandins help to regulate blood pressure, gastric acid secretion and play major function in anaphylaxis and inflammation [20].

The geometric isomers of the fatty acids in transforms observed in the 3 samples were in very low amount and included trans oleic acid ranging from 0.08% to 0.06%, trans-linoleic acid ranging from 0.075% to 0.025%. This result is in agreement with the detection of Ergonul *et al.* [15] in the mushrooms they studied where trans-isomers of unsaturated fatty acids had very low value range (0.02-0.12%). Health wise, trans-fatty acids have been indicated to have negative correlation with HDL-Cholesterol and positive correlation with LDL-cholesterol [22] because of the high level of risk associated with cardiovascular

diseases. Since this study indicated that the samples were rich in polyunsaturated fatty acids, particularly cis-linoleic acid, they are therefore important as part of human diet as sources of essential fatty acids and should be added in the diet of humans from the nutritional, stability and physiological point of view.

The PUFA: SFA ratio of the mushroom samples highlighted was quite reasonable because currently, emphasis stresses that PUFA and MUFA should be increased in diets. The approach can serve as a measure to averting diseases associated with dietary fats rich in saturated fatty acids, which include heart attack and stroke. According to Kang *et al.* [23] increasing dietary PUFA: SFA ratio has been recommended for the prevention of cardiovascular diseases. It is also important to note that higher PUFA: SFA ratio in diets enhances oxidative stress because PUFA are attacked by free radicals leading to lipid per oxidation. The results highlighted in this study suggest that PUFAs from the three samples may therefore be needed in diet formulation and supplementation procedures as agents for cardio-protection.

The results in this study are in consonant with the highlight of Kang *et al.* [23] who reported that glutamic acid had the highest value followed by aspartic acid in all the amino acids present in oyster mushroom (*P. sajor caju*). Oyetayo *et al.* [24] also indicated results that was in agreement of our report in this study on a research conducted on amino acid composition of edible oyster mushroom where glutamate and aspartate were predominant. It is possible that the consistent report with the previous results could be attributable to the use of these acidic amino acids as precursors for the derivation of the backbone of other amino acids in proteins [24].

The previous reports by Oyetayo *et al.* [24] on *P. Sajor Caju* and Kang *et al.* [23] of the presence of all the essential amino acids in the samples they analyzed are in accordance with the report in our study. The present study showed that arginine and leucine were amongst the most abundant essential amino acid present. Kang *et al.* [23] and Oyetayo *et al.* [24] gave similar report that leucine and arginine were the most predominant essential amino acids in the mushrooms they analyzed. Essential amino acids are synthesized and ingested because humans cannot make them. The records therefore suggest that the samples may contribute significantly to the supply of essential amino acids in liuman diets as well as animal feeds.

Considering the use of proteins biologically, it is true that the total protein content is an important feature but the level and balance of essential amino acids [25] serve as key factor in the determination of nutritional value. When the supply of one or more essential amino acid is inadequate, the rate at which protein synthesis occurs reduces [26]. The quality of dietary protein in foods could be measured using diverse methods but the ratio of available amino acids in the food compared with the human needs is a better method [27]. The study amino acid also revealed a very low concentration of norvaline. Ming *et al.* [28,29] reported that this isomer of valine is essential to humans as it promotes growth of muscles and the regeneration of tissues.

CONCLUSION

The result in this study has highlighted that the cultivation of mushrooms by substrate organic supplementation techniques may enhance their nutrient content. The fatty acid and amino acid composition of the samples of macrofungi show that they can serve as good sources of essential nutrients in human diets and feed formulation for livestock.

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