Phytonutrients and antioxidant activity of extracts of *Leucaena leucocephala* Lam (Wit) and six varieties of *Moringa oleifera* Lam used by the poultry farmers of Burkina Faso.

Anne Flora Drabo[1,*], Benjamin Kouliga Koama[1,2], Windmi Kagambega[1], Sami Eric Kam[1,3], Marie P. Létourneau-Montminy[5], Roland Nâg-Tiéro Meda[1] and Georges Anicet Ouédraogo[1].
[1]Research and Teaching Laboratory in Animal Health and Biotechnology, University Nazi-Boni, 01 BP 1091 Bobo-Dioulasso, Burkina Faso.
[2]Laboratory of Traditional Medicine and Pharmacopoeia, Research Institute of Health Sciences, 01 BP 545 Bobo-Dioulasso, Burkina Faso.
[3]Laboratory for Bacteriological Research, INSP / Centre MURAZ, 01 BP 390, Bobo-Dioulasso, Burkina Faso.
[4]Genetic Laboratory, Plant Biotechnologies and Phytogenetics Resources Management, National Institute for Environment and Agricultural Research (INERA), 01 BP 910, Bobo-Dioulasso, Burkina Faso.
[5]Department of Animal Sciences, Laval University, Quebec City, Canada.
** Corresponding author E-mail: dr.floranna@yahoo.com; Telephone: (+226) 68355855 / 03714104.*
Keywords: Phytonutrient, *Leucaena leucocephala*, *Moringa oleifera*, antioxidant activity.

Submitted 07/08/2025, Published online on 30th September 2025 in the *Journal of Animal and Plant Sciences (J. Anim. Plant Sci.) ISSN 2071 – 7024*

1 ABSTRACT

Leucaena leucocephala* and *Moringa oleifera* are used in poultry feeds due to their potential nutritional values. The present work aimed to characterize the phytonutrients profile and evaluate the antioxidant potential of various plant specimens. The total phenolic and flavonoid contents of hexanic and methanolic extracts were determined using the Folin-Ciocalteu and aluminium chloride ($AlCl_3$) colorimetric methods, respectively. The plant samples were analyzed for dry matter, moisture, crude protein, nitrogen, fibre, lipids, energy, ash, minerals, and fatty acid profile using standard procedures. Antioxidant capacity was determined using DPPH, ABTS, and FRAP assays, employing Trolox and quercetin as reference standards. The methanolic extract of *Leucaena leucocephala* exhibited the highest total phenolic content, reaching 27.99 ± 0.24 mgGAE/100mg. However, the hexanic extract of M45-1 presented the best flavonoids contents (9.45 ± 00 QE/100mg). All methanolic extracts showed antioxidant activity in the tree assays. The methanolic extract of *Leucaena leucocephala* exhibited a stronger DPPH free radical scavenging capacity than quercetin, with a value of 703.86 ± 0.13 µmol AAE/g extract. The highest antioxidant activity using the $ABTS^{\bullet+}$ radical inhibition method was recorded for the hexanic extract of M4-1 (8077.22 ± 1.27 µmol AAE/g) in comparted with Trolox. The methanolic extract of M6-1 (2361.72± 00 µmol AAE/g extract) showed greater Fe^{3+} reducing activity than quercetin. All extracts contained total phenolics and total flavonoids contents. The chemical composition of *Leucaena leucocephala* and *Moringa oleifera* included proteins, nitrogen, ADF, NDF, lipids, energy, essential minerals and polyunsaturated fatty acids. Protein contents in *Leucaena leucocephala* seeds (37.82±0.47% dry basis) were high. Due to their phytonutrients composition, *Leucaena leucocephala* and *Moringa oleifera* could be exploited in the poultry feeding.

2 INTRODUCTION

In Burkina Faso, poultry production plays a crucial socioeconomic role, providing income for an estimated 1.6 million households, especially benefiting women in rural communities (FAO, 2018). However, poultry production contributes approximately 6% to Burkina Faso's Gross Domestic Product (FAO, 2018; MRAH, 2022). In addition to being an interesting source of proteins, calories and micronutrients, poultry farming contributes to quantitatively and qualitatively improving of populations diet (Nahimana *et al.,* 2020). According to the studies by poultry farming and the consumption of local poultry products, play a vital role in various aspects of community life, including social, cultural, economic and religious practices. These include wedding celebrations, traditional medicinal use and practices that foster social cohesion such as gift-giving and hosting visitors (Weiman *et al.,* 2016; Mebanga *et al.,* 2020; Pindé *et al.,* 2020). Poultry farming while economically and socially important, is still subject to multiple constraints that restrict development. Economically, feed remains the most burdensome input, representing about 70% of total farm expenditures (Oladokun and Johnson, 2012). In fact, conventional protein- and energy-rich ingredients are becoming not only inaccessible, but also expensive. Fish meal, a key protein source, represents about 25% of production cost. Its elevated price remains a major barrier to the development of poultry farming in many countries, especially in Burkina Faso. Energy sources rely on cereals and in particular maize, which are extremely expensive on the market and widely used for human consumption (PAM-SONAGESS, 2022). And yet, energy and protein sources are the main determinants of the growth performance result in poultry production. To enhance the production conditions of indigenous chickens in Burkina Faso, the use of locally available feed resources is a viable strategy for reducing production costs. Nevertheless, several studies on alternative feed sources have identified certain plants such as *Moringa oleifera* (Lam), *Leucaena leucocephala* (Lam), *Cassia tora* (Linn), *Hibiscus sabdariffa* (Linn) can be used in the diet of poultry (Sourokou Sabi, 2014) without damage their zootechnical performance. *Leucaena leucocephala* and *Moringa oleifera* were among the alternative local resource protein sources and energy sources available locally and at low cost. In addition, *Leucaena leucocephala* does not compete with human food. *Leucaena leucocephala* and *Moringa oleifera* are nutritional and medicinal plants used in poultry for their anti-inflammatory activities, antibacterial, anti-parasitic, antioxidant, growth, digestibility, egg-laying performance, yolk colour egg, egg mass and eggshell quality (Agbor *et al.,* 2013; Abbas, 2013; Yang *et al.,* 2017; Xu *et al.,* 2018; Siti *et al.,* 2019). *Leucaena leucocephala* and *Moringa oleifera* are notable for their high protein content, with crude protein levels ranging from 20% to 34% in *Leucaena leucocephala* and 20% to 29% in *Moringa oleifera* on a dry matter basis. In terms of metabolizable energy for poultry, *Leucaena leucocephala* provides between 700 and 1365 kcal/kg, while *Moringa oleifera* offers approximately 2005 kcal/kg. Both plants also possess a valuable nutritional profile, including essential amino acids, vitamins and minerals (Safwat *et al.,* 2014). Their substitution or incorporation as an alternative protein-energy ingredient in poultry feed could therefore improve poultry production. Environmental factors influence phytonutrients levels. For these reasons, this study aimed to quantify the phytonutrient content and assess the antioxidant activity of extracts from *Leucaena leucocephala* and six varieties of *Moringa oleifera* commonly used in poultry feed in Burkina Faso.

3 MATERIAL AND METHODS

3.1 Plants collection: In June 2019, leaves, pods and seeds of *Leucaena leucocephala*, along with leaves from six distinct *Moringa oleifera* varieties were collected from Bobo-Dioulasso and the Farako-Bâ recherche station, located approximately 10 km southwest of Bobo-Dioulasso. The plant samples were taxonomically verified by Dr. OUOBA Yempabou Herman, a botanist and ecologist at the University of Nazi BONI (Bobo-Dioulasso), and Dr. SANOU Jacob, a researcher at INERA (Farako-Bâ) and developer of several food crop varieties. The leaves of six varieties of *Moringa oleifera* were codified (M4-1; M12-1; M2-2; M9-3; M45-1; M6-1). The collected plant materials were carefully washed, air-dried at room temperature, and pulverized into fine powder for further analysis.

3.2 Extracts preparation: A quantity of 20g of plant powder was successively extracted with 200ml of hexane followed by methanol using a Soxhlet apparatus. The resulting extracts were concentrated to dryness and stored at 4°C until further analysis.

3.3 Determination of Phenolic Compounds: Total phenolic and flavonoid contents were measured using Folin-Ciocalteu and aluminium trichloride calorimetric method, in the same order, following the procedure described according to Meda et al. (2010). Results were expressed as milligrams of gallic acid equivalents per 100mg of dried extract (mg GAE/100mg) for total phenolics, and as milligrams of quercetin equivalents per 100mg of dried extract (mg QE/100mg) for total flavonoids.

3.4 Evaluation of Antioxidant Activity: Three spectrophotometric assays were employed to determine the antioxidant activity of the extracts, based on the methodology reported by Meda et al. (2010). These included the $ABTS^{\bullet+}$ radical cation decolorization test, the DPPH free radical scavenging test, and the ferric reducing antioxidant power (FRAP) determination. Values are reported as micromoles of ascorbic acid equivalents per gram of dried extract (µmol EAA/g extracts).

3.5 Nutritional value: The nutrients content of *Leucaena leucocephala* samples and six varieties of *Moringa oleifera* leaves have been estimated using the methods was described by authors. Dry matter and ash contents were determined using the validated procedures described by AOAC (1990). Crude fat was extracted using anhydrous diethyl ether with a Soxtec™ 2050 apparatus, in accordance with AOAC (2001) guidelines. The Kjeldahl method employing a digestion block and the Foss 8400 system, was used to determine crude protein and total nitrogen (AOAC, 2001). Acid Detergent Fibre (ADF) and Neutral Detergent fibre (NDF) were measured using the Ankom 2000 fibre Analyzer. Gross energy content was assessed with a Parr 6300 calorimeter and energy values were calculated based on sample weight. For mineral analysis, ash samples were digested using 5 ml of concentrated nitric acid (HNO_3) combined with 12.5 ml of 50% hydrochloric acid (HCl), then gently boiled on a hot plate. After cooling, the digests were filtered and diluted to 100ml with distilled water. Individual mineral elements were quantified by atomic absorption spectrophotometry, except for phosphorus, which was determined using a UV-visible spectrophotometer (AOAC, 2000). The fatty acid profile was analysed through direct methylation following the method of Sukhija and Palmquist (1988), with slight modifications.

3.6 Statistical Analysis: All data are reported as mean ± standard deviation (SD). Statistical processing of the data was conducted using R (version 4.1.0), with significance set at p-value ≤ 0.05. XLSTAT software (version 2016.02.27444) was employed to perform linear regression analyses.

4 RESULTS

4.1 Phenolic Compounds Content: Table 1 displays the total phenolic and flavonoid levels in the plant extract. the total phenolic and flavonoid contents of the plant extracts. In the methanolic extracts (ME), total phenolic content varied between 10.85 to 27.99 mgGAE/100mg of extract, whereas the hexanic extracts (HE) showed values between 4.78 and 13.42 mg GAE/100 mg of extract. However, leaves ME of *L. leucocephala* had a better total phenolic content (27.99 mg GAE/100mg extract). Concerning the varieties of *M. oleifera* the highest content was measured in ME of M12-1 (16.28 mg GAE/100g extract). The difference was significant for the ME (P-value = 0.006341) as in HE (P-value = 0.06907) derived from the leaves of both plant species. Also, the difference was significant between the leaves of six varieties of *M. oleifera* with P-values = 0.004066 (ME) and 0.003537 (HE). The methanolic extracts (ME) exhibited total flavonoid contents ranging from 2.89 mg QE/100mg extract for M2-2. to 6.01 mg QE/100 mg extract for M2-2. The difference of the total flavonoids contents for ME was significant between the two species (P-value = 0.0438) and within varieties of *M. oleifera* (P-value = 0.003537). The flavonoid content of ME from *L. leucocephala* was 5.90 mg QE/100mg extract. The best of total flavonoids content was identified in HE of M45-1 (9.45mg QE/100mg extracts). We can notice these the difference was significant of both plants species as the varieties for HE.

Table 1: Phenolic and flavonoid contents in methanolic and hexanic extracts of *Moringa oleifera* and *Leucaena leucocephala*.

Plants	Varieties	Organ	Total phenolic (mgGAE/100mg extracts)				Total flavonoid (mgQE/100mg extracts)			
			methanolic extract	P-value	hexanic extract	P-value	methanolic extract	P-value	hexanic extract	P-value
Moringa oleifera	M2-2	Leaves	14.71 ± 0.68	0.006341* 0.004066**	11.13 ± 0.37	0.06907* 0.003537**	6.01± 0.18	0.0438* 0.003537**	0.71 ± 00	0.006289* 0.003273**
	M4-1		12.63 ± 0.37		13.06 ± 0.21		5.40 ± 0.13		3.81 ± 00	
	M6-1		10.85 ± 0.12		11.99 ± 00		2.89 ± 0.09		6.51 ± 0.13	
	M9-3		13.21 ± 0.61		9.14 ± 0.49		4.44 ± 0.13		3.89 ± 0.16	
	M12-1		16.28 ± 00		11.99 ± 0.21		2.62 ± 00		1.90 ± 00	
	M45-1		13.56 ± 0.24		13.42 ± 0.12		3.46 ± 0.09		9.45 ± 00	
Leucaena leucocephala			27.99 ± 0.24		4.78 ± 0.12		5.90 ± 0.22		Undetermined	

Values are expressed as mean ± standard deviation of three independent replicates. Statistically significant differences between varieties are indicated by * ($p \leq 0.05$), and those between species by ** ($p \leq 0.01$).

4.2 Antioxidant activity: Table 2 summarises the antioxidant activities of the extracts. Three methods were performed to assess these activities. Antioxidant activities were ranged between 22.99±0.02 µmol AAE/g extract and 703.86±0.13 µmol AAE/g extract. The methanolic extract of *L. leucocephala* exhibited the highest DPPH radical scavenging activity (703.86±0.13 µmol AAE/g extract). The greatest $ABTS^{\bullet+}$ radical scavenging capacity was recorded in the hexanic extract of M4-1 (8077.22±1.27 µmol AAE/g extract). Similarly, the strongest ferric reducing power, reflecting the ability to reduce Fe^{3+} to Fe^{2+}, was also found in the methanolic extract of *L. leucocephala* 1748.15 ± 0.98 µmol AAE/g extract) and M6-1 (2361.72± 00 µmol AAE/g). We can notice than the HE of M4-1 (8077.22 ± 1.27 µmol EAA/g) showed the best activities to reduce the radical cation $ABTS^{\bullet+}$ compared to Trolox (8005.11 ± 9.09 µmol AAE/g). The ME of M6-1 (2361.72± 00 µmol AAE/g) presented the best ability to reduce Fe^{3+} to Fe^{2+} compared to quercetin (2231.51 ± 12.28 µmol AAE/g).

Table 2: Antioxidant potential of hexanic and methanolic extracts from *Moringa oleifera* and *Leucaena leucocephala.*

Samples	**Varieties**	**Tests**					
		DPPH (µmol AAE/g extract)		**ABTS (µmol AAE/g extract)**		**FRAP (µmol AAE/g extract)**	
Moringa oleifera		**ME**	**HE**	**ME**	**HE**	**ME**	**HE**
	M2-2	371.09± 0.14^{c}	30.98 ± 0.20^{a}	6466.59 ± 0.73^{d}	6154.07 ± 0.73^{d}	1007.21 ± 00^{c}	Undetermined
	M4-1	Undetermined	210.22 ± 0.12^{b}	7524.32 ± 0.73^{b}	8077.22 ± 1.27^{a}	219.98 ± 0.17^{f}	243.10 ± 0.00
	M6-1	471.51 ± 0.39^{b}	31.40 ± 0.31^{b}	6971.41 ± 1.93^{c}	7716.63 ± 1.27^{b}	2361.72± 00^{a}	Undetermined
	M9-3	234 ± 00^{e}	Undetermined	7860.87 ± 00^{a}	7283.92 ± 2.19^{c}	401.64 ± 0.06^{e}	277.85 ± 0.00
	M12-1	297.04 ± 0.18^{d}	Undetermined	5841.56 ± 2.19^{e}	7596.44 ± 1.93^{b}	694.60 ± 00^{d}	Undetermined
	M45-1	231.51 ± 0.02^{e}	22.99 ± 00^{b}	7533.03 ± 2.19^{b}	7644.52 ± 0.00^{b}	156.27 ± 5.43^{g}	Undetermined
Leucaena leucocephala		703.86 ±0.13^{a}	Undetermined	1586.59 ± 00^{f}	6274.27 ± 0.00^{d}	1748.15 ± 0.98^{b}	Undetermined
Trolox		755.76 ± 00	755.76 ± 00	8005.11 ± 9.09	8005.11 ± 9.09	6034.63 ± 12.04	6034.63 ± 12.04
Quercetin		645.99 ± 0.00	645.99 ± 0.00	14351.50 ± 0.00	14351.50 ± 0.00	2231.51 ± 12.28	2231.51 ± 12.28

Different letters within the same column indicate statistically significant differences ($p \leq 0.05$) between the two extracts.

4.3 Nutritional value: The results of the analysis are presented as percentages (%) on a dry matter basis. As shown in table 3, the data present the proximate chemical composition of six *Moringa oleifera* varieties (leaves) as well as the leaves, seeds and pods of *Leucaena leucocephala*. All samples of *M. oleifera* contained proteins contents with the highest contents measured in M4-1 (26.49%). However, protein and lipid contents respectively in *L. leucocephala* seeds (37.82±0.47% and 16.79±1.48%) were higher than pods and leaves. Compared to the other samples, the gross energy of leaves of *L. leucocephala* had the highest with a value of 5030.12±14.31 kcal/100g followed by seeds (4762.22±5.86 Kcal/100g). Lipid, nitrogen, fibre (ADF and NDF) and minerals were contained in all samples. Among minerals, calcium contents were highest in the leaves of *L. leucocephala* (2.22±0.01%).

.

Table 3: Nutritional profiles of *Moringa oleifera* leaves and various organs of *Leucaena leucocephala*

Chemical analysis on dry matter basis	*Moringa oleifera leaves*						*Leucaena leucocephala*		
	M2-2	**M4-1**	**M6-1**	**M9-3**	**M12-1**	**M45-1**	**Leaf**	**Seed**	**Pod**
Dry matter (%)	89.18±0.22	87.10±0.18	88.43±0.03	88.82±0.23	87.04±0.00	89.56±0.28	90.16±0.04	89.67±0.18	88.19±0.17
Moisture (%)	10.82±0.22	12.90±0.17	11.57±0.03	11.18±0.22	12.96±0.00	10.44±0.28	9.84±0.04	10.33±0.18	11.81±0.17
Crud protein (%)	23.28±0.44	26.49±0.12	22.64±0.25	25.38±0.07	24.52±0.14	23.05±0.47	21.67±0.17	37.82±0.47	24.55±0.10
N (%)	3.73±0.07	4.24±0.01	3.62±0.04	4.06±0.01	3.79±0.06	3.81±0.00	3.47±0.02	5.85±0.21	3.93±0.01
NDF (%)	26.68±0.50	30.45±0.50	26.70±1.49	28.84±1.87	26.06±0.84	29.65±0.64	29.68±1.48	29.74±0.43	38.18±0.41
ADF (%)	18.03 ±0.14	18.56 ±1.33	16.52 ±1.33	18.87 ±0.04	19.04 ±0.06	16.97 ±0.35	17.31±0.05	19.25±0.61	36.10±0.60
Lipid (%)	10.38±0.31	7.36±0.20	10.08±0.16	9.06±0.05	7.85±0.03	10.21±0.17	10.06±0.07	16.79±1.48	10.08±1.36
E (Kcal/100g)	501.53±1.59	478.07±1.99	504.81±0.19	504.66±0.92	526.43±1.11	470.59±0.47	5030.12±14.31	4762.22±5.86	44.46±9.61
Ash (%)	5.55±0.15	8.09±0.30	5.91±0.06	6.50±0.01	7.12±0.01	5.95±0.20	7.55±0.17	4.41±0.01	5.57±0.09
Ca (%)	0.75±0.10	1.59±0.00	0.95±0.01	1.11±0.02	1.29±0.00	0.88±0.02	2.22±0.01	0.51±0.01	0.71±0.00
P (%)	0.02±0.00	0.02±0.01	0.02±0.02	0.02±0.03	0.02±0.04	0.02±0.05	0.04±0.00	0.03±0.00	0.02±0.00
Mg (%)	0.31±0.00	0.54±0.17	0.30±0.00	0.37±0.12	0.57±0.01	0.36±0.01	0.27±0.00	0.14±0.20	0.28±0.00
Zn (%)	0.27±0.09	0.34±0.05	0.24±0.08	0.26±0.00	0.22±0.10	0.31±0.13	0.23±0.02	0.57±0.00	0.47±0.15
K (%)	1.71±0.07	2.33±0.04	1.64±0.02	2.09±0.05	1.71±0.07	1.73±0.00	1.44±0.01	1.84±0.02	2.28±0.10
Fe (%)	0.13±0.02	0.14±0.03	0.12±0.02	0.14±0.01	0.13±0.03	0.14±0.04	0.14±0.01	0.12±0.03	0.13±0.03

4.4 Fatty acid content of *Moringa oleifera and Leucaena leucocephala* were expressed percentages (%) on dry matter basis (table 4). Among the 22 fatty acids identified, eight were saturated, two were monounsaturated, and the remaining were polyunsaturated: five omega-3, four omega-6, one omega-9 and two omega-11. Palmitic and stearic acids were the predominant saturated fatty acids, with the highest levels detected in *Leucaena leucocephala* pods (37.34% and 9.75% respectively). Regarding omega fatty acids, high levels of α-linolenic acid were observed in *Leucaena leucocephala* leaves and *Moringa oleifera* variety M6-1 (44.64% and 43.25%) respectively. In *Leucaena leucocephala* seeds, linolenic acid and oleic acid were particularly abundant (53.73 and 14.55% respectively).

Table 4: Composition of fatty acid in *Moringa oleifera* leaves and in leaves, seeds and pods of *Leucaena leucocephala*.

Fatty acid content (% MS)			*Moringa oleifera*						*Leucaena leucocephala*		
Classification	**Symbol**	**Name of compounds**	**M2-2**	**M4-1**	**M6-1**	**M9-3**	**M12-1**	**M45-1**	**Leaf**	**Seed**	**Pod**
Saturated fatty acids	C14:0	Myristic acid	4.01	2.93	3.93	4.08	3.2	4.68	0.99	0.14	1.13
	C15:0	Pentadecanoic acid	0.33	0.27	0.28	0.33	0.29	0.36	0.29	0.15	1.49
	C16:0	Palmitic acid	31.38	30.15	26.43	31.35	29.71	30.22	22	17.93	37.34
	C17:0	Margaric acid	0.5	0.4	0.41	0.44	0.4	0.5	0.43	0.12	0.85
	C18:0	Stearic acid	4.14	4.96	3.68	3.96	4.9	3.77	8.97	4.79	9.75
	C20:0	Arachidic acid	0.97	1.38	0.9	0.97	1.41	1.07	1.32	1.33	3.26
	C22:0	Docosanoic acid	1.91	2.12	1.73	2.04	2.3	2.19	0.97	1.58	2.62
	C24:0	Tetracosanoic acid	2.9	3.52	2.84	3.18	3.68	3.44	2.00	1.16	3.69
Mono-saturated fatty acids	C16:1	Palmitoleic acid	0.21	0.28	0.19	0.23	0.24	0.22	1.86	0.36	0.36
	C22:1	Erucic acid	0.42	0.37	0.53	0.61	0.52	0.69	0.29	0.13	1.28
Omega-3	C18:3n3	α-linolenic acid	38.71	32.09	43.25	38.6	31.39	35.87	44.64	1.66	10.89
	C20:3n3	*cis*-11,14,17-Eicosatrienoic acid	0.44	0.24	0.21	0.3	0.31	0.39	0	0	0
	C20:4n3	Arachidonic acid	0.39	0.33	0.34	0.29	0.6	0.53	0	0	0
	C20:5n3	Eicosapentaenoic acid	0	0	0	0	0	0	0	0	0
	C22:6n3	Docosahexaenoic acid	0.78	0.56	0.55	0.63	0.59	0.79	0.97	0	0
Omega-6	C18:2n6	Linolenic acid	8.31	7.64	9.08	7.8	7.56	8.53	10.46	53.73	17.86
	C18:3n6	Ɣ-linolenic acid	0.32	0.34	0.29	0.29	0.33	0.33	0.32	0.14	1.04
	C20:4n6	Arachidonic acid	0	0	0	0	0	0	0	0	0
	C22:2n6	Docosadienoic acid	0.34	0.22	0.26	0.29	0.3	0.28	0.58	0.3	1.63
Omega-9	C18:1c9	Oleic acid	3.23	11.2	4.39	3.97	11.11	5.15	3.35	14.55	5.64
Omega-11	C18:1c11	Vaccenic acid	0.47	0.61	0.49	0.47	0.66	0.51	0.47	1.55	0.87
	C20:1c11	Gondoic acid	0.25	0.4	0.23	0.17	0.5	0.47	0.09	0.38	0.3

5 DISCUSSION

Feed (cost, availability and quality) is decisive in the development of both modern and traditional poultry farming (Abasse *et al.,* 2017). In this context, the present study assessed the nutritional value of *Moringa oleifera* and *Leucaena leucocephala* focusing on key components such as polyphenols, proteins, lipids, energy content, dietary fibres (NDF and ADF), minerals, ash, dry matter and moisture levels in various plant parts (leaves, seeds and pods). The results revealed that all samples contained notable levels of these nutrients. Moreover, the leaves of both species demonstrated substantial amounts of total polyphenols and showed significant antioxidant activity across all three evaluation methods: DPPH, ABTS and FRAP. However, their antioxidant activity was assessed in comparison with the activity of two standards (Trolox and quercetin). The antioxidant activity observed in these two plants was attributed to their total phenolics and flavonoids contents. These findings are consistent with previous reports in the literature, which emphasize that the antioxidant potential of plant extract is closely linked to their phenolic compound content (Kalia *et al.,* 2008; Stagos *et al.,* 2012; Oukacha *et al.,* 2015; Guettaf *et al.,* 2016). Also, polyphenols were identified in both types of hexanic and methanolic extracts. Hexane being a non-polar solvent and the presence of polyphenols in the hexane extracts was due to the Soxhlet extraction method. Polyphenols exert beneficial effects in poultry nutrition, notably by enhancing growth performance (Luo *et al.,* 2017) and improving egg quality (Galli *et al.,* 2018), primarily due to their ability to support gut health and strengthen antioxidant defences (Nm *et al.,* 2018). In addition, polyphenols were antimicrobial and antiviral properties (Abutheraa *et al.,* 2017). Flavonoids are widely recognized for their multiple biological functions, such as anti-inflammatory, antioxidant, and antibacterial properties (Aderogba *et al.,* 2010). We can notice that all samples were abundant in macromolecules particularly lipids and proteins. Their content was higher in *Leucaena leucocephala* seed (37.82±0.47% and 16.79±1.48% respectively). Proteins are macromolecules consisting of twenty amino acids (AA), of which eleven are considered essential. Since these essential amino acids cannot be synthesized by animals, particularly poultry. They must be supplied through the diet in sufficient quantities to meet physiological need (Aftab *et al.,* 2006). In chickens, proteins play a critical role in the development of muscles, feathers, eggs and in cellular regeneration. Alongside proteins, the analysed samples exhibited notably high lipid contents. Lipids, also macromolecules, consist of various fatty acids, including saturated ones such as palmitic and stearic acids, as well as a range of omega fatty acids namely omega-3 (α-Linolenic acid), omega-6 (Linolenic acid) and omega-9 (Oleic acid). These essential fatty acids cannot be endogenously synthesized by poultry, yet they are vital for optimal growth and proper cellular function (Lessire, 2001; Yelakan *et al.,* 2020). Also, the energetic value was well appreciated in both species. In particular, the leaves and the seeds of *Leucaena leucocephala* were more energetic compared to the other samples. Furthermore, metabolizable energy is crucial in poultry nutrition, especially for maintenance, egg production and growth. Both species also demonstrated high levels of crude fibre, including acid detergent fibre (ADF) and neutral detergent fibre (NDF). Previous research has indicated that elevated crude fibre content can positively influence behavioural issues such as feather pecking (a form of cannibalism), as well as improve egg morphology (Albiker *et al.,* 2015). The presence of crude fibres in the plants tested was necessary in the diet of poultry. *Leucaena leucoceplala* (leaves, pods and seeds) and six varieties of *Moringa oleifera* leaves were also found to be rich in trace minerals such as iron and zinc. The elements play key roles in preventing anaemia and feather depigmentation, as well as supporting growth, immune function, disease resistance and blood formation in laying hens. Additionally, all sample contained essential macro-minerals including calcium, phosphorus, magnesium and potassium which are crucial for skeletal development and maintenance

(CELAGRI.be, 2019). *Leucaena leucocephala* and *Moringa oleifera* exhibit a high nutritional value, particularly in terms of protein content, surpassing that of many conventional plants or animal-based protein sources commonly used in poultry nutrition. However, the protein contents quantified in the seeds of *Leucaena leucocephala* were high at 37.82% compared to 21% for *Cassia tora* (Mabeki, 2011); 32.5% for *Hibiscus sabdariffan* (Ouedraogo *et al.,* 2022) and 24.5% for *Moringa oleifera* (Safwat *et al.,* 2014) . Also, protein contents of *Moringa oleifera* varieties M4-1; M12-1; M2-2; M9-3; M45-1 and M6-1 are high compared to that of *Cassia tora*. The combined protein contents in the seeds and leaves of *Leucaena leucocephala* added to the M4-1 variety were higher than those in fish meal, soybean, cotton seed and soybean meal (59. 9%, 33.5%, 44.46%, 39.84% respectively). The lipid content in the seeds of *Leucaena leucocephala* (16.78%) was close to that obtained in soybean (17.98%). The lipid contents observed in these samples were also than those typically reported in raw materials commonly used for poultry feed formulation in Burkina Faso (Ky *et al.,* 2020). Except for the pods of *Leucaena leucocephal*a, all samples exhibited higher energy values compared to the conventional feed ingredients used in poultry rations in Burkina Faso. Similarly, the calcium levels found in *Leucaena leucocephal* leaves and in the M4-1 and M12-1 varieties of Moringa oleifera exceeded those reported in cottonseed and soybean meal. The six varieties of *Moringa oleifera* leaves and *Leucaena leucocephala* leaves, seed and pod could be as a good source of polyphenols, protein, energy, lipid, fibre (NDF and ADF), minerals and fatty acid polyunsaturated. As such, these plant materials could be effectively integrated into the diet of local poultry. In addition to their richness in phytonutrients (necessary for the growth and reproduction of poultry), and their low cost and accessibility, these species may offer a valuable alternative to conventional, high-cost poultry feed.

6 CONCLUSION

This study revealed that all extracts contained measurable levels of total phenolics and flavonoids. Both *Leucaena leucocephala* and *Moringa oleifera* were found to be rich in nutrients, including proteins, nitrogen, ADF, NDF, lipids, energy and a range of essential minerals (calcium, magnesium, potassium, phosphorus, zinc, iron, etc.), as well as polyunsaturated fatty acids. *Leucaena leucocephala* seeds exhibited the highest concentrations of protein, lipid, and zinc. The also contained substantial levels of linolenic and oleic acids. Their leaves and seeds are the richest in energy. The samples of *Moringa oleifera* and *Leucaena leucocephala* collected in Bobo-Dioulasso area from Burkina Faso are rich in phytonutrients. The encouraging functional properties *Moringa oleifera* and *Leucaena leucocephala* make them tremendous alternative raw materials for supplementary feeding and as components of food for poultry.

7 ACKNOWLEDGEMENTS

The authors gratefully acknowledge the support of project BKF5021, funded by the International Atomic Energy Agency (IAEA), for providing the necessary research facilities.
Conflict of Interest: The authors declare that there are no conflicts of interest associated with this publication.

8 REFERENCES

Abbas T. E., 2013. The use of *Moringa oleifera* in poultry diets. *Turkish Journal of Veterinary and Animal Sciences*, 37:492-496. DOI: 10.3906/vet-1211-40.

Abasse T., Maigachi I., Habba W., Diallo D., 2017. "Effect of supplementation of *Moringa oleifera* (Lam) leaf flour in broiler production in Niger." *International Journal of Biological and Chemical Sciences*.

11(2):722–729. DOI: https://dx.doi.org/10.4314/ijbcs.v11i2.15.

Abou-Elezz F. M. K., Sarmiento-Franco L., Santos-Ricalde R., and Solorio-Sanchez F., 2011. Nutritional effects of dietary inclusion of *Leucaena leucocephala* and *Moringa oleifera* leaf meal on Rhode Island red hens' performance. *Cuban Journal of Agricultural Science*. 45(2):164–169. https://www.researchgate.net/publication/327884650.

Abutheraa R., Hettiarachchy N., Kumar-Phillips G., Horax R., Chen P., Morawicki R. and Kwon Y. M., 2017. "Antimicrobial activities of phenolic extracts derived from seed coats of selected soybean varieties." *Journal of Food Science* 82(3):731–37.

Aderogba, M. .., L. .. McGaw, B. .. Bezabih, and B. .. Abegaz. 2010. "Antioxidant activity and cytotoxicity study of *Leucaena leucocephala* (Lam.) de Wit leaf extract constituents." *Nigerian Journal of Natural Products and Medicine* 13(1):1–5.

Aftab, U., M. Ashraf, and Z. Jiang. 2006. "Low Protein Diets for Broilers." *World's Poultry Science Journal* 62(4):688–701.

Agbor E. B., Kenneth J. N. N. and Pamo E. T., 2013. "*Leucaena* and dried poultry waste improve the performance of west African dwarf sheep on a grass diet." *Tropical Animal Health and Production*, 45:1025–1029. DOI: 10.1007/s11250-012-0327-6.

Albiker, D., Aviforum, R. Bieler and E. P. F. Zurich. 2015. "Davantage de fibres brutes pour les poules pondeuses ?" *Aviculture Suisse, Swizarland,* 7–8.

AOAC (Association of analytical communities), 1990. Official Methods of Analysis. 15th Edn., Association of Official Analytical Chemists, Washington, DC., USA., Pages: 684.

AOAC (Association of analytical communities), 2000. Official Methods of Analysis of Association of Analytical Chemists. 17th Edition. AOAC International, Orowitz, 141-144p.

AOAC (Association of analytical communities), 2001. AOAC 2003.06-2006, crude fat in feeds, cereal grains and forages. Association of Official Analytical Chemists, USA. http://www.aoacofficialmethod.org/index.php?main_page=product_info&products_id=1552.

AOAC (Association of analytical communities), 2001. 4.2.11 AOAC official method 2001.11 protein (crude) in animal feed, forage (plant tissue), grain and oilseeds block digestion method using copper catalyst and steam distillation into boric acid. Association of Official Analytical Chemists, USA, 2001-2003. https://img.21food.cn/img/biaozhun/20100108/177/11285182.pdf.

Belem H., Meda R. N. T., Koama B. K., Kagambega W., Da S. N., Drabo A. F., Ncobela C. N., Létourneau-Montminy M. P., Traoré A., Ouédraogo G.A., 2023. Determination of the nutritional value of *Acacia macrostachya* (Reichend.ex DC) and *Cirina butyrospermi* (Vuillet) used in local chicken feeding in burkina faso. *International Journal of Poultry Science* 22(1):61–65. DOI: 10.3923/ijps.2023.61.65.

CELAGRI.be, 2019. L'élevage de poulets de chair en Wallonie. Une initiative du collège des producteurs avec le soutien de la Wallonie. https://www.celagri.be/wp-content/uploads/2020/10/CELAGRI-dossier-elevage-poulets-de-chair.pdf.

FAO (Food and Agriculture Organization). 2018. Rapport pays – élevage durable en Afrique 2050 – Burkina Faso, Rome (Italie), 111p.

Galli G. M., Da A. S., Biazus A. H., Reis J. H., Boiago M. M., Topazio J. P., Migliorini M. J., Guarda N. S., Moresco R. N., Ourique A. F., Santos C. G., Lopes L. S., Baldissera M. D. and Stefani L. M., 2018. Research in veterinary science feed

addition of curcumin to laying hens showed anticoccidial effect , and improved egg quality and animal health. *Research in Veterinary Science* 118:101–106. https://doi.org/10.1016/j.rvsc.2018.01.022.

Guettaf S., Abidli N., Kariche S., Bellebcir L. and Bouriche H., 2016. Phytochemical screening and antioxidant activity of aqueous extract of *genista saharae* (Coss. & Dur.). *Der Pharmacia Lettre* 8(1):50–60. https://www.researchgate.net/publication/298082478. https://doi.org/10.1186/s40781-018-0167-7.

Kalia K., Kapil S., Pratap S. H., Bikram S., 2008. Effects of extraction methods on phenolic contents and antioxidant activity in aerial parts of *Potentilla atrosanguinea* lodd. and quantification of its phenolic constituents by RP-HPLC^{+}. *Journal of agricutural and food chemistry,* 56:10129-10154.

Ky I., Parkouda C., Somda M. K., Diawara B.and Dicko M. H., 2020. Caractéristiques physicochimiques de quelques matières premières utilisées dans la formulation des aliments pour volaille au burkina faso. *Journal of Applied Biosciences* 151:15598-15604. https://doi.org/10.35759/JABs.151.8.

Lessire M., 2001. Matières grasses alimentaires et composition lipidique des volailles. *INRA Productions Animales* 14 (5):365-370.

Luo J, Song J., Liu L., Xue B., Tian G. and Yang Y., 2018. Effect of epigallocatechin gallate on growth performance and serum biochemical metabolites in heat-stressed broilers. *Poultry Science* 97(2):599–606. http://dx.doi.org/10.3382/ps/pex353.

Luqman S., Srivastava S., Kumar R., Kumar A. M. and Chanda D., 2012. "Experimental assessment of *Moringa oleifera* leaf and fruit for its antistress, antioxidant, and scavenging potential using *in vitro* and *in vivo* assays." *Evidence-Based Complementary and Alternative Medicine*, 12 pages. Doi:10.1155/2012/519084.

Mabeki Missoko R., 2011. Essai d'incorporation de la farine de feuilles de *Cassia tora* dans l'alimentation chez les poulets locaux du sénégal : effets sur les performances de croissance, les caractéristiques de la carcasse et le résultat économique. Thèse. Médecine Vétérinaire, EISMV, Dakar (Sénégal), 121p.

Mebanga SA, Gapelbe SA, Mingoas JP. 2020. Effets du chaponnage sur les performances zootechniques du poulet local dans la ville de Ngaoundéré au Cameroun. *International Journal of Biological and chemical Sciences,* 14(3): 788-799. DOI: https://doi.org/10.4314/ijbcs.v14i3.12

Meda N. T.R., Lamien-Meda A., Kiendrebeogo M., Lamien C. E., Coulibaly A.Y., Millogo-Rasolodimby J. and Nacoulma O. G., 2010. "*In vitro* antioxidant, xanthine oxidase and acetylcholinesterase inhibitory activities of *Balanites aegyptiaca* (L.) Del. (Balanitaceae)." *Pakistan Journal of Biological Sciences* 13(8):362–368.

MRAH (ministère des ressources animales et halieutiques), 2022. Aviculture au Burkina Faso : la stratégie nationale de développement de la filière en cours de validation. Communique de presse consultée le 02/08/2024 sur www.agriculturebf.

Nahimana G., Ossebi W., Missohou A. and Ayssiwede S. B., 2020. Analyse de l'importance socio-économique de l'aviculture familiale dans le département de Salemata au Sénégal. *International Journal of Biological and Chemical Sciences* 13(7):3131–3143. DOI: https://dx.doi.org/10.4314/ijbcs.v13i7.13.

Nm J., Ashil J., Balu M. and Krishnakumar Im., 2018. Dietary addition of a standardized extract of turmeric (turmaFEED ^{tm}) improves growth performance and

carcass quality of broilers. *Journal of animal science and technology*, 60:8:1-9. https//doi.org/10.1186/s40781-018-0167-7

Oladokun V. O. and Johnson A., 2012. Feed formulation problem in nigerian poultry farms: a mathematical programming approach. *American Journal of Scientific and Industrial Research* 3(1):14–20. Doi:10.5251/ajsir.2012.3.1.14.20.

Ouedraogo B., Kabore H., Pousga S. and Zoundi S. J., 2022. "Effet de l'incorporation de la farine de graines bouillies d'*Acacia macrostachya* (Reichenb. Ex. DC.) dans l'alimentation sur les performances de croissance des poulets de chair au Burkina Faso." *Journal of Animal & Plant Sciences* 54(1):9858–9867. 54(1):9858-9867 https://doi.org/10.35759/JAnmPlSci.v54-1.5

Oukacha A., Elguiche R., Tahrouch S., Zekhnini A. and Hatimi A., 2015. Antifungal and antioxidant activities of some aromatic and medicinal plants from the southwest of Morocco. *Journal of Chemical and Pharmaceutical Research*, 7(7):672-678.

PAM-SONAGESS (Programme Alimentaire Mondial- Société Nationale de Gestion du Stock de Sécurité Alimentaire), 2022. Bulletin conjoint d'information sur les marchés au Burkina Faso, 8p.

Pindé S., Tapsoba A.S.R., Traoré F., Ouédraogo R., Ba S., Sanou M., Traoré A.,

Tamboura H.H., Simporé J., 2020. Caractérisation et typologie des systèmes d'élevage de la poule locale du Burkina Faso. *Journal of Animal et Plant Sciences,* (46 (2): 8212-8225 https://doi.org/10.35759/JAnmPlSci.v46-2.6.

Safwat A. M., Sarmiento-Franco L., Santos-Ricalde L. and Nieves D., 2014. Effect of dietary inclusion of *Leucaena leucocephala* or *Moringa oleifera* leaf meal on performance of growing rabbits. *Tropical Animal Health and Production.* DOI: 10.1007/s11250-014-0626-1.

Siti N. W., Bidura I., Mayuni S. N and Utami I. A., 2019. "Effect of *Moringa oleifera* leaf powder in diets on feed digestibility and external egg quality characteristics in laying hens." *International Journal of Fauna and Biological Studies,* 6(4):113–118.

Sourokou Sabi S., 2014. Performances zootechnico-économiques des poulets de chair (COBB500) nourris aux rations à base de la farine des graines de la variete verte de bissap (*Hibiscus sabdariffa*, LINN) au Sénégal. Thèse. Médecine Vétérinaire, EISMV, Dakar (Sénégal) 140p.

Stagos D., Portesis N., Spanou C., Mossialos D., Aligiannis N., Chaita E., Panagoulis C., Reri E., Skaltsounis L., Tsatsakis A. M. and Kouretas D., 2012. "Correlation of total polyphenolic content with antioxidant and antibacterial activity of 24 extracts from greek domestic lamiaceae species." *Food and Chemical Toxicology* 50(11):4115–4124.

Sukhija P. S. and Palmquist D. L., 1988. Rapid method for determination of total fatty acid content and composition of feedstuffs and feces. *Journal Agriculture Food Chemical*, 36: 1202-1206.

Valdivié-navarro M., Martinez-aguilar Y., Mesa-fleitas O., Botello-leon A., Betancur C. and Velázquez-martí B., 2019. "Review of *Moringa oleifera* as forage meal (Leaves plus Stems) intended for the feeding of non-ruminant animals." *Animal Feed Science and Technology*. https://doi.org/10.1016/j.anifeedsci.2019.114338.

Weiman C, El Tayeb N, Brandt IA, Yousif S, Abdel Hamid MM, Erhardt G. 2016. Genetic diversity of domesticated and wild Sudanese Guinea fowl (*Numida melangris*) based on microsatellite markers. *Archives Animal Breeding*, 59: 59-64. DOI:10.5194/aab-59-59-2016.

Xu Y.,Tao Z., Jin Y., Yuan Y, Dong T. T. X., Tsim K. W. K. and Zhou Z., 2018. "Flavonoids, a potential new insight of *Leucaena leucocephala* foliage in ruminant

health." *Journal of Agricultural and Food Chemistry* 66 (29):7616–7626. DOI: 10.1021/acs.jafc.8b02739.

Yang S. L., Yang R. C., Zhou X., Yang S. H., Luo L. L., Zhu Y. C. and Boonanuntan S., 2017. "Effects of feeding diets with processed *Moringa oleifera* stem meal on growth and laying performance, and immunological and antioxidant activities in laying ducks." *Poultry Science*, 1-7p. https://doi.org/10.1016/j.psj.2020.04.002.

Yelakan Koné Y., Kinonton C., Koffi R. A., and Bohoua L. G., 2020. Influence de l'huile de soja sur le poids et la taille des œufs des poules pondeuses « Warren ». *Journal of Applied Biosciences* 156:16071–16077. https://doi.org/10.35759/JABs.156.1.