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Comparative Evaluation of Proximate, Mineral, Vitamins, Phytochemical and Antioxidant Properties of Pulp and Seeds of Doum Palm (Hyphaene thebaica) in India

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Medicinal plants are natural gift that contains phytochemicals that are ecofriendly, effective and non-toxic. These chemicals can also prevent antimicrobial resistance. However, the concentration of phytochemicals and nutritional properties underlines certain variation due to geographical location, age of plant, storage condition, extraction methods, amongst others. Therefore, this study was carried out to compare the proximate, mineral, vitamins, phytochemical and antioxidant properties of pulp (DPML) and seeds of Doum palm (DPSM) (Hyphaene thebaica) in India. Proximate evaluation of DPML revealed that it had higher ($p<0.05$) levels of moisture (8.77 %), crude fibre (13.06 %), ether extracts (1.21 %), ash (8.21 %), carbohydrate (69.33 %) and lower protein (6.21 %) relative to DPSM which contained moisture, crude protein, crude fibre, ether extract, ash and carbohydrates at 6.93 %, 8.07 %, 11.69 %, 0.09 %, 6.44 % and 54.08 % respectively. DPML had higher ($p<0.05$) concentration of calcium (387.21 mg/100g), phosphorus (2956.1 mg/100g), potassium (175.1 mg/100g), manganese (28.03 mg/100g), magnesium (186.1 mg/100g), zinc (10.33 mg/100g), copper (8.61 mg/100g), sodium (228.1 mg/100g) and iron (9.11 mg/100g) compared to DPSM which contained calcium, phosphorus, potassium, manganese, magnesium, zinc, copper, sodium and iron at 206.8 mg/100g, 1600.2 mg/100g, 113.5 mg/100g, 15.14 mg/100g, 102.4 mg/100g, 10.05 mg/100g, 5.78 mg/100g, 190.2 mg/100g and 6.08 mg/100g respectively.

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1. Introduction

Plants are an essential source of nutrition and medicinal substances, and they have always been prized natural riches (Singh et al., 2022). They are capable of producing a large range of different compounds, which can be further classified into primary and secondary metabolites. All plants have primary metabolites like sugar and lipids, but only a limited number of plants produce secondary metabolites, which are created by those plants and have particular uses (Alagbe and Anuore, 2023). Secondary metabolites are highly intriguing and potent natural chemicals that are acknowledged for their medical usefulness (Shittu et al., 2021).

A very broad range of physiologically active substances, including alkaloids, glucosinolates, cyanogenic glucosides, flavonoids, tannins, coumarins, lignans, terpenoids, saponins, organic acids, and many more, are part of the defensive chemistry of plants (Alagbe, 2022). These substances function as signaling substances to draw in pollinators or predators in addition to acting as deterrents against herbivory and frequently against microbial infection (Shittu et al., 2021). Biologically active chemicals are typically found in complex combinations found in medicinal plants. They have an impact on several targets. Plants used in phytotherapy often have low toxicity levels (Faten et al., 2009). Treating chronic diseases may benefit from the use of certain of the active secondary metabolites. The doum palm is one ofthe world's potentially beneficial plants (Fletcher, 1997).

Doum palm (Hyphaene thebaica) is a dichotomous, tall, multi-stemmed desert plant belonging to the family Arecaceae and order Arecales. It can grow up to 15 m in height and is endemic to Africa and some parts of Asia especially West India (Orwa et al., 2009; Moussa et al., 1998). The leaves contain strong fibres and are used to make mats, bind parcels and writing paper. The trunk of the palm is used for construction, as well as for manufacture of various domestic utensils (Faten, 2009; Wendakoon et al., 2011). The oblong, yellow orange apple sized fruit has a red outer skin, a thick, spongy and rather sweet, fibrous fruit pulp that tastes like gingerbread and a large kernel (Shehubet al., 2015). The covering of the fruit is edible and can either be pounded to form a powder or cut off in slices; the powder is often dried thenadded to food as a flavoring agent (Reda, 2015; Ghada et al., 2020).

According to Datti et al. (2020), doum palm fruit pulp contains minerals: calcium, phosphorus, manganese, potassium, magnesium, sodium, zinc, iron, copper and cobalt needed for enzymatic reactions in the body of animals. It is also rich in protein at 2.86 %, ash (6.20 %), ether extract (0.92 %), crude fibre (13 %) and carbohydrate at 68.5 %. Phytochemical analysis of doum palm fruit also reveals the presence of tannins, flavonoids, phenols, alkaloids and saponins which are capable of performing multiple biological activities: antimicrobial, antioxidant, immune- stimulatory, hepato-protective, antifungal, antiviral, amongst others (Babiker and Makki, 2013; Bonde et al., 1990). Doum palm pulp extracts also have the capacity to inhibit the activities of some pathogenic organisms such as: Shigella flexneri, Salmonella typhi, Proteus mirabilis, Pseudomonas aeruginosa, Klebsiella pneumonia, Enterococcus faecalis, Listeria monocytogenes and Bacillus cereus due to the presence of phytochemicals (Hussein et al., 2010; Lamiaa and Laith, 2018).

Previous studies have shown that chemical composition of Doum palm can be influenced by age of plants, geographical location, method of processing, climate, storage conditions, amongst others (Alagbe, 2021). This research is timely, because it gives a clue on the nutritional properties of Hyphaene thebaica found in Gujarat as well as to examine whether they can be utilized as a potential feed additive for livestock.

2. Method

Site of the experiment

The investigation was carried out at the Department of Animal Nutrition and Biochemistry, Sumitra Research laboratory, Gujarat, India in the month of January, 2024. The Research Institute is located between 23o 13' N and 72o 41' E. All laboratory procedures were strictly adhered to according to guidelines laid down by Association of Analytical Chemists. Laboratory kits were adjusted following the manufacturer's instruction.

Collection of fresh doum palm and processing

Fresh, dried mature fruits of doum palm were harvested within the premises of Sumitra Research Institute, Gujarat India from different trees and taken to the department of Biological Sciences of the same institute where samples were identified by a certified plant taxonomist and assigned a voucher specimen number AA/SM/24. The collected fruits were crushed using a mechanical splitter to separate doum pulp from the kernel. Each of the component (pulp and seed) were shade dried for five days before it was pulverized into powder and stored separately in a labeled air tight polythene bag before extraction. Doum palm pulp meal was abbreviated as DPML while doum palm seed meal (DPSM) 200 g of the sample were soaked separately into 1litre of water and agitated in a blender for 5 minutes before it was transferred into a container, stirred intermittently and kept for 48 hours before it was filtered through a filter. The extracts (filtrate) were used for the determination of antioxidant properties and vitamin composition in thesamples

Reagents for phytochemical evaluation

Sodium hydroxide, sodium bicarbonate, folin-ciocalteau's reagent, aluminum chloride, sodium nitrate, sulphuric acid, bromocresol solution, ferric ammonium sulphate, amyl alcohol and ammonium thiocyanate solution.

Laboratory equipment used for the experiment

Test tubes, beakers, conical flask, water bath, digital thermometer and conical

flask.

Proximate analysis of DPML and DPSM

Proximate composition of samples was carried out using Perkin Elmer near infra-red kit (Model: FT 9700, China). 200 grams of each sample was passed through the sample collecting vat connected to a monitor (for display of results; scanning grating transmittance). For proper efficiency the equipment was set to a wavelength of 570 to 1100 nm to display results (moisture, crude protein, crude fibre, ether extract,ash and carbohydrates) at an analysis time of 25 seconds.

Mineral evaluation of DPML and DPSM

100 g of each sample was used for mineral analysis using Atomic Absorption Spectrometer (Model: SP-AA 4500, China) equipped with integrated computer controlled longitudinal heated graphite furnace. For efficiency, the machine is set at a programmable temperature up to 3000 oC in 1 oC increment, wavelength repeatability and accuracy of ± 0.1 nm and ± 0.3 nm respectively. Slits are automatically selected at 0.1; 0.2; 0.4; 0.7; 1.4 and 2.0 nm, wavelength range (185 – 900 nm), injection volumes from 1 to 50 µL, heating rate of 2000 oC/s under software control (SPWinAA Software Package) to display results.

Vitamin analysis of DPML and DPSM

Quantifying fat and water soluble vitamins was carried out using Agilent LC/MS kit equipped with jet steam electrospray ionization coupled with diode array detector. For precision, all the manufacturers instruction is strictly adhered to. For the MS chamber: drying gas temperature and sheath gas flow is adjusted at 250 oC and 350 oC, sheath gas flow (12 L/min), capillary (4,000 V) and nozzle voltage (1000 V) while LC chamber is configured at an injection volume of 5 µL, auto sampler temperature (15 oC) and mobile phase: H20 with 0.1 % FA, 4.5 mM ammonium formate and 0.5 mM ammonium fluoride as well as MeOH with 0.1 % FA, 4.5 mM ammonium formate and 0.5 mM ammonium fluoride respectively in each column.

Gas chromatograph analyzer for DPML and DPSM

Different optical densities for phytochemical samples was carried out with YL6500 GC gas chromatograph made up of 3 components viz: inlet, column oven and detector (data acquisition chamber). Inlet chamber is adjusted to a maximum temperature of 450 oC, total flow setting range for samples: 0.01 to 100 mL/minute, pressure range (0.001 to 100 psi) and flow stability (< ± 0.05 mL/min) while the column oven is maintained at a heating rate 120 oC/min, cooling down option (80 oC to 450 oC with LN2 cryogenic cooling), maximum run time of 9,999 min while the data acquisition unit is coupled with flame ionization detector, thermal conductivity detector, electron capture detector, nitrogen phosphorus detector, flame photometric detector and pulsed discharge detector at temperatures of 450 oC, 400 oC, 400 oC, 400 oC, 300 oC and 400 oC respectively.

Quantification of total tannins in DPML and DPSM

5g of DPML and DPSM was added to 1.5 mL of ammonium sulphate in a conical flask, the mixture was covered for 5 minutes and kept under room temperature followed by the addition of 1.0 mL sodium bicarbonate, 10 mL distilled water and stirred before it was introduced to YL6500 GC gas analyzer and adjusted to an opticaldensity of 560 nm.

Estimation of total phenolic compounds in DPML and DPSM

5g of DPML and DPSM was added to 1.5 mL of Folin-Ciocalteau reagent in a beaker, the mixture was covered for 10 minutes and kept under room temperature followed by the addition of 1.0 mL sodium carbonate, 10 mL distilled water and stirred before it was introduced to YL6500 GC gas analyzer and adjusted to an optical densityof 700 nm.

Estimation of flavonoids in DPML and DPSM

5 g of DPML and DPSM was added was added to 0.8 mL nitric oxide mixed together in a test tube, the mixture was incubated for 10 minutes followed by the addition of 0.5 mL of sodium hydroxide. It was introduced to YL6500 GC gas analyzer and adjusted to an optical density of 850 nm according to

standard laboratoryprocedures outlined by Mahmoudi et al. (2016).

Determination of alkaloid concentration

optical density of 510 nm. Other procedures were carried out according to the methods outline by Njoku and Chidi (2009).

Determination of saponins

5 g of DPML and DPSM was diluted with 1.0 mL of distilled water followed by the addition of 0.5 mL ferric ammonium sulphate. The mixture was thoroughly mixed in a test tube, covered and cooled at room temperature for 10 minutes. YL6500 GC gas analyzer and adjusted to an optical density of 650 nm according to standard laboratory procedures outlined by Bayero et al. (2019).

Antioxidant properties of DPML and DPSM

Free radical scavenging activity of the extract was measured by 1,1-diphenyl-2- picryl hydrazyl (DPPH). Here, 2 mL of DPML and DPSM extract was added to 2 mL of 0.4 nM methanolic solution of DPPH. The mixture was then shaken vigorously and allowed to stand at room temperature for 30 min. The absorbance was then measuredat 520 nm using YL6500 GC gas analyzer.

Statistical analysis

Data collected were subjected to analysis adopting Student's T-test and Statistical Analysis System (SAS, version 9.4) PROC ANOVA GLM Analysis of Variance.

3. Result and Discussion

As presented in Table 1, proximate composition of doum palm pulp meal (DPML) and doum palm seed meal (DPSM). DPML had higher ($p<0.05$) levels of moisture (8.77 %), crude fibre (13.06 %), ether extracts (1.21 %), ash (8.21 %), carbohydrate (69.33 %) and lower protein (6.21 %) relative to DPSM which containedmoisture, crude protein, crude fibre, ether extract, ash and carbohydrates at 6.93 %,

as protein supplement in the diets of monogastric animals (NRC, 1994). Results obtained for protein in this experiment, disagrees with the findings of Waleed et al. (2014) and Datti et al. (2020) who recorded 2.86 % and 2.32 % for doum palm seed meal and doum pulp meal respectively. These discrepancies can be attributed to variation in climate, geographical location and age of plants (Alagbe, 2023; Oloruntola et al., 2023). Ash content in a sample is used to determine the concentration of minerals in a sample (Shittu and Alagbe, 2020). Ash content in DPML and DPSM was higher than those reported for Phoenix dactylifera seeds (1.30 %) by Eimad et al. (2015). Crude fibre in diet of animals helps to improve digestion and reduce serum cholesterol level, thus preventing the incidence of coronary diseases (Omokore and Alagbe, 2019). The result in this experiment suggests that DPML and DPSM are good sources of dietary fibre. The values recorded for crude fibre and ether extract is in consonance with the report of Aboshora et al. (2015) when fresh, epicarp and pitted sample of doum fruit was examined. Result on carbohydrate composition of DPML revealed that it is a good source of energy compared to DPSM. Carbohydrate are needed for the maintenance of basal metabolism of various organs and tissues of animals and also needed for proper body motion (Alagbe et al., 2021). Earlier studies have reported 62.70 %, 75.20 % and 43.0 % carbohydrate composition for seeds and meal of cashew nut as well as those of tiger nut residues (Ogunwolu et al., 2010; Samson and Safiya,

2013).

Table 1: Proximate composition of Doum palm pulp meal (DPML) and doum palm seed meal (DPSM)

Variables	*DPML	**DPSM	*p value*
Moisture	8.77 ± 0.17[b]	6.93 ± 0.15[a]	< 0.01
Crude protein	6.21 ± 0.04[b]	8.07 ± 0.06[a]	< 0.01
Crude fibre	13.06 ± 0.03[a]	11.69 ± 0.02[b]	0.02
Ether extracts	1.21 ± 0.04[a]	0.09 ± 0.06[b]	< 0.01
Ash	8.21 ± 0.02[a]	6.44 ± 0.01[b]	0.01
Carbohydrate	69.33 ± 0.27[a]	54.08 ± 0.12[b]	0.03

*Doum palm pulp meal: DPML; **Doum palm seed meal: DPSM

As presented in Table 2, the mineral composition of doum palm pulp meal (DPML) and doum palm seed meal (DPSM). DPML had higher ($p<0.05$) concentration of calcium (387.21 mg/100g), phosphorus (2956.1 mg/100g), potassium (175.1 mg/100g), manganese (28.03 mg/100g), magnesium (186.1 mg/100g), zinc (10.33 mg/100g), copper (8.61 mg/100g), sodium (228.1 mg/100g) and iron (9.11 mg/100g) compared to DPSM which contained calcium, phosphorus, potassium, manganese, magnesium, zinc, copper, sodium and iron at 206.8 mg/100g, 1600.2 mg/100g, 113.5 mg/100g, 15.14 mg/100g, 102.4 mg/100g, 10.05 mg/100g, 5.78 mg/100g, 190.2 mg/100g and 6.08 mg/100g respectively. This result suggests that DPML is loaded with various minerals needed for the activation of enzymes and movement of nutrients and waste around the body cells of animals (Singh et al., 2022). For instance, calcium is needed for heathy bones, effective blood pressure regulation and muscle contraction (Hall et al., 1991). Phosphorus aids in the synthesis of deoxyribonucleic acid and maintains acid base balance (Hans and Jana, 2018). Magnesium are needed for muscle contraction and acts as co-factors for metabolic enzymes (Fairweather et al., 1996). Zinc boost the body immunity and are needed for making protein and genetic material (Angelova et al., 2014). Copper is needed for iron metabolism and creation of haemoglobin regulating neurotransmitters (Angelova et al., 2014). Sodium enhances proper fluid and pH balance, nerve transmission and muscle contraction (Abbaspour et al., 2008). Potassium regulates heat beats and effective nerve functioning (Miller et al., 2011). Iron is a part of haemoglobin found in red blood cell that carries oxygen in the body and also needed for energy metabolism (). The result obtained is in agreement with the findings of Bonde et al. (1990) when nutritional composition of doum palm fruits in west coast of India was examined.

Table 2: Mineral composition of doum palm pulp meal (DPML) and doum palm seed meal (DPSM)

Variables	*DPML (mg/100g)	**DPSM (mg/100g)	*p value*
Calcium	387.21 ± 0.12[a]	206.8 ± 0.09[b]	0.012
Phosphorus	2956.1 ± 0.02[a]	1600.2 ± 0.01[b]	0.001
Potassium	175.1 ± 0.06[a]	113.5 ± 0.10[b]	0.003
Manganese	28.03 ± 0.02[a]	15.14 ± 0.08[b]	0.010
Magnesium	186.1 ± 0.10[a]	102.4 ± 0.12[b]	0.001
Zinc	10.33 ± 0.03[a]	10.05 ± 0.01[b]	0.002
Copper	8.61 ± 0.01[a]	5.78 ± 0.01[b]	0.001
Sodium	228.1 ± 0.17[a]	190.2 ± 0.14[b]	0.001
Iron	9.11 ± 0.03[a]	6.08 ± 0.02[b]	0.001

*Doum palm pulp meal: DPML; **Doum palm seed meal: DPSM

As presented in table 3, vitamin composition of doum palm pulp meal (DPML) and doum palm seed meal (DPSM). Doum palm pulp meal contained greater concentrations ($p<0.05$) of vitamin A (9.38 iu/100g), vitamin B_1 (26.01 µg/100g), vitamin B_1 (11.73 µg/100g), vitamin B_6 (57.10 µg/100g), vitamin B_{12} (15.61 µg/100g), vitamin C (122.6 µg/100g) and vitamin E (31.62 µg/100g) relative to 5.06 iu/100g, 21.48 µg/100g, 9.45 µg/100g, 42.08 µg/100g, 10.20 µg/100g, 95.18 µg/100g and 23.49 µg/100g reported for vitamin A, vitamin B_1, vitamin B_6, vitamin B_{12}, vitamin C and vitamin E respectively. Vitamins are chemical compounds that are needed in small amounts for biological functions and growth maintenance (Booth et al., 1992). Insufficient inclusion of vitamins in the diets of animals could lead to deficiency syndrome (Nair and Maseeh, 2010). For instance, vitamin B_1 is needed in the production of cholesterol and different kinds of hormones, synthesis of fats and carbohydrates as well as replication of deoxyribonucleic acid (Lykstad and Sharma, 2019). Vitamin B_6 helps in the creation of red blood cells and maintaining the immune system of animals (Marcelina et al., 2018). Vitamin B_{12} is required for the maintenance of the nervous system as well as synthesis of glucose (He et al., 2008). Lack of vitamin B complexes in the diet of animals may result in muscle body weakness (Jeurnick and De, 1995). Vitamin C is an antioxidant that protect cells from free radicals and unstable molecules that can damage body cells (Hoffmann and Berry, 2008). Vitamin D is required to maintain normal levels of calcium and phosphorus in the blood (Hans and Jana, 2018). Antioxidants that protects other nutrients like vitamin A and certain lipids from being damaged is the sole responsibility of vitamin E (Birringer et al.,

2019). Insufficient quantities of vitamin C, D and E in the diets of animals could resultin scurvy, rickets and neuropathy/anemia respectively (He et al., 2008).

Table 3: Vitamin composition of doum palm pulp meal (DPML) and doum palm seed meal (DPSM)

Variables	Units	*DPML	**DPSM	*p value*
Vitamin A	iu/100g	9.38 ± 0.03[a]	5.06 ± 0.02[b]	< 0.01
Vitamin B1	µg/100g	26.01 ± 0.19[a]	21.48 ± 0.16[b]	0.02
Vitamin B2	µg/100g	11.73 ± 0.09[a]	9.45 ± 0.06[b]	0.01
Vitamin B6	µg/100g	57.10 ± 0.12[a]	42.08 ± 0.10[b]	0.01
Vitamin B12	µg/100g	15.61 ± 0.17[a]	10.20 ± 0.14[b]	< 0.01
Vitamin C	µg/100g	122.6 ± 0.44[a]	95.18 ± 0.21[b]	0.02
Vitamin E	µg/100g	31.62 ± 0.11[a]	23.49 ± 0.08[b]	0.01

*Doum palm pulp meal: DPML; **Doum palm seed meal: DPSM

As presented in Table 4, the phytochemical analysis of doum palm pulp meal (DPML) and doum palm seed meal (DPSM). Doum palm pulp meal produced higher concentrations of phenols (82.10 mg/g), flavonoids (39.15 mg/g) and saponins (2.16 mg/g) and lower concentrations of tannins (11.72 mg/g) and alkaloids (6.13 mg/g) relative to doum palm seed meal ($p<0.05$) which contained phenols (65.72 mg/g), flavonoids (30.86 mg/g), tannins (18.83 mg/g), alkaloids (9.17 mg/g) and saponins (1.91 mg/g). The results suggest that both samples contain chemical compounds with pharmacological properties viz: antioxidant, hypoglycemic, anti-bacterial, antifungal, hepato-protective, anti-inflammatory, neuroprotective, antiseptic, antiviral, anti- androgenic, anti-proliferative and antipyretic properties (Alagbe and Ushie, 2022; Shittu and Alagbe, 2020). However, results obtained is in agreement with the findings of Ghada et al. (2010); Mohammed et al. (2010). Flavonoids are known to have antimicrobial, anti-inflammatory, anti-allergic, anti-hyperglycemic and antioxidant properties (Alagbe et al., 2022; Alagbe, 2022). Phenols possess antioxidant properties and are capable of preventing the body against oxidative stress, thus preventing infections (Alagbe et al., 2020; Mohammed et al., 2010). Recent findings demonstrate that tannins possess gastro-protective, anti-inflammatory and antimicrobial activities (Wendakoonet et al., 2011). Alkaloids exhibit anti-cancer, anti-inflammatory, anticonvulsant, anti-dysentery and analgesics activities (Bidlack et al., 2000). Pharmacologically, saponins have been shown to exhibit hormonal and anti-fungal, antioxidants and hypolipidemic and anti-androgenic activities (Simões-Pires et al., 2005).

Table 4: Phytochemical analysis of doum palm pulp meal (DPML) and doum palm seed meal (DPSM)

Variables	*DPML (mg/g)	**DPSM (mg/g)	*p value*
Phenols	82.10 ± 0.08[a]	65.72 ± 0.03[b]	0.003

Flavonoids	39.15 ± 0.17[a]	30.86 ± 0.12[b]	0.001
Tannins	11.72 ± 0.25[b]	18.83 ± 0.21[a]	0.002
Alkaloids	6.33 ±0.00[b]	9.17 ± 0.00[a]	0.001
Saponins	2.16 ±0.01[a]	1.91 ± 0.02[b]	0.001

*Doum palm pulp meal: DPML; **Doum palm seed meal: DPSM

As presented in Table 5, antioxidant properties of doum palm pulp meal (DPML) and doum palm seed meal (DPSM) to scavenge 1,1-diphenyl-2-picryl hydrazyl. DPPH was greater ($p<0.05$) in doum palm pulp meal with 31.82 % compared to doum palm seed meal (26.07 %). The results indicated that both samples possess antioxidant properties. However, DPML has more potential to scavenge reactive oxygen species and free radicals thus preventing cell damage and infections in the body (Alagbe, 2022). Free radicals' steals electron from a healthy cell causing breakdown in activities (Alagbe et al., 2021). Antioxidant defenses suppress free radicals that are toxic to the cells (Singh et al., 2022). The high concentration in vitamin A, C and E recorded in DPML can reduce and detoxify oxygen intermediates in cells of animals. The antioxidant activity of DPML and DPSM is lower than values recorded for Phoenix dactylifera fruit (35.64 to 67.56 %), Soursop pulps (61.22 %), soursop peels and seeds (51.10 %, 48.09 %) recorded by Safia et al. (2016); Hakime et al. (2019). The variation in this results can be attributed to differences chemical compounds, extraction and storage techniques, species amongst other (Singh, 2008).

Table 5: Antioxidant properties of doum palm pulp meal (DPML) and doum palm seed meal (DPSM)

Variables	*DPML (mg/g)	**DPSM (mg/g)	*p value*
1,1-diphenyl-2-picryl hydrazyl (DPPH)***	31.82 ± 0.05[a]	26.07 ± 0.03[b]	0.002

*Doum palm pulp meal: DPML; **Doum palm seed meal: DPSM; ***DPPH: 1,1-diphenyl-2-picryl hydrazyl

4. Conclusion

It was concluded that doum palm pulp meal (DPML) and doum palm seed meal (DPSM) have nutritional and medicinal properties due to the presence of phytochemicals which promotes multiple biological activities such as: antimicrobial, antifungal, hepato-protective, immune-stimulatory, antiviral, antioxidant properties amongst others. DPML also contains higher antioxidant properties compared to doum palm seed meal making it possible to scavenge free radicals, thus preventing infection. Therefore, both DPML and DPSM can be utilized by livestock.

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