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Pharmacological and nutritional characteristics of the pawpaw plant (*Carica papaya* Linn.)

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ABSTRACT

Pawpaw (*Carica papaya* Linn.) is known for its food and nutritional values throughout the world. The medicinal properties of Pawpaw fruit and other parts of the plant are known in traditional medicine. Each part of Pawpaw tree possesses economic value; it is grown on commercial scale. Considerable progress has been achieved regarding the biological activity and medicinal application of Pawpaw and now it is considered as valuable nutraceutical fruit plant. It can be chosen as a source of papain for the development of various industrial and pharmaceutical products. In the present review nutritional value of the fruit and medicinal properties of its various parts have been discussed to provide collective information on this multipurpose commercial fruit crop.

Keywords: Pawpaw, *Carica papaya*, Medicinal plant, Nutraceutical, Fruit, Papain

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Introduction

Pawpaw tree belongs to a family - *Caricaceae* having four genera in the world. The genus *Carica* is represented by four species in India, of which *Carica papaya* Linn. is the most widely cultivated and best-known species. Among the other species, *C. cauliflora* Jacq., *C. pubescens* and *C. quercifolia* are possible sources of breeding material for inducing frost and virus resistance in cultivated Pawpaw. The fruits, leaves and latex obtained from Pawpaw plant are used medicinally and for various other purposes. Papain, a major chemical compound extracted from fruit and stem latex is used in brewing and wine making and, in the textile, and tanning industries (Bruneton, 1999 and Bhattacharjee, 2001). Pawpaw contains broad spectrum of phytochemicals including, polysaccharides, vitamins, minerals, enzymes, proteins, alkaloids, glycosides, fats and oils, lectins, saponins, flavonoids and sterols (Marotta *et al*., 2006a and Marotta *et al*., 2006b). (Table 1)

The review covered origin and distribution, brief morphological characters, nutritional value and results of reported research findings on its medicinal properties.

Origin, Distribution and Morphology

Pawpaw originated from Southern Mexico and Costa Rica. It was introduced as a plantation crop in Australia, Hawaii, Philippines, Sri Lanka, South Africa, India and in all tropical and subtropical regions. It is grown both commercially and in home gardens. Pawpaw is a polygamous species and it is difficult to identify a plant whether it is male, female or hermaphrodite. It is a tree reaching 3-10 m in height, with the habit of a palm; the fleshy stem marked by scars where leaves have fallen off, is surmounted by a terminal panache of leaves on long petioles and with 5-7 lobes (Nkwocha *et al*., 2024). Flowers fragrant, trimorphous, usually unisexual-dioeciously, male flowers in lax many-flowered, densely pubescent

cymes at the tips of the pendulous, fistular rachis; female flowers large, solitary or in few flowered racemes, with a short thick rachis, fruit a large berry, varying widely in size, elongate to globose with a large central cavity, seeds black, tuberculous and enclosed in a transparent aril. The fruit bearing trees are less than 18months old. The leaves and unripe fruit contain milky juice in which the protein ferment papain is present (Ihenacho *et al.*, 2016a and Ihenacho *et al*., 2016b).

Fig. 1. Pawpaw Tree (*Carica papaya*) with Unripe Fruits

Table 1. Chemical Composition of various parts of Pawpaw Plant

Part	Constituents
Fruits	Protein, fat, fibre, carbohydrates, minerals: calcium, phosphorous, iron, vitamin C, thiamine, riboflavin, niacin, and carotene, amino acids, citric and malic acids (green fruits), volatile compounds: linalool, benzylisothiocyanates, *cis* and *trans* 2, 6-dimethyl-3,6 epoxy-7 octen-2-ol Alkaloid; carpaine, benzyl-□-D glucosides, 2-phenylethyl -□-D-glucosides, 4-hydroxy- phenyl-2 ethyl-□-D-glucosides and four isomeric malonated benzyl-□-D-glucosides
Juice	N-butyric, n-hexanoic and n-octanoic acids, lipids; myristic, palmitic, stearic, linoleic, linolenic and cis-vaccenic and oleic acids
Seed	Fatty acids, crude protein, crude fibre, pawpaw oil, Carpaine, benzylisothiocyanate, benzylglucosinolate, glucotropacolin, benzylthiourea, hentriacontane, □-sitosterol, caricin and an enzyme myrosin
Root	Carposide and an enzyme myrosin.
Leaves	Alkaloids carpain, pseudocarpain and dehydrocarpaine I and II, choline, carposide, vitamin C and E
Bark	□-Sitosterol, glucose, fructose, sucrose, galactose and xylitol
Latex	Proteolytic enzymes, papain and chemopapain, glutamine cyclotransferase, chymopapains A, B and C, peptidase A and B and lysozymes

Nutritional value

Pawpaw is a common man's fruit, which is reasonably priced and has a high nutritive value. It is low in calories and rich in natural vitamins and minerals (Ahaotu *et al*., 2018a). Pawpaw places first among the fruits for vitamin C, vitamin A, riboflavin, folate, calcium, thiamine, iron, niacin, potassium and fibre (Ahaotu *et al*., 2018b). The comparative low calories content (32 kcal/100g of ripe fruit) makes this a favourite fruit of obese people who are into weight reducing regime (Ahaotu *et al.,* 2018c). Pawpaw has more carotene compared to other fruits such as apples, guavas, sitaphal and plantains, which help to prevent damage by free radicals.

Unripe green pawpaw is used as vegetable; it does not contain carotene but all other nutrients were presented (Table 2). It is also used in salads, pies, sherbets, juices and confections. Pawpaw when consumed regularly will ensure a good supply of vitamin A and C, which are essential for good health especially for eye-sight and can help to prevent early age blindness in children. The fruit is a rich source for different types of enzymes. Papain, vegetable pepsin present in good amount in unripe fruit is an excellent aid to digestion, which helps to digest the protein in food at acid, alkaline or neutral medium. Thus, it can be prescribed for dyspeptic patients, as papain may help in the digestion of proteins. The celiac disease patients, who cannot digest the wheat protein gliandin, can tolerate it, if it is treated with crude papain. Pawpaw has the property of tenderizing meat. This knowledge is being put to use by cooking meat with raw pawpaw to make it tender and digestible (Dominguez de Maria *et al*., 2006).

The fermented pawpaw fruit is a promising nutraceutical as an antioxidant. It improves the antioxidant defense in elderly patients even without any overt antioxidant deficiency state at the dose of 9g/day orally (Kamaruz zaman *et al*., 2005). The pawpaw lipase, a hydrolase enzyme tightly bonded to the water insoluble fraction of crude papain, is considered as a "naturally immobilized" biocatalyst (Fouzder *et al*., 1999).

The dried fruit skin is a potential source as dietary ingredient for broiler chickens, it gives similar food consumption, food conversion efficiency, survivability and meat yields to a control diet when used up to 120g/kg of diet (Dominguez de Maria *et al*., 2006). Fouzder *et al.,* (1999) have reported that, dried pawpaw skin could safely be used up to 90g/kg in the diet of growing pullets. The pawpaw seed is also used in

the ethno-veterinary practices (Lans *et al.,* 2000). Effective antioxidant supplementation Bio-normalizer, a natural Japanese health food prepared by the fermentation of pawpaw, is able to improve the haemorrheology in alcoholics either by directly affecting the ethanol related lipo-peroxidation and xanthine oxidase system activation or by modifying red blood cell membrane characteristics (Marotta *et al.,* 2001). It also exhibits therapeutic properties against various pathological disorder including tumours and immunodeficiency. Its protective action is based on the free radical scavenging activity as well as normalization of an organism's superoxide level. It is proposed that, normalization of an organism's superoxide level, which is due to inactivation of the ferrous ions, the catalyst of the superoxide driven Fenton reaction, is one of the molecular mechanism of Bionormalizer activity (Savickiene *et al.,* 2002). Pawpaw markedly increases iron (Fe) absorption from rice meal, which was measured by using the erythrocyte utilization of radioactive Fe method (Chen *et al.,* 2007). The fruit is rich in vitamins, minerals, proteins, polysaccharides, lectins, saponins and flavonoids, and can be used in the prevention of complications of diabetes mellitus (Kermanshai *et al.,* 2001). The black seeds are edible and have a sharp, spicy taste. They are sometimes ground up and used as a substitute for black pepper. The young and tender leaves of pawpaw are steamed and eaten like spinach (Stepek *et al*., 2005).

Table 2. Nutritive value of 100g of Pawpaw fruit

Constituents	Ripe Pawpaw	Green Pawpaw
Protein	0.6 g	0.7 g
Fat	0.1 g	0.2 g
Minerals	0.5 g	0.5 g
Fibre	0.8 g	0.9 g
Carbohydrates	7.2 g	5.7 g
Energy	32 kcal	27 kcal
Total carotene	2,740□m	0
Beta carotene	888 □m	0

Medicinal and Pharmacological properties

Many biologically active phytochemical(s) have been isolated from pawpaw and studied for their action, recently an antifungal chitinase has been gene cloned and characterized from pawpaw fruit. The chitinase is classified as class IV chitinase based on its amino acid sequence homology with other plant chitinases. The recombinant pawpaw chitinase also has antibacterial activity (Calzada *et al.,* 2007). The purified chemo papain from commercially available spray dried latex of the fruits has shown immunological properties (Leite *et al.,* 2005). The anthelmintic activity of pawpaw seed has been variously ascribed to carpaine (an alkaloid) and carpasemine (later identified as benzyl thiourea) and benzyl isothiocyanates (Dawkins *et al*., 2003), cysteine proteinases from pawpaw fruit have also been reported (Nayak *et al*., 2007). Carpaine, an alkaloid with an intensively bitter taste and a strong depressant action on the heart, has been obtained from the fruit and seed, but especially from the leaves (Nkuo-Akenji *et al*., 2001).

Various pharmacological action(s) and medicinal uses of different parts of pawpaw are well reported (Regine *et al*., 2001) (Table 3). Biological activities of pawpaw are reported with the crude extracts and different fractions from latex, seed, leaf, root, stem bark and fruit. However, crude extracts of different parts of pawpaw have been used as traditional medicine for the treatment of various diseases. However, apart from these, there are several reports on the therapeutic properties and pharmacological actions of pawpaw based on recent scientific investigations as indicated below.

Antimicrobial

The seed of pawpaw has antimicrobial activity against *Trichomonas vaginalis* trophozoites. The report suggested the use of pawpaw seed in urinogenital disorder like trichomoniasis with care to avoid toxicity (Okeniyi *et al*., 2007). The seed and pulp of pawpaw was shown to be bacteriostatic against several entero-pathogens such as *Bacillus subtilis, Enterobacter cloacae, Escherichia coli, Salmonella typhi, Staphylococcus aureus, Proteus vulgaris, Pseudomonas aeruginosa* and *Klebsiella pneumoniae* by the agar cup plate method (Hounzangbe-Adote *et al.,* 2005). Purified extracts from ripe and unripe fruits also produces very significant antibacterial activity on *S. aureus, Bacillus cereus, E. coli, P. aeruginosa* and *Shigella flexneri* (Bhat Praveen *et al*., 2001).

The aqueous extract of fruit exhibited antimicrobial activity and promoted significant wound healing in diabetic rats. The seeds of irrespective stage of fruit maturity have bacteriostatic activity on Gram positive and Gramnegative organisms, which could be useful in treating chronic skin ulcers. The pawpaw seed macerate has a clinical potential on conjugal R plasmid transfer from *Salmonella typhimurium* to

Escherichia coli, on *in vitro* and in the digestive tract of genotobiotic mice. Herbal formulations containing pawpaw leaves and root or leaves alone as one of the constituent has antibacterial activity against *Salmonella typhi, Sparatyphi and S. typhimurium;* however, water, acetone and ethanol extract of pawpaw leaves showed no microbicidal activity (Adebivi and Adaikan, 2005).

Anthelmintic

The airdried pawpaw seeds given as elixir with honey has shown significant effect on the human intestinal parasites, without significant side effects. It is reported that their consumption offers a cheap, natural, harmless, readily available monotherapy and preventive strategy against intestinal parasitosis, especially in tropical communities (Eno *et al.,* 2000). Preliminary pharmacological report on anthelmintic activity of pawpaw seed is also available. Benzyl isothiocyanates, present in seeds is the chief or sole anthelmintic (Wilson *et al.,* 2002).

The latex of pawpaw has anthelmintic efficacy against *Heligmosomoides polygyrusin* experimentally infected mice, which suggests its potential role as an anthelmintic against potent intestinal nematodes of mammalian hosts (Eno *et al.,* 2000). It also has anthelmintic activity against natural infection of Ascaris suum in pigs and found to be 100% effective at the dose of 8g/kg body weight (Abeywardena *et al*., 2002). The plant extracts of pawpaw possess a dose dependent significant effect on the egg, infective larvae and adult worms of Trichostrongylus colubriformis (Runnie *et al*., 2004). Alcoholic extracts of pawpaw showed potential in vitro anti-parasitic action, which affects eggs, infective larvae and adult Haemonchus contortus (Cherian, 2000).

Anti-amoebic

The cold macerated aqueous extract of matured pawpaw seeds has shown anti-amoebic activity against Entamoeba histolytica (Adebivi *et al.,* 2003).

Antimalarial

The petroleum ether extract of the rind of raw pawpaw fruit exhibits significant antimalarial activity. There may be significant commercial potential in extracting the active element from this plant, which grows abundantly throughout the tropics and the rind of which is discarded as waste, can be exploited for antimalarial activity (Bungorn *et al*., 2001).

Antifungal

The latex of pawpaw and Fluconazole has synergistic action on the inhibition of *Candida albicans* growth. This synergistic effect results in partial cell wall degradation (as indicated by transmission electron microscopy observations) (Rajkapoor *et al.,* 2002). Latex alone is statically effective on *C. albicans* when added to a culture during the exponential growth phase and approximately 60% was achieved. This fungistatic effect is the result of cell wall degradation due to a lack of polysaccharides constituents in the outermost layers of the fungal cell wall and release of cell debris into the culture medium (Hewitt *et al.,* 2002). Latex proteins appear to be responsible for antifungal action and minimum protein concentration for producing a complete inhibition was reported as about 138mg/ml (Udoh *et al*., 2005).

Effect on smooth muscles

Ethanol extract of pawpaw seeds at 0.1-6.4mg/ml showed concentration dependent inhibition of jejunal contractions and found significantly irreversible. Thus, seed extract is capable of weakening the contractile capability of isolated rabbit jejunum (Uche-Nwachi *et al*., 2001). Pentane extract of pawpaw seeds has shown relaxation action on strips of dog carotid artery that had been pre-contracted with Phenylephrine. At the higher concentration, these are reported to be cytotoxic due to increasing the membrane permeability to Ca^{2+}(Verma and Chinoy 2001). A crude ethanol extract of unripe fruit produces a significant depression of mean arterial pressure but the extract has about 28% more depression action than hydralazine in the hypertensive rats. Fruit juice of pawpaw probably contains antihypertensive agent(s), which exhibits mainly alpha adeno receptor activity (Pathak *et al.,* 2002). Pawpaw leaves extracts exhibited more than 50% relaxing effect on aortic ring preparations. This property demonstrates that many edible plants common in Nigerian diets possess potential health benefits, affording protection at the vascular endothelium level (Ahaotu *et al*., 2018a).

Rat uterine contractile activity was remarkably increased by different doses of pawpaw latex extract in proestrus and estrus stages compared to metestrus and diestrus stages of the estrous cycles. Crude pawpaw latex contains a uterotonic principle which might be a combination of enzymes, alkaloids and other substances which can evoke sustained contraction of the uterus acting mainly on the alpha-adrenergic receptor population of the uterus at different stages (Lohiya

et al., 2008). Ethanol extract (80%) of seeds causes a concentration dependent tocolysis of uterine strips isolated from gravid and non-gravid rats. High concentration extract is capable of causing irreversible uterine tocolysis probably due to the damaging effect of benzyl isothiocyanates on the myometrium (Lohiya *et al.,* 2002).

Diuretic

Aqueous root extract of pawpaw when given orally at a dose of 10 mg/kg to rats produces significant increase in urine output and shows similar profiles of urinary electrolyte excretion to that of Hydrochlorothiazide (Kusemiju *et al.,* 2002).

Hepatoprotective

The ethanol and aqueous extracts of the fruit possess remarkable hepatoprotective activity against *Candida* (Sharma and Mahanta, 2000) induced hepatotoxicity. But hepatoprotective mechanism as well as active principles responsible for hepatoprotective activity of this plant is not yet known (Lohiya *et al.,* 2000).

Topical use

Pawpaw fruits are used as topical ulcer dressing thereby promoting de-sloughing, granulation and healing; it also reduces the odour in chronic skin ulcers. It is cost effective and is considered to be more effective than other topical applications in the treatment of chronic ulcers (Marotta *et al.,* 2007). It is currently used as the major component of burns dressings, where it is well tolerated by the children. Economic and widely available, the pulp of the Pawpaw fruit is mashed and applied daily to full thickness onto the infected burns. It appears to be effective in de-sloughing necrotic tissue, preventing burn wound infection and providing a granulating wound suitable for the application of a split thickness skin graft. Possible mechanisms of action include the activity of proteolytic enzymes Chymopapain and papain, as well as an antimicrobial activity (Mehdipour *et al*., 2006).

Male anti-fertility

Seed extract showed pronounced hypertrophy and hyperplasia of pituitary gonadotrophs. Whereas the male rats treated with seed extract revealed gradual degeneration of Germ, Sertoli and Leydig cells as well as germinal epithelium, which confirmed its antifertility activity (Rahmat *et al.,* 2004).

Table 3. Some medicinal uses of Pawpaw plant

Part	Medicinal uses
Latex	Anthelmintic, relieves dyspepsia, cures diarrhoea, pain of burns and topical use, bleeding Haemorrhoids, stomachic,
Ripe fruits	whooping cough. Stomachic, digestive, carminative, diuretic, dysentery and chronic diarrhoea, expectorant, sedative and tonic, relieves obesity, bleeding piles, wounds of the urinary tract, ringworm and skin diseases psoriasis.
Unripe fruit seeds	Laxative, diuretic, dried fruit reduces enlarged spleen and liver, used in snakebite to remove poison, abortifacient, anti-implantation activity and antibacterial activity.
Seed juice	Carminative, emmenagogue, vermifuge, abortifacient, counter irritant, as paste in the treatment of ringworm and psoriasis, anti-fertility agents in males.
Root	Bleeding piles and enlarged liver and spleen.
Leaves	Abortifacient, diuretic, checking irregular bleeding from the uterus, piles, anti-fungal activity.
Flowers	Young leaves as vegetable, jaundice (fine paste), urinary complaints & gonorrhoea (infusion), dressing wounds (fresh leaves), antibacterial activity, vermifuge, in colic, fever, beriberi, abortion (infusion), asthma (smoke).
Stem	Jaundice, emmenagogue, febrifuge and pectoral properties.
Bark	Jaundice, anti-haemolytic activity, STD, sore teeth (inner bark), anti-fungal activity.

Aqueous extract of pawpaw seeds, 3 weeks after commencement of administration showed that the lumina of the seminiferous tubules were more prominent and emptier in the experimental animals with no evidence of spermatids and spermatozoa (Mojica-Henshaw *et al.,* 2003). Mehdipour *et al*., (2006) have reported its effect on Cauda epididymal microenvironment (Rimbach *et al*., 2000).

The benzene chromatographic fraction of the chloroform extract of the seeds possesses reversible male contraceptive potential and the effect appears to be mediated through the testis (Marotta *et al.,* 2007) and may be directly rendered on the spermatozoa (Aruoma *et al.,* 2002) without adverse toxicity. Another study revealed inhibition of sperm motility due to other epididymal factors rather than the sub-cellular characteristics of testis and epididymis (Ihenacho *et al*., 2016a). A possible mechanism of action and preliminary studies on the antifertility effect of crude seeds on the gonads of male albino rats (Ihenacho *et al.,* 2016b). A recent report revealed that it has good contraceptive efficacy in langur monkey and the action is mediated through inhibition of sperm motility (Rimbach *et al*., 2000).

The chloroform extract of seeds has shown

contraceptive efficacy and reversibility in decreasing the sperm concentration in male adult rabbits. It produces gradual decline in the sperm concentration, reached severe oligospermia (fewer than 20 million/ml) after 75 days treatment and attained uniform Azoospermia after 120 days of treatment. It also affects the sperm motility and viability after 45 days of treatment and reached less than 1% after 75 days of treatment (Maniyannan *et al*., 2004). It may selectively act on the developing germ cells, possibly mediated via Sertoli cells, leading to Azoospermia (Lohiya *et al*., 2008). The crude chloroform extract of seed causes suppression of Cauda epididymal sperm motility, which reduces fertility to zero % within 40 to 60 days of treatment (Wilson *et al*., 2002). Reversible sterility could be induced in male rats using seed's aqueous extract without adverse effects on libido and toxicological profile (Lohiya *et al*., 2008) and it could serve as an effective male contraceptive in rodents (Abeywardena *et al*., 2002). Even aqueous extract of pawpaw bark has potential contraceptive activity (Udoh *et al*., 2005). However, aqueous extract of the seeds of pawpaw failed to exhibit contraceptive effects at any of the dose regimens tested on male rabbits, contrary to the observations made in the previous studies. Unaltered toxicological profiles indicated that the drug was free of side effects (Uche-Nwachi *et al*., 2001). Pawpaw seed extract changes the biochemical parameters (except cholesterol levels) and the contractile pattern of vas deferens. The distal vas deferens will affect more than the proximal vas and recovery will be slower probably due to its higher threshold requirement for androgen (Udoh *et al*., 2005). A short-term administration of an aqueous extract of pawpaw seed manifests an androgen deprived effect on the target organs and thereby causes antifertility effect in adult male albino rats. The data revealed that functional sterility could be induced in male rats by pawpaw seed extract treatment, which promises to be a potential male contraceptive as also supported by its traditional use (Hewitt *et al*., 2002).

Female anti-fertility

Hewitt *et al*., (2002) however reported that the composite root extract containing pawpaw root extract as one of the constituent, induces morphological changes in the endometrial surface epithelium in albino rat uterus. The characteristic smooth regular pattern of normal epithelium appears to have changed at places by haphazardly oriented groups of cells and loss of microvilli indicating a disorganized picture (Calzada *et al*., 2007). Whereas seeds aqueous extract has shown abortifacient properties on female Sprague rats (Dawkins *et al*., 2003) and the petroleum ether, alcoholic and aqueous extracts inhibits ovulation in rabbits (Udoh *et al*., 2005). The pawpaw seed extracts did not exhibit anti-zygotic, anti-implantation, early abortifacient or antifertility activity (Calzada *et al*., 2007).

Normal consumption of ripe pawpaw during pregnancy may not pose any significant danger. However, the unripe or semi-ripe pawpaw (which contains high concentration of the latex that produces marked uterine contractions) could be unsafe in pregnancy (Dawkins *et al*., 2003).

Histaminergic

Crude latex causes contraction of the isolated guinea pig ileum strips, which is mediated via H1-receptor and dependent on extracellular Ca^{2+} influx (Wilson *et al*., 2002). Pawpaw flower pollen is able to induce respiratory IgE-mediated allergy. The existence of common allergens among pawpaw flower pollen, fruit and papain has been demonstrated by RAST inhibition (Bungorn *et al*., 2001).

Immuno-modulatory

The involvement of oxidative stress mechanisms in several biological and pathological processes including ageing, cancer, cardiovascular and neurodegenerative diseases has continued to fuel suggestions that processes can potentially be modulated by treatment with free-radical scavengers and antioxidant. The fermented pawpaw preparation has shown its ability to modulate oxidative DNA damage due to H O in rat pheochromocytoma cells and protection of brain oxidative damage in hypertensive rats (Abeywardena *et al*., 2002). It has also exhibited potential supportive role on oxidative inflammatory damage in cirrhosis caused by hepatitis C virus (Wilson *et al*., 2002). The safety and antioxidative stress potential of pawpaw juice is found to be comparable to the standard antioxidant compound □- tocopherols (Kermanshai *et al*., 2001). The preparation containing yeast fermented pawpaw as one of the constituent has antioxidant actions and that it may be prophylactic food against age related and neurological diseases associated with free radicals (Nayak *et al*., 2007).

Bacteriostatic activity of pawpaw could be correlated to its scavenging action on superoxide and hydroxyl radicals, which could be part of the

cellular metabolism of such enteropathogens (Bungorn *et al*., 2001). Bio-catalyzer, which contains yeast fermented pawpaw, may be useful as health foods against neural lipid peroxidation, traumatic epilepsy and ageing (Kermanshai *et al.,* 2001). Consumptions of guava and pawpaw fruits reduce oxidative stress and alter lipid profile. Thus, it could reduce the risk of disease caused by free radical activities and high cholesterol in blood (Abeywardena *et al*., 2002).

Pawpaw seed extract is currently being marketed as a nutritional supplement with purported ability to rejuvenate the body condition and to increase energy. The product claims to improve immunity against common infection and body functioning. This provides the evidence for its immuno-modulatory and anti- inflammatory actions (Nayak *et al*., 2007).

Fermented pawpaw preparation exerts both immuno-modulatory and antioxidant activity in the macrophage cell line RAW 264 and it is a macrophage activator, which augments nitric oxide synthesis and TNF-alpha secretion independently of lipopolysaccharides (Rajkapoor *et al.,* 2002). The antioxidant cocktail derived from fermentation of unpolished rice, pawpaw and seaweeds with effective microorganisms of lactic acid bacteria, yeast and photosynthetic bacteria has shown inhibition of lipid peroxidation *in vivo*, a point dependent on the concentrations of bioactive flavonoids (Marotta *et al.,* 2006b).

Conclusion

Pawpaw is the unique source of various types of compounds having diverse structure. A lot of research works have been done on the biological activity and possible application of these compounds and hence extensive investigation on its pharmaco-dynamics, kinetics and proper standardization. Clinical trials are needed to exploit their therapeutic utility to combat various diseases.

References

Abeywardena M, Runnie I, Nizar M, Suhaila M and Head Rand Suhaila Momamed (2002). Polyphenol-enriched extract of oil palm fronds (*Elaeis guineensis*) promotes vascular relaxation via endothelium-dependent mechanisms. Asian Pac J Clin Nutr, 11(7): 467-472.

Adebivi A and Adaikan PG (2005). Modulation of jejunal contractions by extract of *Carica papaya* Linn. Seeds. Phytother Res, 19(7): 628-632.

Adebivi A, Ganesan Adaikan P and Prasad RN (2003). Tocolytic and toxic activity of papaya seed extract on isolated rat uterus. Life Sci, 74(5): 581-592.

Ahaotu EO, Amadinze C and Ahaotu EO (2018c). Carcass and Organ Weight Indices of Feeding Different Levels of Pawpaw Leaf Meal (*Carica papaya*) on Finisher Broiler Birds. Journal of Meat Science and Technology, 06(1): 01-04

Ahaotu EO, Kwushue V and Ahaotu EO (2018a). Performance Implications of Feeding Different Levels of Pawpaw (*Carica papaya*) Leaf Meal on Finisher Broiler Birds. Journal of Poultry Science and Technology, 6(1): 01-04.

Ahaotu EO, Onyegbula T and Ahaotu EO (2018b). Haematological Characteristics and Organoleptic Test of Feeding Different Levels of Pawpaw (*Carica papaya*) Leaf Meal on Finisher Broiler Birds. International Journal of Animal and Veterinary Sciences, 05: 10-14.

Aruoma OI, Deiana M, Rosa A, Casu V, Piga R, Peccagnini S, Dessi MA, Ke B, Liang YF and Higa T (2002). Assessment of the ability of the antioxidant cocktail-derived from fermentation of plants with effective microorganisms (EM-X) to modulate oxidative damage in the kidney and liver of rats *in vivo*, studies upon the profile of poly- and mono-unsaturated fatty acids. Toxicol Lett, 135(3): 209-217.

Bhat Praveen Gand Surolia Namita (2001). *In vitro* Antimalarial activity of extracts of three plants used in the traditional medicine of India. Am J Trop Med Hyg, 65(4): 304-308.

Bhattacharjee SK (2001). *Carica papaya*, *In*: Hand book of Medicinal Plants, 3rd Revised Edn, by Shashi Jain (Ed), Pointer publisher, Jaipur, 1-71.

Bruneton J (1999). *Carica papaya*, *In*: Pharmacognosy, Phytochemistry of Medicinal plants, 2ndEdn, Technique and Documentation, France, 221-223.

Calzada F, Yepez-Mulia L and Tapia-ContrerasA (2007). Effect of Mexican medicinal plant used to treat trichomoniasis on *Trichomonas vaginalis* trophozoites. J Ethno pharmacol, 113(2): 248-251.

Chen YT, Hsu LH, Huang IP, Tsai TC, Lee GC and

ShawJF (2007). Gene cloning and characterization of a novel recombinant antifungal chitinase from papaya (*Caricapapaya*). J Agric Food Chem, 55(3): 714-722.

Cherian T (2000). Effect of papaya latex extract on gravidandnon-gravidratuterine preparations *in-vitro*. J Ethnopharmacol, 70(3): 205-212.

Dawkins G, Hewitt H, Wint Y, Obiefuna PC and Wint B (2003). Antibacterial effects of *Carica papaya* fruit on common wound organisms. West Indian Med J, 52(4): 290-292.

Dominguez de Maria P, Sinisterra JV, Tsai SW and Alcantara AR (2006). *Carica papaya* lipase (CPL), an emerging and versatile biocatalyst. Biotechnol Adv, 24(5): 493-499.

Eno AE, Owo OI, Itam EH and Konya RS (2000). Blood pressure depression by the fruit juice of *Carica papaya* Linn. In renal and DOCA-induced hypertension in the rat. Phytother Res, 14(4): 235-239.

Fouzder SK, Chowdhury SD, Howlider MA and Podder CK (1999). Use of dried papaya skin in the diet of growing pullets. Br Poult Sci, 40(1): 88-90.

Hewitt H, Whittle S, Lopez S, Bailey E and Weaver S (2002). Topical use of papaya in chronic skin ulcer therapy in Jamaica. West Indian Med J, 49(1): 32-33.

Hounzangbe Adote S, FourasteI, Moutairou Kand Hoste H (2005). *In vitro* effects off our tropical plants on the activity and development of the parasitic nematode, *Trichostrongylus colubriformis*. J Helminthol, 79(1): 29-33.

Ihenacho RA, Ahaotu EO, Ayo –Enwerem CM and Oguegbuchulam MN (2016a). Carcass Characteristics of *Achatina fulica* fed with *Carica papaya* leaves, *Amaranthus spinosus* leaves and *Telfairia occidentalis* leaves. Proc. 5th Int. Conf/Workshop on Giant African Land Snail (NetGALS), 148-150.

Ihenacho RA, Ahaotu EO, Ihiaha PO and Oguegbuchulam MN (2016b). Performance Characteristics of *Achatina fulica* fed with *Carica papaya* leaves, *Amaranthus spinosus* leaves and *Telfairia occidentalis* leaves. Proc. 5th Int. Conf/Workshop on Giant African Land Snail (NetGALS), 141-154.

Kamaruzzaman M, Chowdhury SD, Podder CK and Pramanik MA (2005). Dried papaya skin as a dietary ingredient for broiler chickens. Br Poult Sci, 46(3): 390-393.

Kermanshai R, McCarry BE, Rosenfeld J, Summers PS, Weretilnyk EA and Sorger GJ (2001). Benzyl isothiocyanate is the chief or so lean the lminticin papaya seed extracts. Phytochemistry, 57(3): 427-435.

Kusemiju O, Noronha C and Okanlawon A (2002). The effect of crude extract of the bark of *Carica papaya* on the seminiferous tubules of male Sprague-Dawley rats. Niger Postgrad Med J, 9(4): 205-209.

Lans C, Harper T, Georges K and Bridgewater E (2000). Medicinal plants used for dogs in Trinidad and Tobago. Prev Vet Med, 45(3-4): 201-220.

Leite AA, Nardi RM, Nicoli JR, Chartone-Souza E and Nascimento AM (2005). *Carica papaya* seed macerate as inhibitor of conjugative R plasmid transfer from *Salmonella typhimurium* to *Escherichia coli, in vitro* and in the digestive tract of gnotobiotic mice. J Gen Appl Microbiol, 51(1): 21-26.

Lohiya NK, Manivannan B, Goyal S and Ansari AS (2008). Sperm motility inhibitory effect of the benzene chromatographic fraction of the chloroform extract of the seeds of *Carica papaya* in langur monkey, *Presbytisentellus entellus*. Asian J Androl, 10(2): 298-306.

Lohiya NK, Mishra PK, Pathak N, Maniyannan B, Sriram S, Bhande SS and Panneerdoss S (2002). Chloroform extract of *Carica papaya* seed induced long term reversible azoospermia in langur monkey. Asian J Androl, 4(1): 17-26.

Lohiya NK, Pathak N, Mishra PK and Manivannan B (2000). Contraceptive evaluation and toxicological study of aqueous extract of the seeds of *Carica papaya* in male rabbits. J Ethnopharmacol, 70(1): 17-27.

Maniyannan B, Mishra PK, Pathak N, Sriram S, Bhande SS, Panneerdoss S and Lohiya NK (2004). Ultra structural changes in the testis and epididymis of rats following treatment with the benzene chromatographic fraction of the chloroform extract of the seeds of *Carica papaya.* Phytother Res, 18(4): 285-289.

Marotta F, Pavasuthipaisit K, Yoshida C, Albergati F and Marandola P (2006b). Relationship between aging and susceptibility of erythrocytes to oxidative damage, in view of nutraceutical interventions. Rejuven Res, 9(2): 227-230.

Marotta F, Safran P, Tajiri H, Princess G, Anzulovic H, Ideo GM, Rouge A, Seal MG and Ideo G (2001). Improvement of haemorheological abnormalities in alcoholics by an oralantioxidant. Hepatogastroenterology, 48(38): 511-517.

Marotta F, Weksler M, Naito Y, Yoshida C, Yoshioka M and Marandola P (2006a). Nutraceutical supplementation, effect of a fermented papaya preparation on redox status and DNA damage in healthy elderly individuals and relationship with GSTM1 genotype, a randomized, placebo- controlled, cross-over study. Ann N Y Acad Sci, 1067(1): 400-407.

Marotta F, Yoshida C, Barreto R, Naito Y and Packer L (2007). Oxidative-inflammatory damage in cirrhosis: effect of vitamin E and a fermented papaya preparation. J Gastroenterol Hepatol, 22(5): 697-703.

Mehdipour S, Yasa N, Dehghan G, Khorasani R, Mohammadirad A, Rahimi R and Abdollahi M (2006). Antioxidant potentials of Iranian *Carica papaya* juice *in-vitro* and *in-vivo* are comparable to alpha-tocopherol. Phytother Res, 20(7): 591-594.

Mojica-Henshaw MP, Francisco AD, De Guzman F and Tingo XT (2003). Possible Immuno mudulatory actions of *Carica papaya* seed extract. Clin Hemorheol Microcirc, 29(3-4): 219-229.

Nayak SB, Pereira L Pinto and Maharaj D (2007). Wound healing activity of *Carica papaya* L inn. In experimentally induced diabeticrats. Indian J Exp Biol, 45(8): 739-743.

Nkuo-Akenji T, Ndip R, Mc Thomas A and Fru EC (2001). Anti Salmonella activity of medicinal plants from Cameroon. Cent Afr J Med, 47(6): 155-158.

Nkwocha G, Benjamin E, Kevin A, Adewale A, Roseline N, Emmanuel A, Francis A and Marcus C (2024). Growth performance, haematological and serum biochemical indices of Weaner pigs fed Carica papaya seed and leaf meal as dietary supplement. Online Journal of Animal and Feed Research, 11-30. DOI: 10.51227/ojafr.2024.46.

Okeniyi JA, Ogunlesi TA, Oyelami OA and Adeyemi LA (2007). Effectiveness of dried *Carica papaya* seeds against human intestinal parasitosis: a pilot study. J Med Food, 10(1): 194-196.

Pathak N, Mishra PK, Maniyannan B and Lohiya NK (2002). Sterility due to inhibition of sperm motility by oral administration of benzene chromatographic fraction of the chloroform extract of the seeds of *Carica papaya* in rats. Phytomedicine, 7(4): 325-333.

Rahmat A, Abu Bakar MF, Faezah N and Hambali Z (2004). The effects of consumption of guava (*Psidium guajava*) or papaya (*Carica papaya*) on total antioxidant and lipid profile in normal male youth, Asia Pac J Clin Nutr, 13(Suppl): S106.

Rajkapoor B, Jayakar B, Kavimani S and Murugesh N (2002). Effect of dried fruits of *Carica papaya* Linn. On hepatotoxicity. Biol Pharm Bull, **25**(12): 1645-1646.

Regine Helena Silva dos Fernandes Vieira, Dalia dos Prazeres Rodrigues, Flavia Araujo Goncalves, Francisca Gleire Rodrigues de Menezes, Janisi Sales Aragao and Oscarina Viana Sousa (2001). Microbicidal effect of medicinal plant extracts (*Psidium guajava* Linn. And *Carica papaya* Linn.) upon bacteria isolated from fish muscle and known toinduce diarrhea in children. Rev Inst Med Trop S Paulo, 43(3): 145-148.

Rimbach G, Park YC, Guo Q, Moini H, Qureshi N, Saliou C, Takayama K, Virgili F and Packer L (2000). Nitric oxide synthesis and TNF-alpha secretion in RAW 264.7 macrophages, mode of action of a fermented papaya preparation. Life Sci, 67(6): 679-694.

Runnie I, Salleh MN, Mohamed S, Head RJ and Abeywardena MY (2004). Vaso relaxation induced by common edible tropical plant extracts in isolated rat aorta and mesenteric vascularbed. J Ethnopharmacol, 92(2-3): 311-316.

Savickiene N, Dagilyte A, Lukosius A and Zitkevicius V (2002). Importance of biologically active components and plants in the prevention of complications of diabetes mellitus. Medicina (Kaunas), 38(10): 970-975.

Sharma HN and Mahanta HC (2000). Modulation of morphological changes of endometrial surface epithelium by administration of composite root extract in albino rat. Contraception, 62(1): 51-54.

Sripanidkulchai B, Wongpanich V, Laupattarakasem P, Suwansaksri J and Jirakulsomchok D (2001). Diuretic effects of selected Thai indigenous medicinal plants in

rats. J Ethnopharmacol, 75(2-3): 185-190.

Stepek G, Buttle DJ, Duce IR, Lowe A and Behnke JM (2005). Assessment of the anthelmintic effect of natural plant cysteine proteinases against the gastro intestinal nematode, *Heligmosomoides polygyrus*, *in vitro*. Parasitology, 130(Pt2): 203-211.

Uche-Nwachi EO, Ezeokoli DC, Adogwa AO and Offiah VN (2001). Effect of water extract of *Carica papaya* seed on the germinal epithelium of the seminiferous tubules of Sprague-Dawley rats. Kaibogaku Zasshi, 76(6): 517-521.

Udoh P, Essien I and Udoh F (2005). Effects of *Carica papaya* (pawpaw) seeds extraction the morphology of pituitary-gonadal axis of male Wistar rats. Phytother Res, **19**(12): 1065-1068.

Verma RJ and Chinoy NJ (2001). Effect of papaya seed extract on micro environment of cauda epididymis. Asian J Androl, **3**(2): 143-146.

Wilson RK, Kwan TK, Kwan CY and Sorger GJ (2002). Effects of papaya seed extract and benzyl isothiocyanate on vascular contraction. Life Sci, 71(5): 497-507.

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