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Research Paper

Nutritive value of some indigenous plant rhizomes resembling Ginger

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Abstract

Rhizomes of certain Ginger like species, viz. ***Alpinia officinarum* Hance**, ***A. galanga* Willd.**, ***A. zerumbet* (Pers.) Burtt & R M Smith** (syn. *A. speciosa* K. Schum.), ***A. calcarata* Rosc.** and ***Kaempferia galanga* Linn.** have high medicinal value belonging to family Zingiberaceae. These rhizomes have a good nutritive value also (350.9 Cal per 100 g) and are quite rich in protein and carbohydrate, but low in fat. Rhizomes of ***A. officinarum***, ***A. zerumbet*** and ***A. calcarata*** have high iron content with a moderate and balanced content of carbohydrate, protein, fat and crude fibre. Rhizomes of ***A. galanga*** are lowest in fat content but richest in carbohydrate. ***A. calcarata*** is lowest in Mn, Ni and K but richest in Ca and Na. Study shows the biologically important metals Cr, Mn, Cu, Zn, Ca and Na to be sufficient in rhizomes of ***K. galanga***. All these studied materials have a moderate to good antimicrobial activity.

Keywords: *Alpinia galanga, Alpinia calcarata*, *Alpinia officinarum, Alpinia speciosa, Alpinia zerumbet*, *Kaempferia galanga*, Antimicrobial activity, Mineral elements, Nutritive value, Trace elements, Zingiberaceae.

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Introduction

Herbs have been an integral part of human life. Before he learned to hunt animals, primitive man had depended on plants for both food and medicine. Medicines from plants were used to cure but simultaneously magic spells were intoned as the plant material was applied. This was the usual method of healing in most part of the world[1]. Nutritive value of plant has its own importance. Carbohydrates, fats and proteins form the major portion of the diet, while minerals and vitamins form comparatively a smaller but never a less important part[2]. The use and importance of Ginger is well known. In the present study, the medicinal and nutritional importance of certain plants of same family (Zingiberaceae) have been investigated and found to be quite interesting. The rhizomes of ***Alpinia officinarum***, ***A. galanga***, ***A. zerumbet***, ***A. calcarata*** and ***Kaempferia galanga*** have been investigated, accompanied by the study of their antimicrobial activity.

A. officinarum

A. officinarum Rhizome

A. galanga

A. galanga Rhizome

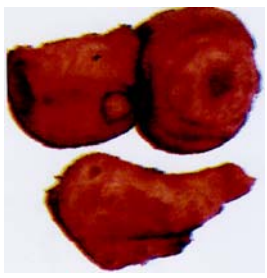
A. zerumbet

A. zerumbet Rhizome

Alpinia calcarata

A. calcarata Rhizome

Kaempferia galanga



K. galanga Rhizome

The plant ***Alpinia officinarum*** **Hance** (Lesser galangal) known as *Chhota kolonjana* in Hindi is a native of China but now cultivated in India in the plains of West Bengal, Assam and Eastern Himalayas. Its rhizomes furnish the drug known as the lesser galangal, much used in indigenous medicine as an aromatic stimulant and carminative. ***A. officinarum*** has been used both in Ayurvedic and Chinese medicine since very early times (c. AD 500 in China), and in Europe since the Middle Ages[3]. The rhizome is reported to be a very effective herb that acts mainly on the digestive system, also relieves pain, lowers fevers and controls bacterial and fungal infections[3]. It is given to young children to make them talk early. Fourteen flavonoids of *rhizoma galangae* have been reported[4], followed by the establishment of antifungal activity of the flavonoids[5]. Components present in the rhizomes are found to be antihepatotoxic[6], chemopreventive agent[7] and dermatophytoses[8]. Growth inhibiting effect of essential oil from rhizome on human intestinal bacteria is reported[9]. Some antioxidative components from rhizomes are also isolated and characterised[10].

Alpinia galanga **Willd.** (Greater galangal) known as *Bara kulanjan* in Hindi is a native of Indonesia but has now become naturalized in many parts of India mainly in the Eastern Himalayas and South-West India. Raw rhizome is a popular ingredient in many Indonesian and Malaysian dishes for its Ginger-like flavour[3]. The plant is reported to improve sexual attributes in male mice; it causes a significant gain in the weight of sexual organs and increases sperm motility and sperm count[11]. In indigenous medicine, the rhizomes are used in rheumatism and catarrhal affections, especially in bronchial catarrh and in respiratory troubles of children. Antitumour principles from rhizome have been reported[12]. Gastric antisecretory, antiulcer and cytoprotective properties of ethanolic extract of ***A. galanga*** in rats have also been reported[13]. Ohigashi[14] has designated this plant among promising cancer preventing dietary plants.

Alpinia zerumbet **(Pers.) Burtt & R M Smith** [syn. *A. speciosa* (Wendl.) K. Schum., *Costus zerumbet* Pers. and *Zerumbet speciosum* Wendl. p.p.] the Light galangal, known as *Chatiun* in Hindi is a handsome herb, occurring in the Eastern Himalayas from West Bengal eastwards and frequently cultivated in gardens for its foliage and showy flowers[11, 15]. Whole plant is fragrant like the cardamom. The rhizomes are useful in rheumatism and catarrhal afflictions. In afflictions of the gastrointestinal tract, the drug can be used like other volatile oils[16]. The rhizomes exhibit antiulcer activity[17]. The Rhizomes contain 5,6-dehydrokawain and dihydro 5,6-dehydrokawain reported to inhibit the aggregation of ATP release from rabbit platelets induced by arachidonic acid and collagen[18]. Very recently the presence of phenolic compounds in rhizomes has been reported and their use as a source for natural antioxidant in tea preparations or in food products such as meat, dairy and bakery has been suggested[19].

Alpinia calcarata **Rosc.** (syn. *A. bracteata* Rosc., *Renealmia calcarata* Haw) is known as *Toroni* in Oriya and *Kattchenu* in Malyalam[15]. It is often cultivated in gardens in Eastern and Southern India for its white flowers[11]. Rhizome decoction of it was traditionally used against inflammation, but now-a-days the herb is accredited with antitubercular properties and found good in rheumatism, stomach disorder, bronchial catarrh and is a good tonic and stimulant[20]. Antinociceptive activities of aqueous and ethanolic extracts of rhizomes in rats have been reported[21] in a Sri Lankan sample. Recently the effect of aqueous extract of ***A. calcarata*** rhizomes on reproductive competence of male rats has been investigated by Ratnasooriya *et al*[22].

Kaempferia galanga **Linn.** known as *Chandramula* in Hindi, is a small handsome herb found throughout the plains of India and cultivated for ornament and for its aromatic rhizome. The rhizomes are considered stimulating, expectorant, carminative and diuretic. They are used in the preparation of gargles. In Philippines, a decoction of the rhizome is used for dyspepsia, headache and malaria[11]. Cytotoxic principles in ***K. galanga*** have been isolated[23]. Ethanolic extract of the plant *in vivo* shows hypolipidemic action[24]. Recently the vasorelaxant effect of compound from the plant on smooth muscles of the rat aorta has been reported followed by its bioassay-guided isolation[25]. Very recently, a detailed study of the two species *Rajani* and *Kasthuri* of this plant has been published[26].

A study of nutritive values of the plants is likely to prove quite useful, particularly if supported by antimicrobial activities. In view of the developing awareness towards importance of balanced presence of various biologically important metals in our body, a study

towards the presence of such metals is also conducted for these plants in the present work.

Materials and Methods

Authenticated rhizomes of ***A. officinarum*** were procured from Kolkata whereas rhizomes of ***A. galanga*** and ***A. zerumbet*** were purchased from Dehra Dun. The rhizomes of ***A. calcarata*** were procured from Pantnagar, while those of ***K. galanga*** were procured from Central Plantation Crops Institute, Kerala, the authenticity further verified at Forest Research Institute, Dehra Dun. Specimen of materials have been deposited in the Herbarium of Plant Medicine Section of the Chemistry Department of Gurukula Kangri University under registry nos. 12/15, 11/15, 17/15, 19/15 and 15/15, respectively and are available for inspection. Plant materials were washed with lukewarm deionised water and dried in shade. The washed and dried materials were grinded to fine powder and used to prepare the samples for mineral analysis[27].

Analyses of materials for mineral and trace elements

In each case the powdered plant material was taken in a precleaned and constantly weighed silica crucible and heated in a muffle furnace to 400°C till there was no evolution of smoke. The crucible was cooled at room temperature in a desiccator and carbon-free ash was moistened with concentrated sulphuric acid, heated on a heating mantle till the fumes of sulphuric acid ceased to evolve. Crucible with sulphated ash was then heated in a muffle furnace at 600°C till the weight of the content was constant (~2 to 3h). One gram of sulphated ash obtained above was dissolved in 100 ml of 5% HCl to obtain the solution ready for determination of mineral elements through Atomic Absorption Spectroscopy (AAS). Standard solution of each element was prepared and calibration curves were drawn for each, using (Elmer Trans-3100) AAS.

Analyses of materials for nutritive value

For determination of nutritive value, the following parameters were studied by using the crushed plant material.

Determination of ash content was carried out by weighing 5.0 g of sample in each case in a silica crucible which had previously been heated to about 600°C and cooled. The crucible was heated first over a low flame till all the material was completely charred, followed by heating in a muffle furnace for about 3-5 h at 600°C. It was cooled in a desiccator and weighed. To ensure completion of ashing, the crucible was again heated in a muffle furnace for half an hour, cooled and weighed. The procedure was repeated till two consecutive weights were the same and the ash was almost white or greyish white. Weight of ash gave the ash content[28].

Usual method was adopted for determination of moisture content, 2.0 g of sample material was taken in each case in a flat bottom dish and kept overnight in an air oven at 100-110°C and weighed. The loss in weight gave the moisture content.

Crude fat was determined by extracting 20.0 g of moisture free sample in each case with petrol in a Soxhlet extractor, heating the flask on a sand bath for about 6 h till a drop taken from drippings left no greasy stain on filter paper. After boiling with petrol, the residual petrol was filtered using Whatman no. 40 filter paper and the filtrate was evaporated in a preweighed beaker. Increase in weight of beaker gave crude fat[29].

Crude protein was determined using micro Kjeldahl method. One gram oven dried material was placed in the digestion flask, 10 g of powdered potassium sulphate, 0.5 g of copper sulphate and 25 ml of conc. sulphuric acid were added to it and digestion conducted by placing the flask in an inclined position and heating it below the boiling point of acid for about 5-15 minutes. The temperature was raised until the acid boiled briskly. A funnel was placed in the mouth of the flask to restrict the circulation of air. Heating was continued till the solution became clear. The contents were cooled and diluted by adding 200 ml of water. 0.5 g of granulated zinc and 50 ml of 40% NaOH solution were added to make the reaction strongly alkaline. The contents were mixed and at once attached to the distillation apparatus. In the receiving flask 25 ml 0.1 N sulphuric acid was taken. When two-thirds of the liquid had been distilled, it was tested for completion of reaction. The flask was removed and titrated against 0.1 N caustic soda solution using methyl red indicator for determination of Kjeldahl nitrogen, which in turn gave the protein content.

Because of its importance, the crude fibre was determined to be reported along with the nutritive value. For determination of crude fibre, the estimation was based on treating the moisture and fat free material with 1.25% dilute acid, then with 1.25% alkali, thus

imitating the gastric and intestinal action in the process of digestion. 2.0 g of the moisture and fat free material was taken in a 400 ml beaker marked at 200 ml level. Added 200 ml of 1.25% H_2SO_4 and boiled for half an hour. After filtration and washing, the residue was treated with 200 ml of 1.25% caustic soda solution. It was filtered, washed with hot water and then 1% HNO_3 and again with hot water. Ignited the residue to get the ash, and weighed. The loss in weight gave the weight of crude fibre[34].

Percentage of carbohydrate was given by:

100 – (% ash + % moisture + % fat + % protein).

Nutritive value was finally determined by:

Nutritive value = (4 × % protein) + (9 × % fat) + (4 × % carbohydrate).

Antimicrobial activity

Four microorganisms, the Gram (+) *Staphylococcus aureus*, *Bacillus subtilis* and the Gram (–) *Escherichia coli* and *Pseudomonas aeruginosa,* were used to determine the antibacterial activity. The test pathogenic bacteria were maintained on nutrient agar medium slants at 4°C. The media culture tubes and other materials were autoclaved at 15 lb/in^2 for 15 minutes. Petridishes (90 mm diam.) were sterilized at 110°C for 24 hours. Study was carried out by filter paper disc diffusion method[31]. Extracted materials at 30% concentrations were used for the assay. A control run was conducted using 1% solution of Streptomycin/Ofloxacin. Results recorded are the averages of three replicates in each case.

Results and Discussion

Results of the presence of various mineral elements in studied plant materials are given in Table 1, while the results of nutritive values are given in Table 2, and also summarised in Fig. 1. Results of antimicrobial activity are given in Table 3.

Among the various biologically important metals, the percentage of chromium is lowest in all the studied materials except ***A. calcarata*** (0.24 to 0.76 ppm), but not low as compared to honey (0.29 ppm). Chromium plays a vital role in metabolism of carbohydrates and its deficiency leads to diabetes. Deficiency of chromium results in

Table 1 : Concentrations of various elements in ppm in rhizomes

Name of species	Cr	Mn	Fe	Ni	Cu	Zn	Mg	Ca	Na	K
Alpinia officinarum	0.680	72.30	85.50	21.02	0.753	9.331	569.5	438.8	152.8	3570
Alpinia galanga	0.283	12.44	17.23	0.328	0.485	6.038	968.0	348.3	31.80	1525
Alpinia zerumbet	0.242	9.491	54.80	0.140	1.872	1.660	575.2	681.0	285.9	2166
Alpinia calcarata	1.281	2.020	55.48	0.130	0.960	2.030	516.4	899.7	417.4	868.8
Kaempferia galanga	0.761	79.90	18.90	0.251	0.792	14.52	313.4	508.2	71.50	1375

Table 2 : Nutritive value of studied rhizomes

Name of species	Ash content (%)	Moisture content (%)	Crude fat (%)	Crude protein (%)	Carbohydrate (%)	Crude fibre (%)	Nutritive value (Cal/100 g)
Alpinia officinarum	3.22	12.4	2.26	5.25	76.9	17.0	348.9
Alpinia galanga	3.04	12.5	1.14	4.44	78.9	18.6	311.7
Alpinia zerumbet	7.21	9.11	2.01	5.64	76.0	8.60	344.6
Alpinia calcarata	2.4	14.5	1.68	6.39	75.0	7.25	340.8
Kaempferia galanga	3.42	11.0	1.70	7.88	76.0	9.00	350.9

Table 3 : Antimicrobial activity of the studied rhizomes (Concentration of solution = 30 %)

Name of species	Inhibition zone (mm)				
	S. aureus	*B. subtilis*	*E. coli*	*P. aeruginosa*	Standard
Alpinia officinarum	21±0.3	9±0.2	8±0.2	10±0.3	39
Alpinia galanga	20±0.8	11±0.3	18±0.4	9±0.3	27
Alpinia zerumbet	12±0.5	12±0.4	9±0.2	10±0.2	31
Alpinia calcarata	17±0.5	11±0.3	14±0.6	11±0.4	28
Kaempferia galanga	14±0.6	8±0.2	9±0.2	8±0.2	28

Each value represents the mean of three replicates ± SE. Standard was 1% solution of Streptomycin in the case of ***A. officinarum***, ***A. galanga*** and ***K. galanga*** and 1% solution of Ofloxacin in the case of ***A. zerumbet*** and ***A. calcarata***.

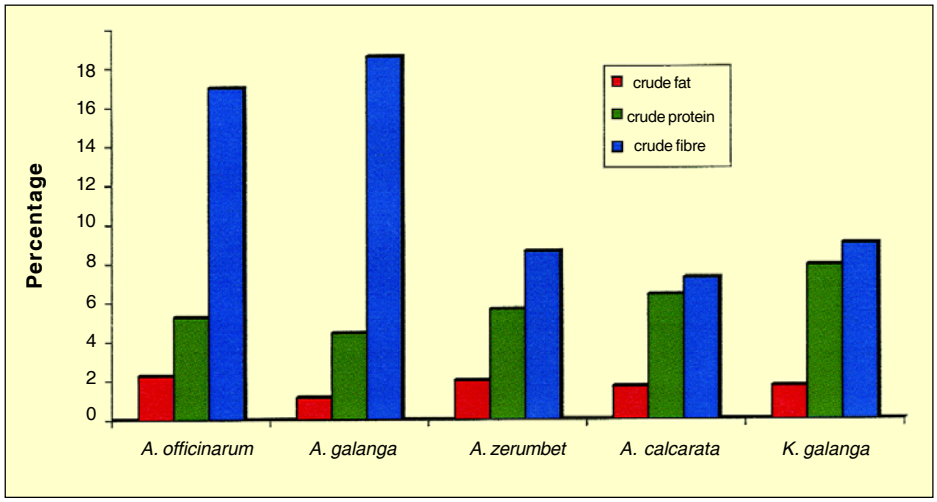


Fig. 1: Percentages of crude protein, crude fat and crude fibre

hyperglycaemia, growth failure, cataract and atherosclerosis[32]. Manganese is quite low in ***A. calcarata*** (2.02 ppm) but moderate in other species (4.56 to 79.9 ppm). Mn is essential for haemoglobin formation, but excess is harmful. Iron is sufficient in all the five studied materials. Importance of iron is well known. Nickel is high in rhizomes of ***A. officinarum***. It is an active metal in several hydrogenases and plant ureases. Chicks and rats raised on deficient Ni diet show impaired liver function and morphology[33]. Copper is quite low (0.48 to 2.16 ppm) in all the studied materials. Cu is a component of many enzyme systems such as cytochrome oxidase, lysyl oxidase and ceruloplasmin, an iron-oxidizing enzyme in blood[34]. The observation of anaemia in Cu deficiency may probably be related to its role in facilitating iron absorption and in the incorporation of iron into haemoglobin. Percentage of zinc is moderate (1.66 to 14.5 ppm). Zn is a component of many metalloenzymes, including some enzymes which play a central role in nucleic acid metabolism[35]. In addition, Zn is a membrane stabilizer and a stimulator of the immune response. Its deficiency leads to impaired growth and malnutrition. Magnesium and Calcium are required in sufficient quantity by human body and in all the five studied materials they are sufficient. Mg has electrochemical and enzyme activating functions[33]. Mg is required in the plasma and extracellular fluid, where it helps to maintain osmotic equilibrium. It is required in many enzyme-catalysed reactions, especially those in which nucleotides participate where the reactive species is the magnesium salt, e.g. $MgATP^{2-}$. Lack of Mg is associated with abnormal irritability of muscle and convulsions and excess Mg is associated with depression of the central nervous system. Ca is highest in ***A. calcarata*** rhizomes. Ca constitutes a large proportion of the bone, human blood and extracellular fluid; it is necessary for the normal functioning of cardiac muscles, blood coagulation and milk clotting, and the regulation of cell permeability. It also plays an important part in nerve-impulse transmission and in

the mechanism of neuromuscular system. Sodium and Potassium take part in ionic balance of the human body and maintain tissue excitability. Because of the solubility of salts, Na plays an important role in the transport of metabolites. K is of importance as a diuretic. Both are in suitable amounts in all the studied materials except ***A. calcarata*** where Na is comparatively high and K is low.

The nutritive value of all the five studied materials is very good (311.7 to 350.9 Cal/100g). The crude protein is maximum in the rhizome of ***K. galanga***. Crude fibre is low in ***A. calcarata*** rhizomes. Though no study of rhizome has been done earlier, Yeoh and Wong[36] have reported good nutritive value and high protein content in the leaves of ***K. galanga***.

All the studied materials have a good to moderate activity towards the growth inhibition of all the four pathogens taken.

Conclusions

Alpinia galanga, A. zerumbet, ***A. officinarum*** and ***A. calcarata*** rhizomes seem to be the balanced ones. A low fat and high protein diet supplement is ***Kaempferia galanga*** rhizome.

Results of antimicrobial study of these materials against certain Gram (+) and Gram (–) human pathogens indicate good to moderate inhibition. It further recommends the possible edible use of these materials.

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