

PRODUCTION OF ORGANIC SALT FROM MARSH BARBEL (*HYGROPHILA AURICULATA*) IN GAMBELLA TOWN, SOUTH-WEST ETHIOPIA.

Gatluak Deng Rang

gatluakrangdit@gmail.com

Gambella University

Pul Deng Lul

Gambella University

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Abstract

Organic salt derived from Hygrophila auriculata presents a new alternative to traditional salt because of its potential health advantages. Researchers conducted an extraction and chemical analysis of organic salt obtained from Hygrophila auriculata specimens gathered in Gambella town, Southwest Ethiopia. After drying the plant specimens they were burned to ash which was then dissolved filtered and crystallized to produce organic salt. Atomic absorption spectrophotometry analysis showed that the organic salt contained significant potassium levels between 1.4 and 2.6 mg/l, calcium levels between 1.2 and 1.9 mg/l, magnesium levels between 0.02 and 0.4 mg/l, and sodium levels between 1.3 and 2.0 mg/l. Researchers found organic salt presented a greater potassium-to-sodium ratio than standard table salt which positions it as a healthier substitute to decrease hypertension risks. The salt demonstrated alkaline pH characteristics which could play a role in its potential health advantages. The study results emphasize the value of Hygrophila auriculata as a natural source of mineral-rich salt which provides a sustainable and health-friendly substitute for standard table salt.

1. INTRODUCTION

1.1 Background of the Study

Hygrophila auriculata is an annual thorny, upright herb that can grow up to 1.5 meters in height, typically with unbranched stems featuring thick nodes. Its leaves are sub-sessile, and the plant is characterized by yellowish-brown spines in the axils, with flowers ranging in color from purple to blue. It belongs to the Acanthaceae family and is widely distributed in tropical and subtropical regions, often found along freshwater bodies or stagnant water sources (Nadkarni, 1978; Chauhan & Dixit, 2010).

For centuries, indigenous communities have developed specific knowledge regarding plant use, management, and conservation (Tilahun Tolossa, 2018). Organic materials play a significant role in cultural practices, medicine, and nutrition worldwide (Belayneh et al., 2014). The growing demand for organic products, particularly plant-based foods and medicines, highlights the importance of secondary metabolites as sources of medicinal agents (Okoli *et al.*, 2009). Research continues to explore new plant-derived drugs with novel therapeutic properties (Charles *et al.*, 2011).

Medicinal plants are globally recognized as valuable sources of new drugs (WHO, 2002). In Europe, over 1,300 medicinal plants are used, with 90% harvested from wild sources. Similarly, in the United States, 118 out of the top 150 prescription drugs originate from natural sources (WHO, 2006). In developing countries, approximately 80% of the population relies on herbal medicine for primary healthcare, and more than 25% of prescribed medicines in developed nations are derived from wild plant species (Yeneayehu *et al.*, 2017).

Hygrophila auriculata holds significant potential for food production and medicinal applications. Traditionally, its leaves, roots, and seeds have been used to treat inflammation, jaundice, hepatic obstruction, urinary infections, edema, gout, diabetes, and bacterial infections (Sunita & Abhishek, 2008).

The demand for plant-based medicines, health products, food supplements, and cosmetics is increasing globally due to their perceived safety, minimal side effects, and affordability. *Hygrophila auriculata* is among the plants with promising potential for organic salt production. Historically, indigenous communities have used organic salts in economic activities before the advent of colonization. Between 1950 and 1987, Porteres documented 158 plant species used in organic salt preparation. However, with the introduction of cheaper industrially produced inorganic salts (NaCl) from salt mines, traditional organic salt production declined (Alexander, 1989).

Organic salts continue to be used in traditional rituals and religious practices. In Central African countries like Chad, organic salts are still produced and consumed for dietary and therapeutic purposes. They serve as alternatives to inorganic salts, particularly for treating atrophic gastritis, jaundice, hypertension, and cough (Allameidji, 2011). However, traditional organic salt production methods are time-consuming and yield low quantities, with little known about their chemical composition. Modernizing this process to enhance yield and determine its chemical properties could provide an alternative to industrial salt, which primarily consists of sodium chloride (Mbaiguinam *et al.*, 2012).

This study aims to prepare organic salt from *Hygrophila auriculata*, analyze its chemical composition, and evaluate its medicinal applications.

1.2 Problem Statement

The excessive consumption of inorganic sodium chloride (NaCl) poses a significant public health threat, associated with elevated rates of cardiovascular diseases, hypertension, and related conditions (Wardener & MacGregor, 2002). Nevertheless the well-documented risks, global NaCl consumption persists at alarming levels due to its widespread availability, accessibility, and established preference. According to epidemiological evidence, hypertension attributed to excessive NaCl intake is a leading cause of mortality, exemplified by approximately 25,000 annual deaths in France alone. Consequently, innovative solutions are required to mitigate these health risks (Alderman *et al.*, 1998). Furthermore, the loss of indigenous knowledge related to organic salt production compounds this issue. Historically, organic salt production played a pivotal role in economically and nutritionally sustainable practices within African communities. However, the widespread adoption of mass-produced inorganic salts has resulted in the erosion of these traditional practices, which offered a healthier alternative. Revitalizing organic salt production methods and integrating them with contemporary technology provides a unique opportunity to address the growing health crisis. By harnessing traditional knowledge, it is possible to develop safer and more sustainable dietary alternatives, thereby reducing the incidence of salt-related diseases and promoting public health on a broader scale.

1.3 Significance of the Study

The production of organic salts is crucial for reducing the consumption of sodium chloride (NaCl) and mitigating related health risks. This study holds significance for several reasons, It provides an alternative to inorganic salts, particularly benefiting individuals with health conditions caused by high sodium chloride intake. It supports global efforts to reduce inorganic salt consumption in food products.

It offers a practical solution to overcoming the challenge of salt addiction by introducing an organic alternative. It informs policymakers on strategies to promote the reduction of NaCl consumption through dietary guidelines and regulations. The study contributes valuable knowledge to academic institutions and the scientific community.

1.4 Aim and Objectives of study

1.4.1 General Objective: The general objective of this study is to produce organic salt from *Hygrophila auriculata* and determine its chemical composition in Gambella town.

1.4.2 Specific Objectives

- To prepare organic salt from *Hygrophila auriculata*.
- To determine the chemical composition of the organic salt.
- To compare the Physico-chemical characteristics of organic salt with NaCl.

1.5 Scope and Limitations of the Study

This study focuses on the production of salt from *Hygrophila auriculata* and its medicinal applications. The research is limited to Gambella town due to the availability of *Hygrophila auriculata* in the area. However, several challenges were encountered, including limited access to transportation, lack of laboratory equipment, insufficient research funding, and other logistical constraints.

2. LITERATURE REVIEW

2.1 *Hygrophila auriculata*

Many applications have been proposed to explain what motivated human to uses and study *Hygrophila auriculata*. Many researchers explained wide varieties of the uses of the plant but this literature review will focus on ethno-medicinal uses of *Hygrophila auriculata*, pharmacological effect, phytochemical contents, antimicrobial activities and its traditional uses for organic salt production.

2.2.1. Traditional uses and pharmacological effects of *Hygrophila auriculata*

2.2.1 Ethno-medicinal uses of *Hygrophila auriculata*

The traditional, folklore and ethno medicinal studies shown that the seeds, roots ,stems, leave ,aerial part of plant whole plants and the ashes of *Hygrophila auriculata* were utilized to cure various human health issues and prevent certain diseases like allergy, anemia, arthritis, hypertension, body pain, cancers, constipation, cough, diarrhea, dysentery, edema, malaria, tuberculosis ,urogenital disorder and venereal diseases (Patra *et al.*,2009, Hussain *et al.*,2010, Chauhan and Dixit,2010,Dash *et al.*,2012).

The indigenous people use different parts of the plant to treat various health problems. The seed of the plant has been used for the treatment of venereal disease and diarrhea (Srivastava et al., 2012, Mall and Tripathi, 2016).

The powder extracted from the roots of the plant has been used also to cure the cancer, body pain, dropsy, tuberculosis and urogenital complains (Adhikari et al., 2010). This shows that *Hygrophila auriculata* is potential medicinal herb with multifunctional. The vindhya tribe of India region use the leaves of the plant to cure the tuberculosis and other related ailments respiratory system diseases generally for the cough (Ayyanara and Ignacimuthu, 2011).

The same study was reported from the other province like Rampal, Bangladesh, the powdered extract from the whole plant was used for the treatment of gastro-intestinal (GIT) diseases like dysentery, diarrhea, colic, acidity, constipation, bloating, lack of appetite and stomachache (Behera et al., 2010).

In similar to current study, the powder and ashes obtained from *Hygrophila auriculata* has been used for the treatment of diuretic, hepatitis obstruction and dissolution of gall stones, kidney dysfunctions and urogenital tract disease (Behera et al., 2010).

2.2.2 Pharmacological uses of *Hygrophila auriculata*

Based on the pharmacological activities of the plant, a different therapeutic activity has been reported from *Hygrophila auriculata*. The plant has analgesic effect, anti-motility, anti-bacteria effect and anti-helminthic effect (Patra, 2008).

Different studies have been conducted both invitro and invivo that reported toxicity, anti-microbial and nepro-protective effect of *Hygrophila auriculata* which shown the effectiveness of the plant extract. The petroleum ether extract, methanol extract of the leaves, stems and roots of the *Hygrophila auriculata* inhibited the *Bacillus subtilis*, *candida albicans* and *staphylococcus aureus* has been reported by Boily and Van in 1986 and cited by (Neeraj et al., 2018).

The aqueous leaves extract of the plant also has been successfully demonstrated to have inhibitory activities against all pathogens (Doss and Anand, 2013). In the same tract, methanol extracted from the *Hygrophila auriculata* has been used as anti-cancer. The mechanism action of the plant's extract is due to its anti-proliferation activities as it has capacities to break tumor cell communication by inhibiting Acetyl cholinesterase (AChE) and Lipoxxygenases (LOX) enzyme expression inhibited tumor growth and increased body weight (Mazumbar et al., 1997 cited by Neeraj, 2018).

The *Hygrophila auriculata* has found to have significant increase in accumulation of glycogen (liver and muscle) and tri acyl glycerol (adipose tissues) and had no effect on intestinal glucose absorption (Fernando et al., 1998 cited by Neeraj et al., 2018). This shows that the plant has anti-diabetic activities by enhancing insulin secretion and anti-toxicant action (Muthulingam, 2010).

The petroleum ether, chloroform, ethanol and aqueous extract of the *Hygrophila auriculata* leaves have been used for anti-helminthic activities (Arjunet al., 2008).

2.2.3 Phyto-chemical of the *Hygrophila auriculata*

Based the study conducted *Hygrophila auriculata* has been investigated and found to have various metabolites and others chemical components such as flavonoids, alkaloids, triterpenes such as flavonoids, alkaloids, aliphatics esters, sterols, minerals, amino acids ,fatty acids and essential oils (Mandal *et al.*,2010).

2.2.4 Traditional uses of *Hygrophila auriculata* for salt production

A vegetable salts (organic salts) have been produced and consumed by many peoples from Oceania, central Africa and America. Different people have been produced organic salts for century. In eastern highlands of the papua New Guinea, where the consumption and trade of potassium salts of organic origin has been widely spreader among Anga-speaking group. The Anga salt was the most renowned that Baruya, which has served as sort of money and exchanged over great distances. The Baruya salt was obtained from the cultivated *Coix gigantean* and its preparation require sophisticated technique carried out by specialist, Tsaimaye (Godelier, 1969, 1986, Lemmonier, 1984, cited by Neeraj *et al.*, 2018).

Buang also prepare fine salt from the same plant with similar technique (Hooley and Terit, 1972 cited by Neeraj *et al.*, 2018). A number of report of organic salt having been produced in south and central America (Echeveri *et al.*, 2001, cited by Neeraj *et al.*, 2018), but chemical analysis of the salts are scarce (Schmeda-Hirschmann, 1994 cited by Neeraj *et al.*, 2018). A well study was conducted to produce organic salts from 57 different plant species and chemical analysis of 49 species of the resulting salt by Witoto Indians of north-west Amazonia (Echeveni *et al.*, 2011).

The techniques used by witoto for organic salts preparation are basically similar to those reported in other part of the world .This salts are made by burning plants material from selective species, lixiviating the ashes through the uses of filter, and dehydrating the result brine to obtain dry salts. Even though different studies has been conducted, there are others to prepare salts from selective species which can be used for the treatment of diseases and will be uses as option to help those people suffering from certain diseases caused certain kind of diseases caused by sodium chloride consumption which is inorganic salt. The techniques that will be used in this study will have slight different from the previous because the study will use current technological equipment to prepare salts from plan origin.

2.2.5 Antimicrobial Activities of *Hygrophila auriculata*

Hyrophila auriculata is one of the multifunctional medicinal herbs which can be used for different medical proposes. Methanol extract of *Hygrophila auriculata* leaves has antimicrobial activity against certain bacteria like *Bacillus subtilis*, *candida albicans*, *mycobacteria smegmatis* and *staphylococcus auresus*, *Enterobacter aerogenes*,*Burkholderia pseudonallei* (Boily and Van Puyvelde 1987 ,Samy,2005).

Subsequently, in another study alcohol and chloroform extracts of leaves of the plant were reported to possess significant antibacterial activity against *Escherichia coli*, *S. Aureus*, *Bacillus subtilis* and *Pseudomonas aeruginosa* (Arjun *et al.*,2008).

Aqueous leave extract can Inhibit growth of *B. Cereus*, *S. Aureus*, *S. Pneumonia*, *E. Coli*, *P. Aeruginosa*, *K. Pneumonia*, *Salmonella typhi*, *Proteus vulgaris*, *Shigella flexneri*, *Aspergillus niger* and *C. Albicans* (Doss and Anand ,2013). Then, the diethyl ether, Petroleum ether, chloroform and n-butane extract was tested against pathogens such as *S. Epidermidis*, *E. Coli*, *Corneybacterium spp.*, *Vibrio Cholerae*, *E. Fecalis*, *S. Typi*, *V. Cholerae*, *C. Albicans* and, *A. Niger*. However, inhibitory activity was found Against *S. Epidermidis* and *C. Albicans* (Hussain and Kumaresan, 2013). This shown that *Hygrophila auriculata* is multifunction medicinal herbs.

3. MATERIALS AND METHODS

3.1 Description of Study area

The study was conducted in Gambella region, which is located in south-West Ethiopia. The region is bordered on the south by Southern nation, Nationality and People Republic (SNNPR), on the west by South Sudan, on the North and East by Oromia Region. Its distance to Addis Ababa is 766Km. The land mass of the region has an estimated area of 29,782.82 KM². The Altitude of Gambella region ranges from 1,000 to 2,000 m above mean sea level in the east, to 500–900 m in the center, and 300 to 500 m in the west reflecting a progressive decline from east to west. Mean annual rainfall is about 1200mm and some falls throughout the year, but with 85% between May and October. Mean annual temperature is 26.7°C (Degife *et al.*, 2019)

3.2 Study design and period

The experimental design was used to conduct processes of the study. Data were collected from March to May, 2022. The study used both quantitative and qualitative data. The test samples were taken from the *Hygrophila auriculata* from the swarm areas around Baro River for production of organic salts and minerals analysis.

3.3 Data sources and Methods of Collection

3.3.1 Collection of plant specimens and Procedures of salt preparation

The samples of *Hygrophila auriculata* were collected to prepare organic salt for this study. The plants were collected at Gambella town around swarm's areas where it grown in March, 2022. After the collection of *Hygrophila auriculata* it was dried at high temperature for two weeks. The plant specimens were burned in to ashes after it was dried. After burning of plant specimens in to ashes, 100gram of ashes from *Hygrophila auriculata* were put in to the basin and dissolved at 500ml of distilled water. The

solutions were mixed and keep at room temperature for one (1) hour and fifteen (15) minutes. The solutions were filtrated through sifter, and then the filtrate were placed in an oven at 100C° until it was crystallized, then the organic salt (ashes salt) were formed. In addition, to the plant, already prepared ashes salt from *Hygrophila auriculata* was collected from the open market in Gambella town. The prepared salt samples were packed in polyethylene plastics bags and transported to laboratory for determination of chemical contents.

3.3.2 Salt extraction method

The salt was extracted by following the method used by Mianpeurem, (2012). This salt preparing method was adapted from the indigenous ash salt processing method but there was some variation. Collected plant samples were burned in broken pots and 100g of ashes was dissolved in 500ml distilled water. The solution was mixed well and keeps at room temperature for 1:15 minutes. The solution was passed through filter and the filtrate was placed in dry oven (model 105, industrial estate, ambala cantt-india) at 105 degree Celsius until it crystallizes. The crystallized salt was collected from the oven; sun dried and keeps at room temperature until it was analyzed.

3.3.3 Determination of minerals composition in Organic (vegetable) salt

The mineral contents of the Organic (vegetable) salt were determined by atomic absorption spectrophotometer (AAS) (AA320N Wincom Shangia). The analysis was carried out following the AOAC method as described by (Keyata *et al.*, 2021) with some variation. 0.5g of organic (ashes) was dissolved using 36.5 ml of HCL and 11.5 ml of NHO3. The samples were heated on hotplate and the solutions were diluted to 100 ml with deionized water. Then the filtrate of each sample was used for determination of mineral contents by atomic absorption spectrophotometer using acetylene as source of energy for atomization. The technique was used to quantified the macronutrients (sodium, calcium, magnesium, and potassium)

Table 1
Parameters of atomic absorption spectrophotometer instrument

Metal	WL (nm)	SW (nm)	RSP	AV	Flame	Current(mA)	Unit	D2
Calcium	422.7	0.2	1.5s	3n	AIR-C2H2	15.0	Mg/L	OFF
Sodium	589.0	0.2	1.5s	3n	AIR-C2H2	10.0	Mg/L	ON
Potassium	766.5	0.2	1.5s	3n	AIR-C2H2	10.0	Mg/L	ON
Magnesium	285.2	0.2	1.5s	3n	AIR-C2H2	10.0	Mg/L	OFF

WL = wavelength, SW = Slit Width, RSP = repetitive spark pair, D2 = Deuterium lamp, mA = mega ampere.

3.3.5 Data analysis and Interpretation

Data were analyzed using SPSS version 26 and results were presented in the form of tables. The minerals were subjected to analysis of variance (ANOVA) at 5% confidence interval and the result was presented as mean $\pm$ standard deviation. The Pearson correlation test was carried out to determine the relationship of the minerals.

4. RESULT AND DISCUSSION

4.1 Amount of Organic Salt Produced from *Hygrophila auriculata*

Table 1
Yield of Organic Salt from *Hygrophila auriculata*

Plant Species	Weight of the Produced Salt (g)
<i>Hygrophila auriculata</i>	51.2g

The extraction process from *Hygrophila auriculata* resulted in a total yield of 51.2 grams (0.0512 kg) of organic salt. This significant yield indicates the plant's potential as a source of organic salt, showcasing its viability for production purposes.

While there are limited studies on organic salt extraction and its chemical composition for direct comparison, a relevant study conducted in Chad provides some insights. This study reported the elemental composition of three plant species: maize (*Zea mays*), sorghum stem (*Sorghum bicolor*), and papaya false trunks (*Carica papaya*). All these species exhibited lower salt yields compared to *Hygrophila auriculata*, which produced a notably higher yield of 34%. This finding aligns with traditional practices in Chad, where *Hygrophila auriculata* is utilized for vegetable salt production (Mianperen *et al.*, 2012). Additionally, another study highlighted *Hygrophila spinosa* as a prominent plant species for vegetable salt production across several African countries (Escheveni & Roman-Jitudutjaano, 2011).

4.2 Mineral Composition Analysis of *Hygrophila auriculata* Salt

Table 2
Mineral Composition Analysis of *Hygrophila auriculata* Salt

Salt Type	Ca(mg/l)	Na (mg/l)	Mg(mg/l)	I(Mg/l)	K (mg/l)
Organic salt	1.6 ± 0.2 ^c	1.4 ± 0.3 ^b	0.11 ± 0 ^d	12 ± 0.5	1.8 ± 0.4 ^b
	1.5 ± 0.2 ^d	1.3 ± 0.1 ^b	0.2 ± 0.1 ^c	11 ± 0.3	2.2 ± 0.1 ^a
	1.2 ± 0.0 ^f	1.3 ± 0.2 ^b	0.3 ± 0.2 ^b	9.02 ± 0.5	1.9 ± 0.3 ^b
	1.7 ± 0.2 ^b	1.2 ± 0.1 ^b	0.2 ± 0.2 ^c	12 ± 0.56	1.4 ± 0.3 ^b
	1.8 ± 0.4 ^a	1.5 ± 0.4 ^b	0.08 ± 0 ^e	12 ± 0.44	1.7 ± 0.5 ^b
	1.6 ± 0.1 ^c	1.6 ± 0.5 ^b	0.03 ± 0 ^e	12 ± 0.7	1.8 ± 0.5 ^b
	1.9 ± 0.7 ^a	1.5 ± 0.2 ^b	0.02 ± 0 ^e	11.02 ± 0.5	1.5 ± 0.1 ^b
	1.8 ± 0.1 ^a	1.6 ± 0 ^b	0.05 ± 0 ^e	12 ± 0.5	1.59 ± ^b
	1.7 ± 0.3 ^b	1.5 ± 0 ^b	0.13 ± 0 ^d	12 ± 0.5	1.6 ± 0.2 ^b
	1.5 ± 0.5 ^d	1.61 ± 0 ^b	0.07 ± 0 ^e	12 ± 0.56	1.8 ± 0.3 ^b
	1.4 ± 0.2 ^e	1.5 ± 0.1 ^b	0.05 ± 0 ^e	10.9 ± 0.4	2.6 ± 0.7 ^a
	1.2 ± 0.2 ^f	1.9 ± 0.3 ^b	0.06 ± ^e	12 ± 0.2	1.7 ± 0.7 ^b
	1.2 ± 0.5 ^f	2 ± 1.0 ^a	0.17 ± ^d	9.08 ± 0.6	2.1 ± 0.8 ^a
	1.2 ± 0.1 ^f	1.99 ± 0 ^b	0.4 ± 0.5 ^a	8.8 ± 0.8	1.7 ± 0.3 ^b
	1.3 ± 0.4 ^f	1.8 ± 0.4 ^b	0.04 ± 0 ^e	11.7 ± 0.5	1.8 ± 0.3 ^b
	1.2 ± 0.2 ^f	1.71 ± 0 ^b	0.09 ± 0 ^e	10.3 ± 0.5	1.6 ± 0.1 ^b
Mean	1.52	1.36	0.15	-	1.9
Min	1.15	0.66	0.02	-	1.4
Max	1.92	3.4	0.4	-	2.6
CV	16.8	28.3	94.6	-	21.3
Significance	**	***	NS	Ns	*
(*Significance levels: * ≤ 0.05, ** ≤ 0.01, *** < 0.01, NS = Non-significant, CV = Coefficient of Variation)					

Variance Analysis of Mineral Content

The variance analysis of the mineral composition in the salt extracted from *Hygrophila auriculata* revealed significant differences ($P \leq 0.05$) in the levels of potassium, sodium, and calcium. However, the differences in magnesium content were found to be non-significant ($P > 0.05$). The specific mineral content measured was as follows: Calcium (Ca): Ranged from 1.2 ± 0.0 mg/L to 1.9 ± 0.7 mg/L. Potassium (K): Varied from 1.4 ± 0.3 mg/L to 2.6 ± 0.7 mg/L. Magnesium (Mg): Ranged from 0.02 ± 0 mg/L to 0.4 ± 0.5 mg/L.

Minerals are essential for various metabolic activities, including bone formation and nerve impulse transmission. Calcium is particularly crucial for the formation of bones and teeth, as well as for muscle contraction (Avuwa *et al.*, 2022). The results indicate that the organic salt from *Hygrophila auriculata* contains significantly higher calcium levels compared to common salt, which has a calcium content of only 0.36 ± 0.00 mg/L (Table 3). This elevated calcium content suggests potential health benefits, such as supporting bone and dental health and possibly reducing the risks of cancer, diabetes, and hypertension (Abosede *et al.*, 2019).

Table 3

Chemical Composition of Common Salt (NaCl)

Salt Type	Ca (mg/L)	Na (mg/L)	Mg (mg/L)	I (mg/L)	K (mg/L)
Common Salt	$0.36 \pm 0.00^*$	$42.3 \pm 0.09^*$	$0.16 \pm 0.00^*$	57 ± 0.87	$0.21 \pm 0.00^*$

The magnesium content in this study aligns with findings from Kishor *et al.* (2021), but contradicts results from Sadiq *et al.* (2015), likely due to differences in methodology or environmental conditions.

The potassium content in *Hygrophila auriculata* salt ranged from 1.4 ± 0.3 mg/L to 2.6 ± 0.7 mg/L. Potassium is vital for maintaining body fluid volume, acid-electrolyte balance, and normal cell function. Insufficient potassium intake is linked to elevated blood pressure and hypertension, while increased dietary potassium can help lower blood pressure (Cappuccio *et al.*, 1991). The high potassium levels in organic salt, compared to common salt, emphasize its potential health benefits in managing hypertension and related conditions. The sodium content in *Hygrophila auriculata* salt ranged from 1.2 ± 0.1 mg/L to 2.0 ± 1.0 mg/L, which is significantly lower than the sodium concentration found in common salt. Excessive sodium intake is associated with hypertension and increased cardiovascular disease risk. Therefore, a diet rich in potassium and low in sodium is recommended for better health outcomes.

4.3 Ionic Composition and pH Analysis of *Hygrophila auriculata* Salt

4.3.1 Ionic Composition Comparison

The ionic composition of *Hygrophila auriculata* salt compared to common salt (NaCl) is presented in Table 4

Table 4
Ionic Composition of Common Salt (NaCl) vs. *Hygrophila auriculata* Salt

Salt Type	Carbonate (mg/L)	Chloride Ions (%)
Common Salt	0.38 ± 0.005*	60 ± 0.08*
Organic Salt	4.82 ± 0.002	11.25 ± 0.7

The analysis indicates that the anionic composition of *Hygrophila auriculata* salt has a significantly lower percentage of chloride ions compared to common salt, where chloride ions make up approximately 60% of NaCl (Nafees, 2013). This lower chloride ion content supports the argument that organic salt is a healthier alternative, potentially reducing the risks associated with high sodium chloride intake.

4.3.2 PH Analysis

The study also revealed a significant difference ($P < 0.05$) in the pH values between *Hygrophila auriculata* salt and common salt. The organic salt exhibited a significantly higher pH value, indicating its alkaline nature. Previous studies have reported that plant-derived salts typically possess strong alkaline properties, with pH values ranging from 11 to 14, while common salt (NaCl) is generally slightly acidic, with a pH around 6 (Binega, 2006).

The alkaline nature of *Hygrophila auriculata* salt may be attributed to the presence of potassium or sodium carbonate and hydroxides, which are key components of alkaline salts (Israel & Akan, 2016). This suggests that the organic salt obtained from *Hygrophila auriculata* has significant potential health benefits, including maintaining pH balance in the body and reducing acidity-related ailments.

Conclusion and Recommendations

This study investigated the yield and chemical composition of organic salt extracted from *Hygrophila auriculata*, comparing it to conventional common salt. The findings indicate that *Hygrophila auriculata* can produce a substantial amount of organic salt, suggesting its potential as a valuable plant species for salt production, especially in regions where traditional salt sources are limited. The key Findings of the study are: The organic salt derived from *Hygrophila auriculata* is rich in essential minerals, including calcium, potassium, magnesium, and sodium. Notably, it contains higher levels of potassium and calcium compared to common salt, while exhibiting lower sodium levels. This mineral profile may confer potential health benefits, particularly in the management of hypertension and enhancement of cardiovascular health. The pH analysis revealed that the organic salt is alkaline, in contrast to the slightly acidic nature of common salt. The alkaline properties of *Hygrophila auriculata* salt may play a role in maintaining a balanced pH in the human body, which is associated with improved metabolic functions.

Recommendations

Based on the study's findings, several recommendations are proposed:

- To Initiate Public Health Awareness campaigns to promote the use of *Hygrophila auriculata* salt as a healthier alternative to common salt, emphasizing its potential health benefits.
- To encourage health professionals to recommend this organic salt for individuals at risk of hypertension and cardiovascular diseases.
- To conduct additional studies to explore the long-term health impacts of consuming *Hygrophila auriculata* salt. Research should focus on the bioavailability of its minerals and their absorption rates in the human body.
- To develop large-scale production techniques to enhance the efficiency of salt extraction while preserving its beneficial mineral composition.
- To collaborate with the food industry to facilitate the introduction of organic salt into commercial markets as a healthier salt alternative.
- To investigate the effects of different soil types and environmental conditions on the yield of *Hygrophila auriculata* salt to optimize production.
- To Promote sustainable harvesting methods to ensure the continuous availability of *Hygrophila auriculata* without disrupting local ecosystems

Declarations

Clinical trial

- Not applicable'.

Ethics Consent to Participate

- Not applicable.

Author Contribution

Gatluak Deng Rang conceptualized the study, designed the methodology, and led the data collection and analysis. Pul Deng Lul contributed to the literature review and supported data interpretation. Gatluak Deng wrote the original manuscript draft. Both authors reviewed and edited the manuscript. so, Gatluak is the corresponding author and takes full responsibility for the content of the article.

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Data Availability

The data generated or analyzed in this study are not publicly accessible in order to protect participant confidentiality. However, they may be obtained from the corresponding author upon reasonable request.

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Figures



Figure 1

Photograph of *Hygrophila auriculata* plant

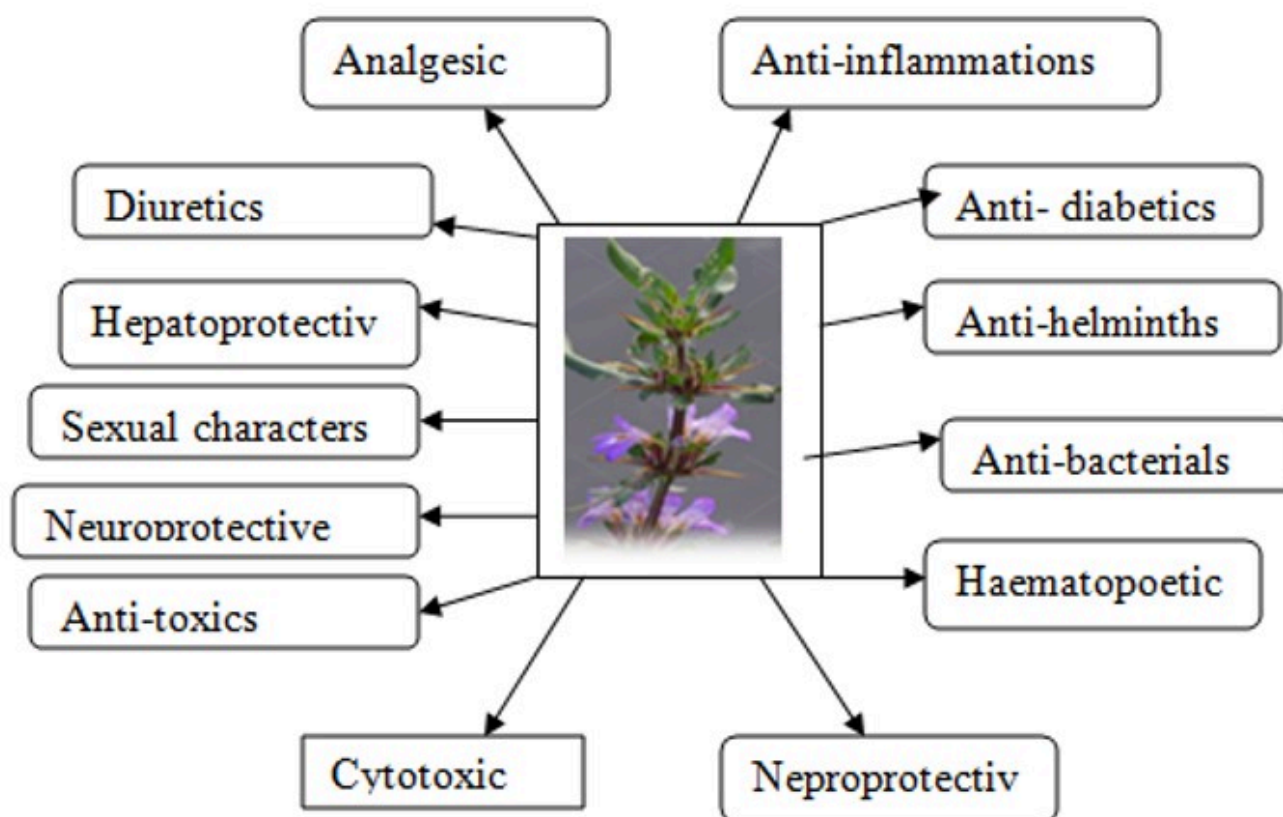


Figure 2

Therapeutic effect of *Hygrophila auriculata*

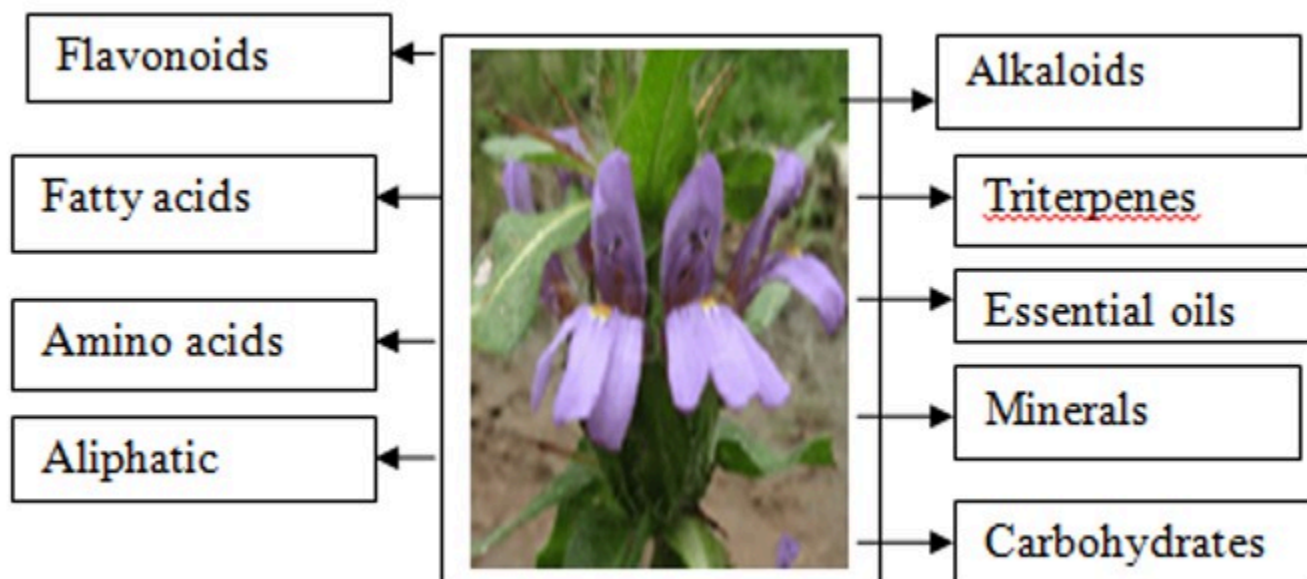


Figure 3

Phytochemicals contents of *Hygrophila auriculata*

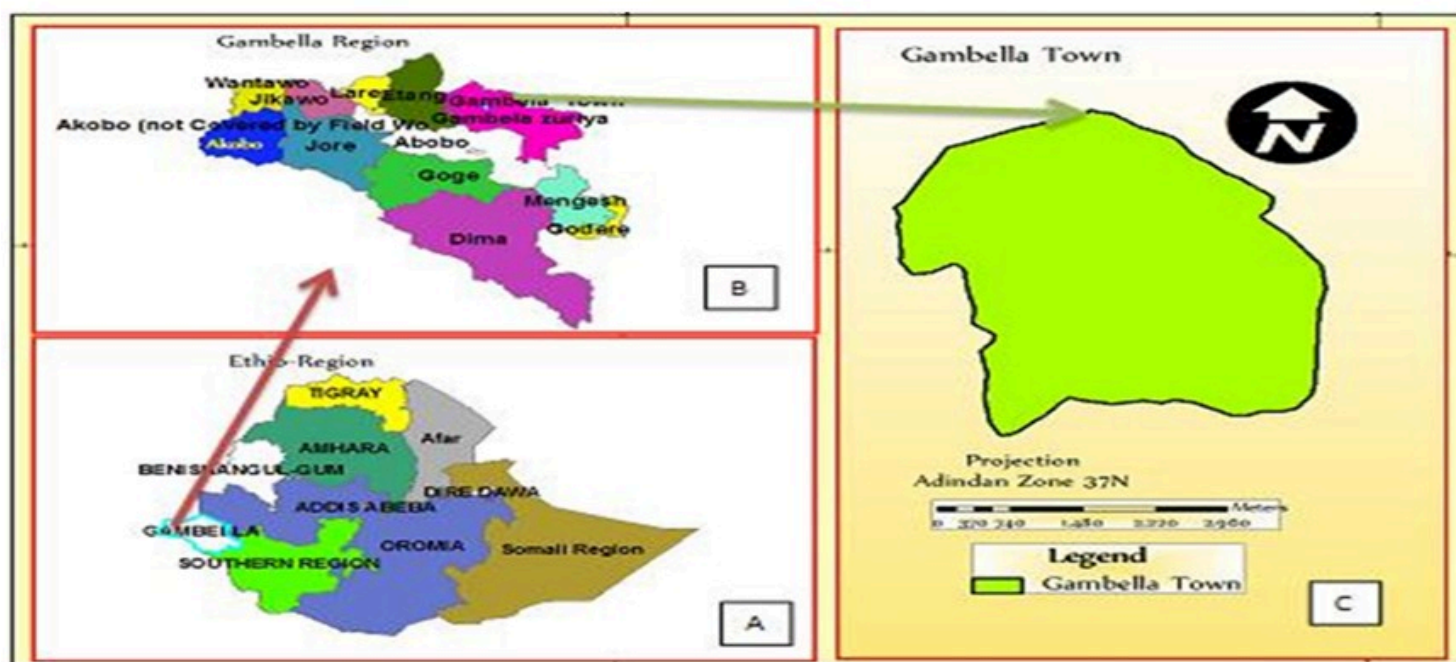


Figure 4

Map of Gambella town

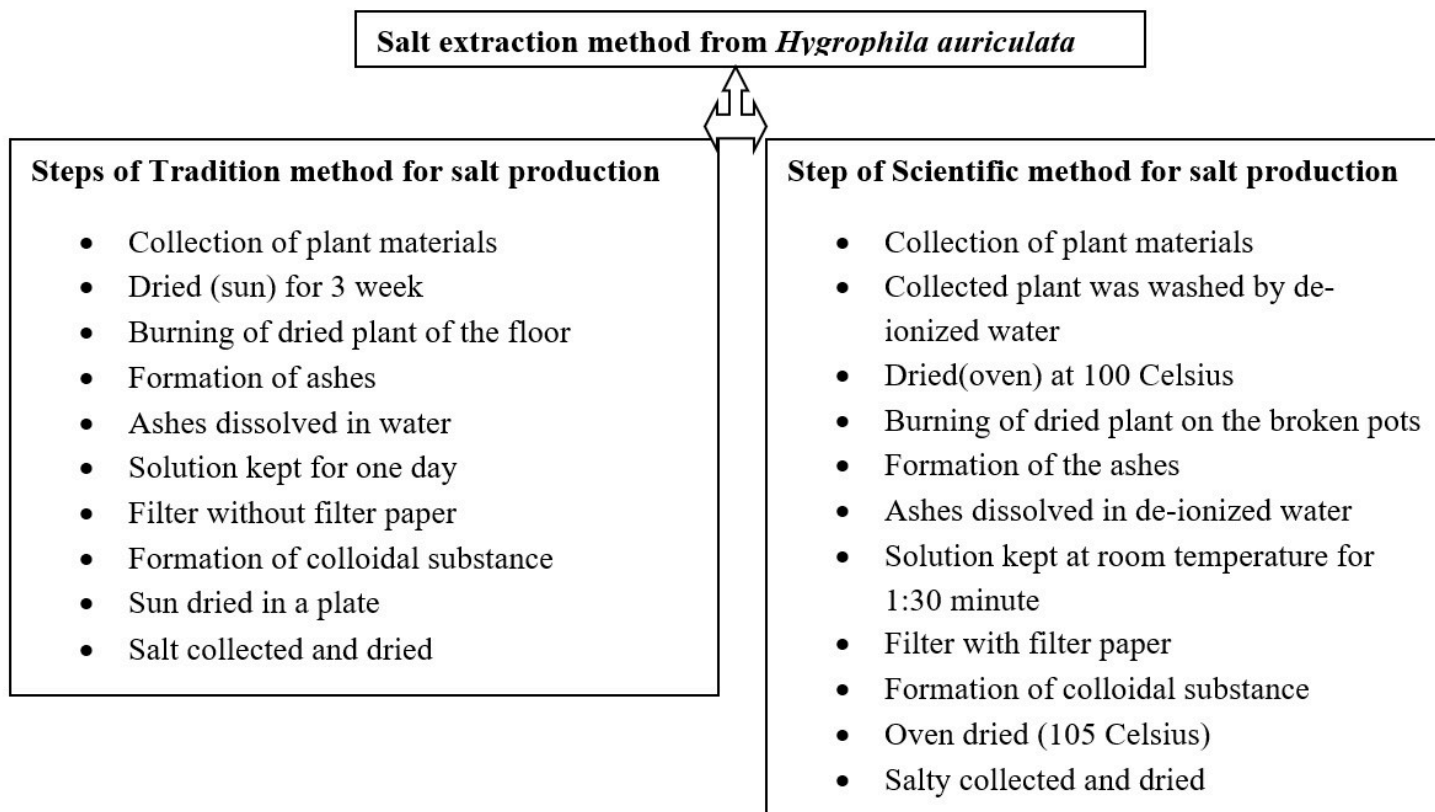


Figure 5

Traditional and scientific method of organic salt preparation (from Indigenous system)

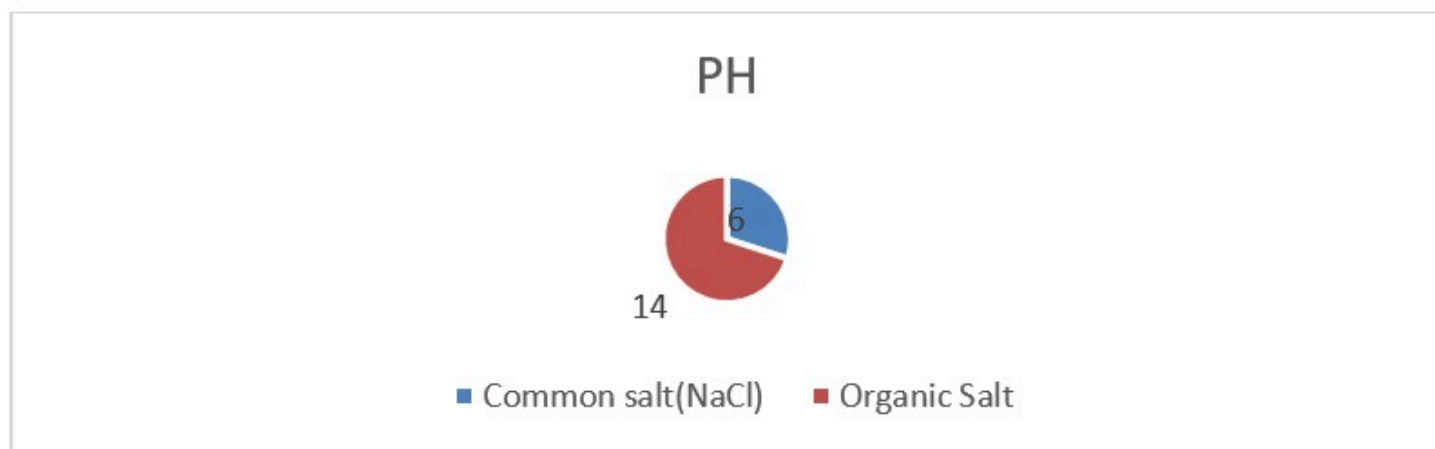


Figure 6

Figure 1: pH Value of Common Salt vs. Organic Salt

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