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RESEARCH ARTICLE

# CHEMICAL ANALYSES OF SALT SUBSTITUTES DERIVED FROM *PHELO* AND ITS ROLE IN THE HEALTH CARE SYSTEM OF THE LOCAL INDIGENES OF *KARBI* TRIBE

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**ABSTRACT**

**Background**: Today salt is the most desired and routinely added major food ingredient. The taste of salt or saltiness is universally accepted by human society since time immemorial. The *Karbi* tribehas been observed using a liquid condiment locally known as *Phelo* as salt substitute since time immemorial. But at present, it is observed that the extraction practice of *Phelo* is vanishing from this region because of the replacement of these local condiments with the commercially available refined salts and soda powder. Therefore the present study was an attempt to help uncover the forgotten salt resources and highlight their therapeutic potentialities. **Methods**: Extraction of *Phelo* was done by the traditional method adopted by the local indigenes. Derivation of salt substitutes was done by an evaporation method. And the chemical analyses were performed according to the methods established in Indian standard: Specification of edible common salt (1985). **Results**: It was observed that *Musa balbisiana, Carica papaya, Brassica nigra, Dendrocalamus hamiltonii,* and *Sesamum indicum* were the five plants used for extraction of *Phelo* by the *Karbi* tribe. The observed Physico-chemical values and minerals estimated from the derived salt substitutes showed varied differences. **Conclusion**: Today many man-made harmful food ingredients and food additives causing many deleterious health issues are the main cause of concern among the people, so the present study will provide a new herbal salt substitute with up-to-date nutritional information which is very natural and safe for human consumption.



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# INTRODUCTION

Salt is probably the first and the oldest condiment discovered by humans and it is also the most commonly used food additive by present-day human civilizations. The taste of salt (saltiness) is one of the basic human tastes sensations and it is the most essential commodity in our daily cooking (Neog, 2013). The right amount of salt is very much needful for our body to perform its metabolic activities. Salt, a very useful trade commodity has been the subject of interest since its discovery and inception to humans (Gopalakrishnan, 2015). Depending on its availability, people from different regions since ancient times uses several different types of salt or salt-like additives derived from different sources for cooking. These include refined commercial (table) salt (NaCl), crude plants or plant parts (Tara, 2016; Ohstsuka, 1987). It is observed that salts of plant origin are the main source of salt (NaCl) in some regions of the world where salt (NaCl) is unavailable. In India, the *Karbi* tribe, a major ethnic group residing in the majority in the hilly district of Karbi Anglong of state Assam since time immemorial has been extracting a liquid condiment as salt-substitute to fulfil their salt requirement from five different plants namely *Musa balbisiana* (peels), *Carica papaya* (stems), *Brassica nigra* (whole individual plants after harvest), *Dendrocalamus hamiltonii* (stems) and *Sesamum indicum* (whole individual plants after harvest). The locally extracted condiment is known as *Phelo* in the region. *Phelo* is obtained by burning the mentioned plant to ash and then filtering it, the filtrate obtained is then called *Phelo* and is used as salt to supplement their salt requirement or as an additive for alkaline cooking by the *Karbis*.

It is highly alkaline in nature and salty in taste. Cuisines cooked with *Phelo* are locally known as *Kangmoi-han* and are one of the most desired cuisines among the *Karbis* and the other friendly indigenous groups in the region. The local indigenes consider *Kangnoi-han* as a very nutritious and healthy diet and they also believed that regular consumption of *Kangmoi-han* helps relievecertain stomach problems. The main reason for the *Karbi* group of people enjoying such unique salt extraction practice is the physical features of their land accompanied by their confined to the region. The taste of *Phelo* is culturally preferred in the region and Karbi Anglong *Phelo* is ever-present in the diet of the local people. But in the present-day modern culinary heritage of the *Karbi* tribe, it is observed that the practice of using *Phelo* as a saltsubstitute is only limited to the people living in rural areas where bio-resources are rich and market supplies are not organized. The main reasons for its loss from the urban areas are that people in urban areas mainly depend more on ready-to-use soda powder for alkaline cooking and its salt requirement is fulfilled by the commercially available common salts.

The other reasons include lack of nutritional data on these salt-alike traditional condiments or compounds, *Phelo*, and also the preparation of *Phelo* is time-consuming and cannot be stored in liquid form for a longer period resulting in the vanishing of this age-old traditional knowledge of salt extraction. To date, no scientific reports have been reported about *Phelo* from the region although it is the most used condiment by the locals in their exotic culinary preparation and also in many therapeutic purposes. Therefore this paper is an attempt to transform these liquid salt-substitutes derived as *Phelo* to a solid form by the traditional method of evaporation and analyze its salt properties. This report may help to revive the long-forgotten salt resources and provide us with a piece of up-to-date scientific information regarding the elemental compositions of the extracted salt-substitutes and will help the present day modern society get a natural ingredient, with many therapeutic potentialities as today most of the people prefer for naturalness in food and food ingredients.

# MATERIALS AND METHODS

**Preparation of Phelo and derivation of salt-substitutes by an evaporation method:** Before extraction of *Phelo* the ash of the named plants *Musa balbisiana*, *Carica papaya*, *Brassica nigra*, *Dendrocalamus hamiltonii,*and *Sesamum indicum* were collected from different localities of Karbi Anglong district according to their availability and brought from the field to the laboratory with the help of local people in five different zip-lock plastic bags which were marked by plant names accordingly from which they were ashes. Then one by one each ash sample were transferred into five different *Phelo-bisir* (a conical shaped like bamboo crafted traditional tool used by the locals for sieving *Phelo*)and freshwater was added from above, when water leach through the ash and escaped at the bottom it was collected in bottles, which was called *Phelo*. The five different *Phelo* samples extracted were then evaporated to dryness in five different porcelain crucibles with a traditional sand-bath method and allowed to cool. The white crystalline solid mass obtained was the salt-substitutes. The saltsubstitutes were then collected in an airtight container, marked, and stored at room temperature for chemical analyses.

**Physicochemical analysis of salt-substitutes:** The physicochemical analyses were done according to the methods described in the Indian standard: Specification for edible common salt (Third edition) (IS 253, 1985)

**Determination of moisture content**: About 20g of the sample was weighed and dried in an oven at $150^0$C for four hours. Then cooled in a desiccator and weighed. The process of drying, cooling, and weighing was repeated until a constant mass was obtained. It was calculated as follows:

$$\text{Moisture \%} = \frac{M1 - M2}{M1} \times 100$$

Where,
M1 = Initial mass in gram
M2 = Final mass in gram

**Total alkalinity**: About 4.4g of sample was weighed and dissolved in 100ml of freshly boiled and cooled water in a conical flask and 5 drops of methyl orange and 50ml of standard hydrochloric acid (1N) was added to it. The content was then stirred thoroughly and was titrated with standard hydrochloric acid (0.1N) until the colour changed from orange to red. It was calculated as follows:

$$\text{Total alkalinity (as NaHCo}_3\text{), \% by mass} = \frac{8.4VN}{M}$$

Where,

V = Volume in ml of standard hydrochloric acid (1N) required for titration
N = Normality of standard hydrochloric acid used
M = Mass in g of the sample

**Particle size**: About 100g of sample was taken and sieved. The sample retained at 1mm sieve was calculated as follows:

$$\text{Passing \%} = \frac{\text{Total weight of sample passed}}{\text{Total weight of sample retained}} \times 100$$

**Matter insoluble and matter soluble in water**: For matter insoluble, about 20g of the sample was dissolved in 200ml of water and then boiled and cooled. After cooling the solution was filtered through a weighed gooch crucible and washed the residue till it was free from soluble salts. The crucible was then dried with the insoluble residue to constant mass. It was calculated as follows:

$$\text{Matter insoluble in water \%} = \frac{M1}{M2} \times 100$$

Where,

M1= Mass in g of the residue
M2= Mass in g of the sample taken
Matter soluble was calculated by subtracting from 100 the matter insoluble in water.

**Determination of sodium chloride (NaCl) and potassium chloride (KCl): Sample preparation**: About 20g of dried sample was dissolved in 200ml of water in a beaker and was heated to boiling and cooled. The solution was then filtered through a weighed gooch crucible and the residue was washed till it was free from soluble salts.

The filtrate was collected in a one-litre-graduated flask and diluted to the mark and was used for estimation of sodium chloride NaCl and potassium chloride (KCl). For NaCl, from the prepared filtrate solution about 10ml was transferred into a conical flask and 1ml of potassium chromate indicator solution was added and was titrated against standard silver nitrate solution till the reddish-brown tinge persist after shaking. It was calculated as follows:

$$\text{Sodium Chloride (as NaCl) \%} = \frac{VN}{M} \times 584.5$$

Where,

V = volume in ml of silver nitrate used in titration
N = normality of standard silver nitrate solution
M = mass in gram of the dried sample in 1000ml of the solution taken

For KCl, estimation, about 50ml of the solution was transferred to a 100ml conical flask, and 3ml of concentrated hydrochloric acid was added to the solution. The mixture was then placed in an ice bath for 5 to 10 minutes. When the solution was cooled 20ml of previously cooled sodium tetra phenyl boron solution was added and again kept for cooling for 5 to 10 minutes. After cooling it was filtered using a gooch crucible and dried for about 1 hour at $120^0$C, then cooled in a desiccator and weighed. It was calculated as follows:

$$\text{Potassium (as K) \%} = \frac{M1}{M2} \times 218.20$$

Where,

M1 = mass in gram of the precipitate
M2 = mass in gram of the prepared sample taken in 1000ml
Then, potassium (as KCl) was obtained by multiplying the value of potassium obtained by a factor 1.906.

**Sulfate content**: About 20g of the salt sample was dissolved in 400ml of water in a beaker. The solution was then filtered. One drop of methyl orange and 10ml of dilute hydrochloric acid was added to the filtrate and was then boiled. Then 12ml of barium chloride was added drop by drop to the boiling and was continued to boil for 4 minutes till a granular precipitate was obtained. The mixture solution was then allowed to stand for 4 hours and filtered through a Gooch crucible. The crucible was dried to constant mass at $110^0$C and weighed. It was calculated as follows:

$$\text{Sulphate (as } SO_4\text{) \%} = \frac{M1}{M2} \times 41.13$$

Where, M1= mass in g of barium sulphate
M2= mass in g of sample taken

**Elemental analysis of the salt-substitutes:** Estimation of Calcium (Ca), Magnesium (Mg), Lead (Pb), Iron (Fe), Arsenic (As), and Aluminium (Al): The estimation of Ca, Mg, Pb, Fe, As, and Al was done by Flame Atomic Absorption Spectrophotometric method.

**Sample preparation for Flame Atomic Absorption Spectrophotometric:** 1g of each sample was digested with 6ml of triacid [Conc. $HNO_3$ + Conc. $H_2SO_4$ + Conc. HCl (4:2:1)] and evaporated to near dryness. It was then cooled at room temperature, dissolved in distilled water, and then filtered. The filtrate was then transferred to a 50ml volumetric flask and the volume was made up to the mark with distilled water. The solution thus prepared was used for the estimation of the elements by the AAS method (6).

**Iodine content**: Iodine content was estimated by the Iodometric titration method. About 10g of the salt sample was dissolved in 50ml double distilled water then 1ml of sulphuric acid (2N) and 5ml of 10% potassium iodide were added to the solution which in presence of iodine will turn yellow. The reaction mixture was then kept in a dark place for 10 minutes and was then titrated with sodium thiosulphate (0.005N) using 2ml of starch as an indicator.

$$\text{Iodine \%} = \frac{\text{Titration volume(ml)} \times 21 * 15 \times \text{normality of sodium thiosulphate} * 1000}{\text{salt sample weight (gm)}}$$

# RESULTS AND DISCUSSION

It was observed that *Musa balbisiana, Carica papaya, Brassica nigra, Dendrocalamus hamiltonii,*and *Sesamum indicum* were the five plants used for extraction of *Phelo* by the *Karbi* tribe and the results of chemical analyses of salt-substitutes derived from *Phelo* showed significant differences in their physicochemical and elemental compositions. Table 1 represents the physicochemical values of the derived herbal saltsubstitutes. The moisture content ranged from 2.91-10.36% (w/w). The highest value was observed in *Brassica nigra* and the lowest in *Musa balbisiana*. The FSSAI standard for moisture content for common edible salt is a maximum of 6%. In our estimation, we found that moisture contents of salt-substitutes derived from *Musa balbisiana* (2.91%), *Dendrocalamus hamiltonii* (4.69%) and *Sesamum indicum* (3.62%) was in harmony with the FSSAI standard whereas the moisture content of salt-substitutes derived from *Carica papaya* (9.29%)and *Brassica nigra* (10.36%) exceeds the FSSAI standard value for common salt. Moisture content generally refers to the water present in a product and a low value of moisture content is always preferred for food additives and food-grade salts. The less value of moisture content means that the salt is free-flowing, remains in crystal form without forming a lump, and has the longest shelf life. The alkalinity of salt-substitutes ranges from 30.09-61.78% (w/w). The highest alkalinity value was recorded in *Brassica nigra* and the lowest in *Musa balbisiana.*

The results of alkalinity values of salt-substitutes is an indicator that they are highly alkaline and can be a good replacer of food-grade soda powder available for markets. Today for many researcher benefits from alkalies or alkaline products is one of the newer trends in health research. They believe that consumption of an alkaline product within a permissible range helps slow down the aging process in humans, helps regulate the pH of the human body, and prevents various chronic diseases. The matter insoluble and matter soluble range from 0.15-3.90% (w/w) and 96.10-99.85% (w/w). According to FSS regulation and Indian standards, the water-insoluble matter in salt should not be more than 1.0% by weight on a dry basis. Among the five derived salt-substitute, *Musa balbisiana* (0.54)and *Carica papaya* (0.15) were within the specified limit. Whereas *Brassica nigra* (1.72), *Dendrocalamus hamiltonii* (1.23),and *Sesamum indicum* (3.90) were not within the specified limit by FSSAI.

**Table 1**. **Enumeration of the determined physicochemical values of the five salt-substitute derived from Phelo**

| Parameters | *Musa balbisiana* | *Carica papaya* | *Brassica nigra* | *Dendrocalamus hamiltonii* | *Sesamum indicum* |
|---|---|---|---|---|---|
| | % (w/w) | | | | |
| Moisture | 2.91 | 9.29 | 10.36 | 4.69 | 3.62 |
| Alkalinity | 61.78 | 37.98 | 30.09 | 47.34 | 42.29 |
| Matter in-soluble in water | 0.54 | 0.15 | 1.72 | 1.23 | 3.90 |
| Matter soluble in water | 99.46 | 99.85 | 98.28 | 98.77 | 96.10 |
| Particle size | - | 0.86 | 0.68 | 0.98 | 0.72 |
| Sulphates | 18.14 | 28.01 | 38.90 | 29.58 | 24.47 |
| Sodium chloride | 13.07 | 11.45 | 7.34 | 10.61 | 7.04 |
| Potassium chloride | 5.90 | 11.39 | 10.19 | 11.24 | 9.30 |

**Table 2. Enumeration of mineral content estimated from the five different salt-substitute derived from Phelo**

| Elements | Name of the samples | | | | | Units |
|---|---|---|---|---|---|---|
| | *Musa balbisiana* | *Carica papaya* | *Brassica nigra* | *Dendrocalamus hamiltonii* | *Sesamum indicum* | |
| Calcium | 2.60 | 1.60 | 3.98 | 0.60 | 5.20 | ppm |
| Magnesium | 2.50 | 1.90 | 2.42 | 0.50 | 11.50 | ppm |
| Lead | 7.93 | 12.89 | 13.95 | 18.55 | 15.35 | ppm |
| Iron | 12.60 | 33.86 | 38.43 | 15.83 | 33.92 | ppm |
| Arsenic | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | ppm |
| Potassium | 3.10 | 5.98 | 5.35 | 5.90 | 4.88 | ppm |
| Aluminium | 1.05 | 1.20 | 1.01 | 0.92 | 1.03 | ppm |
| Iodine | <50 | 169.10 | 253.70 | 126.80 | 124.60 | ppm |

Since the processing and derivation of salt-substitute are done by simple traditional methods, the presence of a higher concentration of insoluble matter may be due to exposure and settling down of dust particles while during the process of evaporation or could be from sand particles from equipment during production. The particle size of four salt-substitutes was of significant range (*Carica papaya*- 0.86%, *Brassica nigra*- 0.68%, *Dendrocalamus hamiltonii*- 0.98%, and *Sesamum indicum*- 0.72%) except *Musa balbisiana* which was not measurable at 1mm sieve. The sodium chloride (NaCl) content and potassium chloride (KCl) content of the derived salt substitute ranged from 7.04-13.07% w/w and 5.90-11.39% w/w. The highest sodium chloride (NaCl) content was observed in *Musa balbisiana* and the lowest was observed in *Sesamum indicum.* The highest potassium chloride (KCl) content was observed in *Carica papaya* and the lowest in *Musa balbisiana.* From our study, we found that sodium chloride (NaCl) content in *Musa balbisiana* and *Carica papaya* were higher than the potassium chloride (KCl) content, and hence they are more sodium salt than potassium salt. Whereas *Brassica nigra, Dendrocalamus hamiltonii,* and *sesamum indicum* were more potassium salt.

Today the people around the world are concerned about the health risks factors mainly high blood pressure problems associated with high intake of sodium chloride (NaCl). Hence higher dietary potassium may be an alternative solution for the health risks factors associated with sodium intake. Potassium chloride (KCl) may flavor on food at the same time lower the limit of sodium intake thus helping to lower blood pressure and other physiological anomalies connected with high sodium intake (Neog, 2013). The sulfate content of the derived salt-substituted was observed to be very high and ranged from 18.14-38.90% (w/w). The highest value of sulfate was observed in *Brassica nigra* and the lowest value in *Musa balbisiana.* The salt-substitutes derived from *Phelo* were observed to contain many essential elements required for different metabolic functions in the human body. Elemental compositions of the derived salt-substitutes are represented in Table 2.

The Calcium content in the salt-substitutes ranged from 0.60-5.20 ppm, the highest value estimated in *Sesamum indicum* and lowest in *Dendrocalamus hamiltonii,* and the magnesium content ranged from 0.50-11.50 ppm, the highest value observed in *Sesamun indicum* and lowest in *Dendrocalamus hamiltonii.* Iron content was observed to be range from 12.60-38.43 ppm, with the highest value observed in *Brassica nigra* and lowest in *Musa balbisiana.* The highest value of potassium was estimated in *Carica papaya* (5.98 ppm) and the lowest in *Musa balbisiana* (3.10 ppm). Aluminum was recorded highest in *Carica papaya* (1.20 ppm) and lowest in *Dendrocalamus hamiltonii* (0.92 ppm). The presence of calcium, magnesium, iron and aluminum in these salt-substitutes is an indicative property that these salt-substitutes can be used as a dietary salt rich in nutrients that humans need much for good metabolism. The heavy metal arsenic present in the saltsubstitutes was estimated in the lowest permissible limit. The arsenic content of all the five salt-substitutes was estimated below <0.05 ppm. On the other hand, the Lead content in salt substitutes was observed to exceed the maximum permissible limit by FSSAI (2.5 ppm). The maximum level of lead was observed in *Dendrocalamus hamiltonii* (18.55 ppm) and the minimum level in *Musa balbisiana* (7.93 ppm). Lead content was recorded highest in all the salt-substitutes sample, it may be because all the salt-substitutes derived was impure form. The lead content can be minimized by proper washing with water and recrystallization.

The salt-substitutes were observed to have a significant amount of iodine content which ranges from <50 ppm to 253.70 ppm with the highest iodine content estimated in *Brassica nigra* and lowest estimated in *Musa balbisiana.* Today there isan explosion of research papers and articles prioritizing iodine as an essential mineral which a body needs for its proper functioning. The main source of iodine required for our body is iodized salts available in the markets. Some of the important health benefits of iodine reported are it ensure proper thyroid function, is essential for proper brain development in babies, improved cognitive function in children, healthy birth weight, lower risk of goiters, treat fibrocystic breast disease, and treat thyroid cancer (Anjumani, 2020; Phanice, 2012; Gunnarsdottir, 2012; Farebrother, 2021; Pires, 2017). More than 2 billion people in the world today suffer from micronutrient deficiencies caused largely by a dietary deficiency of vitamins and minerals (Phanice, 2012). Hence the salt-substitutes derived from *Phelo* can be a major source of minerals to the present human civilizations.

**Role of Phelo in the healthcare of the local indigenes:** The *Karbi* tribe is known for its dependence upon forest and forest products for their survival. *Phelo* is one such natural product which the *Karbis* loves extracting for its multifunctional uses. *Phelo* is the most socially and culturally important major ingredient cherished by the local indigenes of the region. Its role in household cooking, in treating stomach problems as therapeutic agents, its uses in religious and cultural ceremonies, and also its role in the regional trade cannot be overemphasized. *Phelo* is one of the major ingredients that every *Karbi* household store-inside. In a *Karbi* diet, a dish cooked with *Phelo* is always considered the first dish. They believe cuisines cooked with *Phelo* as medicinal cuisines thathelp cure stomach disorders and keep the stomach clear and stimulate their body metabolism. It was observed that no religious ceremony or ritual in *Karbi* culture is complete without *Phelo.* A dish cooked with *Phelo* known as *Kangmoi-han* is ever-present in the menu of *Karbi* cuisines in every religious ceremony. It was also observed that *Phelo* is also used as a natural wound healer. The *Karbis* apply one or two drops of *Phelo* to a wound for its fast healing as antimicrobial agents. *Phelo* were also used as detergents for washing purposes by the *Karbis*. But today the use of *Phelo* is observed only in rural areas of the region. Before the introduction of salt and soda powder or before industrialization, *Phelo* also use to be a source of income for the *Karbis.* But today *Phelo*is found to be sold only in Karbi Youth festivals, or in zonal festivals in the districts. By creating awareness in regards to the potentialities of derived salt-substitutes could generate a source of income for the local indigenes in the region.

# CONCLUSION

This study is an attempt to popularize and bring out the positive aspects of a natural food additive called *Phelo*, both in its liquid form and derived-salt form, which the *Karbis* have been preserving as their traditional food additive since ancient times. The analysis results in the study support its potentialities as herbal saltsubstitutes. Further studies are recommended to investigate the possibility of the salt-substitutes to be used as therapeutic salts and measure the dosses or quantity limit about the salt-substitutes for their safe consumption.

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