VARIABILITY IN NUTRITIONAL CONTENT OF SOME UNDERUTILIZED EDIBLE AROIDS FOUND IN HILLY TERRAIN OF ASSAM STATE OF INDIA


Institutional Biotech Hub, Department of Biotechnology, Pandu College, Pandu, Guwahati, Assam, India.

ABSTRACT
Aroids are important root crop of the tropics grown for its edible corms. It plays a significant role in the livelihood of millions of relatively poor people in under developed countries. The corm is an excellent source of carbohydrate, protein, minerals and vitamins. The objective of the present study was to evaluate nutritional and nutraceutical properties, mineral and microelement content in certain underutilized edible aroid corms from Assam state of India. Nutritionally, all the variants were found to be rich in carbohydrate, protein, crude fibre and ascorbic acid. In C. esculenta (Tekala kochu) the Carbohydrate (25.0±0.34%), protein (4.39±0.1 %), fat (0.95±0.2 %) and flavanoid content (9.04±0.0 µgQE/mg) were found in higher amount. Thus, crude fibre (5.0±0.05%) and total mineral in the form of ash contents (7.3±0.05%) were found higher in C. esculenta (Bon kochu). Again, the ascorbic acid (112.87.02mg/100g dry weight) and total phenolic content (34.3±0.12µgGAElmg) found higher in X. violeceum (Krishna kochu). The micro-nutrient contents such as calcium (2.53µg/g) and zinc (0.74µg/g) found higher in X. sagittifolium (Radha kochu); Fe (1.05µg/g) found higher in A. macrorrhiza and followed by C. esculenta (Bon kochu) with an amount of0.68µg/g. For antioxidant activity, methanol extracts showed a positive correlation between contents like total phenolics, flavanoids and ascorbic acid; with the increase of these contents, the antioxidant activity of the of all the edible aroid samples taken for present study also increases. Among the investigated aroid variants, C. esculenta (Bon kochu) exhibits highest antioxidant activity (92.36±0.1 µg/g), having the potentiality to be used as food antioxidants.
KEYWORDS: Alocasia, Colocasia, Xanthosoma, Nutraceutical analysis, Assam

INTRODUCTION
Tuber and root crops are the energy reservoirs of nature mainly in the tropical regions. Due to the high starch content and calorie value, these crops have a major role in meeting the food security of marginal farmers and the ethnic people in the humid tropics (Peter, 2008). Aroids are herbaceous plants belong to the family araceae and most of the edible aroids belongs to the genera Colocasia, Alocasia, Xanthosoma and Amorphophallus. Since time immemorial, the ethnic groups from hilly terrains of North East India including Assam have been managing the tuber crops like aroids and yams during food scarcity. When the rice grain stock exhausts gradually, they starts mixing rice with the tubers as additional nutritional supplement. In addition to edible tubers, leaves and petioles of several aroid species are also used as vegetables (Medhi and Borthakur, 2011). Again, during such a scarce situation, the ethnic people collect many types of wild corms, roots and other tubers to supplement their merger food available at home (Vidyarthi, 1987).

Aroids are one of the few major staple foods where underground parts are important in the human diet (Lee, 1999). As such, it has attained considerable economic importance as a fresh crop in many developing countries (Hanson and Imamuddin, 1983). Edible corms of Colocasia esculenta (taro), Xanthosoma sagittifolium (tannia) X. violaceum (blue taro) constitutes one of the six most important root and tuber crops world-wide (Jennings, 1987) and essential food for millions of people. It is of particular significance for its fleshy corms and nutritious leaves, where it is a part of staple diet. Taro corms play an important role in the livelihood of millions of relatively poor people in less developed countries and are an excellent source of carbohydrate (Oke, 1990). Taro leaves contain higher levels of protein and are also excellent source of carotene, potassium, calcium, phosphorous, iron, riboflavin, thiamine, niacin, vitamin A, vitamin-C and dietary fibre (Bradbury and Holloway, 1988; Opara, 2001). Nutritionally, taro corms contain 63-85% water, 1.3-3.0% protein, 0.2-0.4% fat, 6.0% carbohydrates and appreciable quantities of Vitamins-C (15.34-61.72 mg/100 g). There was considerable variability in mineral composition of taro and they appeared to be good sources of potassium, calcium, iron, copper and manganese (Onwueme, 1994). Moreover, its edible corms and leaves are traditionally used to cure some ailments (Tuse et al., 2009).
Information regarding the chemical and nutritional content of Northeast Indian wild edible tubers, rhizomes, corms, roots and stems is meagre (Shantha kumara et al., 2008, Udensi et al., 2008). With this backdrop, an attempt has been made to understand the nutritional values of some edible aroids under the genus Alocasia, Colocasia and Xanthosoma from Assam State of India for its value addition of food resources.

MATERIALS AND METHODS

Study area: Assam comprises the Brahmaputra valley and the Barak valley along with the hill districts of Karbi Anglong and Dima Hasao with an area of 30,285 square miles (78,440 km²) and lies between 27°46’ N to 95°00’ E. The average annual rainfall is 1,717mm and the temperature ranging from 18° to 38°C with average humidity of 76.6%.

Sample description

Altogether seven Aroids were collected from different localities of Assam. Brief descriptions of the collected samples are as follows:

Alocasia macrorrhiza (L.)G.Don

Also known as Giant Taro or Elephant’s ear. The leaves are glossy medium green with paler veins. The larger more or less heart-shaped leaves with rather rounded basal lobes of Alocasia tend to point upward adding to its height, i.e. the angular divergence between the long petiole and the lamina is almost 180°. The thick cylindrical stem arises from a basal corm. Assamese vernacular name is ‘man kochu’.

Colocasia esculenta var. esculenta

This variety belongs to the dasheen type Taro, characterized by a large main corm with few cormels (2-4 nos.). In this type the sterile appendage of the spadix is short. It can be grown under a wide range of agro-climate, from flooded to rain fed upland condition in the tropics. The lamina is almost rounded in shape. The long leaf petiole attaches to the middle of the lamina i.e. peltate leaf. Three variants from different localities were collected for the present study. Assamese vernacular names of the collected variants are ‘konikochu, bon kochu and tekela kochu’.

Colocasia esculenta var. antiquorum

This variety belongs to the eddoe type Taro, mainly characterized by a small or medium corm which is either not edible or even if edible, is less preferred. The corm produces large
numbers of cormels (5-20 nos.). The sterile appendage of the spadix is larger than the male portion. Agro-climatically, this type is mainly grown in irrigated or rain fed upland condition of the tropical and sub-tropical regions. The lamina is almost rounded in shape. The long leaf petiole attaches to the middle of the lamina i.e. peltate leaf. Assamese vernacular name of the collected sample is ‘kola kochu’.

**Xanthosoma sagitifolium**

Xanthosoma commonly known as tannia or new cocoyam. Attachment of the petiole is at the point of notch which divides the lamina into two lobes and is called hastate or sagittate leaf. Leaves are generally dark green with white fleshy edible cormels. The main corm is thick to globose and surrounded by 5-10 lateral cormels. It is cultivated pantropically for edible tubers and cormels and is considered as a complex polymorphic species. Two variants from different localities were collected under cocoyam type for study. Assamese vernacular names are ‘dohi kochu and radha kochu’.

**Xanthosoma violaceum**

Also known as Xanthosoma nigrum (Vell.) Mansfield and generally distinguished by hastate or sagittate leaf with blue violet petiole and main veins. The main corm is thick to globose and surrounded by 5-10 lateral cormels. Tubers are white or yellow flesh coloured and edible but leaf petioles are mostly preferred. Assamese vernacular name is ‘krishna kochu’.

**Sample preparation**

Collected plant samples i.e. edible corms were washed thoroughly, sliced and air dried. The air dried samples were dried in hot air oven at 60°C till getting constant weight. Then the dried materials were turned into powdered form and stored at 4°C for further analysis.

**Methods of analysis**

phyto-chemical analysis was done on moisture free basis. Analysis was carried out to estimate the macro nutrient components viz. total protein, total carbohydrates and the micronutrient includes ascorbic acid and phenolic compounds of the samples.

**Total Protein Estimation**

The total protein content of the samples was estimated by the method developed by Lowry et al., (1951). Extraction was carried out with Tris-EDTA buffer (pH 7.5) used for the enzyme assay.
**Total Carbohydrate Estimation**

The total carbohydrate content of the samples was estimated by Anthrone method (Hedge et al., 1962).

**Crude Fibre Content**

Crude fibre in the samples was determined by the method described by Maynard et al (1970). Extracted fibre was expressed as percentage of the original undefatted sample and calculated according to the following formula:

\[
\text{% crude fiber in ground sample} = \frac{\text{Loss in weight on ignition (W1} - \text{W2)}}{\text{Weight of the sample}} \times 100
\]

**Total fat content**

The total fat content was determined by using Soxhlet apparatus and calculated by the help of the following formula. Accurately weight 1 g sample was taken into the thimble and placed in soxhlet extractor. Petroleum ether was used as solvent. Extraction processes was continuing up to 8 h. After that, remove the thimble from the extractor and allowed to dry, transfer the sample from thimble, weight and calculated.

Weight of sample (g) = W1  
Weight of sample after Soxhlet extraction (g) = W2  
Fat = \(\frac{(W1 - W2)}{W1} \times 100\)

**Ascorbic Acid Content Estimation**

The amounts of ascorbic acid present in the samples were calculated by using 2, 6- dichlorophenol indophenol dye (Sadasivam et al., 1987). Standard ascorbic acid solution is used as the reference and the calculation is done by the following formula:

\[
\text{Amount of ascorbic acid (mg/100gm) sample} = \frac{0.5 \times V2 \times 100ml}{V1 \times 5ml \times \text{Wt. of the sample}} \times 100
\]

Where, V1= volume of oxalic acid, V2= volume of the sample.

**Total Phenol Content Estimation**

The total phenol content was determined by the Folin-Ciocalteau’s method (Singleton V L and Rossi JA. 1965). Results were expressed as μg/mg (Gallic acid equivalent/dry weight) and the calculations were done by using the following formula:

\[
\text{TPC} = C \times \frac{V}{M}
\]
Where, TPC = total phenol content, C = concentration of Gallic acid (mg/ml), V = volume of plant extract (ml), M = weight of pure plant extract (g).

**Determination of Antioxidant activity**

The antioxidant activities of the herb extract along with standard were assessed on the basis of the radical scavenging effect of stable DPPH method as described by Nooman A. Khalaf, et al. (2008). The activities of the samples are measured in terms of percent inhibition (IC$_{50}$) and calculated by the following formulae

\[
\text{Percent (%)} \text{ inhibition of DPPH activity} = \frac{A - B}{A} \times 100
\]

Where, A = Optical density of the blank; B = Optical density of the sample

**Quantitative estimation of Flavonoid**

For quantitative estimation of flavonoid, spectroscopic analysis was done as method described by Kumar S. et al (2008). 0.5 ml extract (1mg/ml concentration) working solution, 1.5 ml of methanol, 0.1 ml Al$_2$Cl$_3$, 0.1 ml of potassium acetate solution and 2.8 ml of distilled water were added and mixed well. Sample blank was prepared in similar way by replacing sample with distilled water. Absorbance was taken in a UV-Vis spectrophotometer at 415 nm and the amount of flavonoid present was calculated by plotting the value in a standard curve of quercetine solution.

**Total Minerals content**

Mineral content in the form of ash were determined by gravimetric method. For this, 1 g of sample (W1) weighted and taken in a pre-weighted crucible tube. After that the tube was put in the muffle furnace at 570°C for 3 h and then cooled in desiccators and reweighed (W2). Total ash contents were calculated according to the formula:

\[
\text{Weight of sample before ignition (g)} = W_1
\]
\[
\text{Weight of sample after ignition (g)} = W_2
\]
\[
\% \text{ of total minerals} = \frac{W_1 - W_2}{W_1} \times 100
\]

**Micronutrients analysis**

Standard methodology as advocated by Jackson, M.L. 1958 and Brooks, R.R. 1986 was utilized for the digestion and complete analytical procedures for the determination of total metal concentration in dried sample powders.
Statistical Analysis
The data were subjected to statistical analysis. All the assays were recorded in triplicates and the values were expressed as mean ± S.D.

RESULTS AND DISCUSSIONS
The nutritional analysis were done for total protein content, carbohydrate, crude fibre content, fat content, ascorbic acid content, mineral content, total phenol content, flavonoid content and micro-nutrient content for A. macrorrhiza, four variants of C. esculenta (includes both Dasheen and Eddoe types), two variants of X. sagittifolium and X. violaceum. Moreover, antioxidant activity of the methanolic extract of various corms was performed using gallic acid and ascorbic acid as standard. The average values were calculated from triplicate observations. The findings of the present investigation are tabulated in the table-1.

From the present study, the following were the maximum and minimum values of the nutritional analysis.

**Total protein content** was recorded highest in C. esculenta (dasheen type-tekela kochu) with the value of 4.39 ±0.1% and the least value in X. Sagittifolium (Dahi kochu) is 2.42±0.097.

**Total carbohydrate content** were recorded highest value in C. esculenta (dasheen type-tekela kochu) was 25.0±0.34% and the lowest in X. sagittifolium (Radha kochu) was 23.95±0.27%.

**Total crude fibre** content was found highest in C. Esculenta (dasheen type-bon kochu), i.e. 5.0±0.5% and minimum in X. Violaceum (Krishna kochu) was 2.8±0.02%.

**Total fat content** found maximum in C. esculenta (dasheen type-tekela kochu) with the value of 0.95±0.2% and minimum recorded in X. violaceum (Krishna kochu), i.e. 0.37±0.2%.

Maximum amount of **total mineral content** found in C. esculenta (bon kochu), i.e. 7.3±0.05% and minimum in C. esculenta (koni kochu) with a value of 3.1 ± 0.026%.

**Total ascorbic acid** content was maximum in C. esculenta (dasheen type-tekela kochu), i.e. 114.2±1.10 mg/100g and least in C. esculenta (eddoe type- kola kochu), i.e. 74.1±1.0 mg/100g.
The highest and lowest amount of the **total phenol content** are found to be 34.9±0.12µgGAE/mg and 14.02±0.14µgGAE/mg for X. violaceum (Krishna kochu) and C. esculenta (dasheen type- koni kochu), respectively.

The highest and lowest amount of **antioxidant activity** (IC$_{50}$) of the observed samples were 194.72±1.4µg/ml and 92.26±0.10 (IC50) µg/ml for C. esculenta (dasheen type- koni kochu) and C. esculenta (dasheen type- bon kochu), respectively.

The highest and lowest amount of **total flavonoid content** of the observed samples were 9.04±0.03 µgQE/mg and 3.52±0.02µgQE/mg for C. Esculenta (dasheen type- tekela kochu) and X. Sagittifolium (radha kochu), respectively.

**Micro- nutrient** like zinc, calcium and iron were observed and found varying range from 0.03µg/g to 0.74µg/g for Zn, 0.09µg/g to 2.53µg/g for Ca and 0.16µg/g to 1.05µg/g for Fe. X. sagittifolium (radha kochu) recorded highest amount of Zn (0.74µg/g) and Ca (2.53µg/g), however, least in Fe (0.16µg/g) content. Fe content recorded highest in A. macrorrhiza was 1.05µg/g, followed by C. esculenta (dasheen type-bon kochu) with an amount of 0.68µg/g. However, C. esculenta (bon kochu) exhibited least in Zn (0.03µg/g) and Ca (0.09µg/g) content.

In the present investigation, C. esculenta (dasheen type-Tekela kochu) recorded highest as carbohydrate (25.0%), fat (0.95%), crude protein (4.39%) ascorbic acid (114.2 mg/100g) and flavanoid content (9.04µg).

Carbohydrate and fat for the present study was found higher than the result reported by Ndabikunze et al (2011) in species of C. esculenta as the value of carbohydrate (23.03%) and fat (0.44%). Chandra et al (2012) also reported about the total carbohydrate to be (26.98%), which is little higher than the present finding. Variation in the phyto-chemical contents of Taro corms might be related to their species origin, geographical sources or planting periods, season of harvest, the agronomic factors of the sampled varieties and soil quality (Bradbury and Holloway, 1988).

Nutritional composition of roots and tubers varies from place to place depending on the climate, the soil, the crop variety and other factors (FAO, 1990). The main nutrient supplied by taro, as with other roots and tubers, is dietary energy provided by the carbohydrates. Sefa-Dedeh and Agyir-Sackey(2002) reported that the nutritional composition of X. sagittifolium
and C. esculenta were that of total fat 0.28 to 0.97 g/100 g, ash 1.56 to 2.98 g/100g and crude fibre 1.11 to 3.00 g/100g, and have found low fat, ash and crude fibre content in X. sagittifolium. However, low levels of protein in taro limits its utilization in preparation of protein rich foods. This can be improved by combining taro with other high protein sources.

Consumption of micronutrient rich foods such as X. violaceum (blue taro) is important for building a strong immune system that helps the body to utilize protein, carbohydrates and other nutrients. Considering the mineral nutrient levels in the cocoyam varieties studied, it suggests that a daily diet of cocoyam has been found to be of high nutritive value whereby 100g cocoyam flour contained greater quantities of Mg and K than the daily requirements (Ndimantang et al., 2006). The values obtained for Ca and Zn in this study, X. sagittifolium, are appreciable and can be consumed for supplementing it with other food sources that are rich in other minerals.

The antioxidants present in natural food items are of great significance since they possess possible protective agents to help consumer by reducing oxidative damage. Many plants and plant products have been scientifically identified and validated as the source of natural antioxidants. Enzymes like Superoxide dismutase and catalase or compounds such as ascorbic acid, phenolic compounds, tocopherols, β-carotene, lycopene and glutathione, etc. (Halliwell and Gutteridge, 1999) act as antioxidant agent.

In present investigation, total phenolic content, ascorbic acid and flavanoid content were determined. C. esculanta (bon kochu) exhibit higher antioxidant activity 92.36±0.10 (IC$_{50}$ value) having ascorbic acid (97.7 mg/100g), phenol content (28.5µgGAE/mg) and flavanoid (8.81µgQE/mg). However, X. sagittifolium (radha kochu) and X violaceum (Krishna kochu) exhibits satisfactory scavenging effect and have good antioxidant activity as they have high total phenol and ascorbic acid content. Literature sources reveals that total phenolics and other natural products like vitamin C and carotenoids have been shown to possess various biological properties related to antioxidant mechanisms (Sarma et al., 2015; Prior et al., 1998; Wang et al., 1996; Luximon-Ramma et al., 2003). Yang et al., 2012 reported that total phenol contents of plant extract played major roles in the antioxidant activity. Thus in the present study the antioxidant potential of Colocasia, Xanthosoma variants may be attributed to the presence of flavonoids, phenolics, ascorbic acids and other constituents present them.
Table: 1: Nutraceutical analysis of the studied aroid samples.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Species (vernacular name)</th>
<th>Protein content (%)</th>
<th>Carbohydrate content (%)</th>
<th>Crude fibre content (%)</th>
<th>Total fat content (%)</th>
<th>Mineral content (%)</th>
<th>Ascorbic acid content (mg/100g)</th>
<th>Total phenol content (µgGAE/mg)</th>
<th>Antioxidant activity (IC&lt;sub&gt;50&lt;/sub&gt;) (µg/ml)</th>
<th>Flavonoid content (µgQE/mg)</th>
<th>Micronutrients (µg/g)</th>
<th>Zn</th>
<th>Ca</th>
<th>Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A. macrorrhiza (Man kochu)</td>
<td>3.73±0.31</td>
<td>24.11±0.37</td>
<td>3.09±0.02</td>
<td>0.80±0.17</td>
<td>4.37±0.31</td>
<td>78.23±0.64</td>
<td>21.14±0.03</td>
<td>142.71±0.97</td>
<td>4.34±0.23</td>
<td>0.7 ± 1 0.1 ± 4 1.0 ± 5</td>
<td></td>
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</tr>
<tr>
<td>2</td>
<td>C. esculenta (Koni kochu)</td>
<td>4.12±0.20</td>
<td>24.23±0.58</td>
<td>3.52±0.08</td>
<td>0.87±0.20</td>
<td>3.10±0.26</td>
<td>107.18±2.4</td>
<td>14.02±0.14</td>
<td>194.72±1.40</td>
<td>7.43±0.11</td>
<td>0.0 ± 8 0.8 ± 5 0.2 ± 0</td>
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<tr>
<td>3</td>
<td>C. esculenta (Bon kochu)</td>
<td>2.80±0.00</td>
<td>24.06±0.40</td>
<td>5.00±0.05</td>
<td>0.89±0.18</td>
<td>7.30±0.05</td>
<td>97.7±0.29</td>
<td>28.5±0.15</td>
<td>92.36±0.10</td>
<td>8.81±0.10</td>
<td>0.0 ± 3 0.0 ± 9 0.6 ± 8</td>
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<tr>
<td>4</td>
<td>C. esculenta (Tekela kochu)</td>
<td>4.39±0.10</td>
<td>25.00±0.34</td>
<td>3.50±0.10</td>
<td>0.95±0.20</td>
<td>5.10±0.02</td>
<td>114.2±1.10</td>
<td>24.39±0.12</td>
<td>119.04±0.99</td>
<td>9.04±0.03</td>
<td>0.1 ± 9 0.3 ± 8 0.2 ± 4</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>5</td>
<td>C. esculenta (Kola kochu)</td>
<td>3.50±0.20</td>
<td>24.10±0.24</td>
<td>3.00±0.10</td>
<td>0.90±0.12</td>
<td>4.20±0.01</td>
<td>74.10±1.00</td>
<td>18.3±0.20</td>
<td>116.82±0.23</td>
<td>8.13±0.02</td>
<td>0.0 ± 9 0.2 ± 7 0.3 ± 5</td>
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<td></td>
<td></td>
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<tr>
<td>6</td>
<td>X. sagittifolium (Dohi kochu)</td>
<td>2.42±0.09</td>
<td>24.67±0.71</td>
<td>3.00±0.20</td>
<td>0.92±0.16</td>
<td>5.03±0.15</td>
<td>90.92±1.40</td>
<td>30.67±2.08</td>
<td>132.29±1.15</td>
<td>6.15±0.16</td>
<td>0.1 ± 2 0.3 ± 1 0.2 ± 9</td>
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<tr>
<td>7</td>
<td>X. sagittifolium (Radha kochu)</td>
<td>2.82±0.02</td>
<td>23.95±0.27</td>
<td>3.50±0.02</td>
<td>0.72±0.02</td>
<td>5.50±0.01</td>
<td>105.25±0.02</td>
<td>32.1±0.12</td>
<td>98.57±0.02</td>
<td>3.52±0.02</td>
<td>0.7 ± 4 2.5 ± 3 0.1 ± 6</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>X. violaceum (Krishna kochu)</td>
<td>2.48±0.02</td>
<td>24.00±0.02</td>
<td>2.80±0.02</td>
<td>0.37±0.00</td>
<td>6.90±0.01</td>
<td>112.87±0.02</td>
<td>34.3±0.12</td>
<td>95.97±0.02</td>
<td>3.89±0.02</td>
<td>0.1 ± 4 0.3 ± 2 0.2 ± 7</td>
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</tbody>
</table>
CONCLUSION
The corn/cormels of edible aroid are essential in the traditionally delicacies of the ethnic people of North east India including Assam state. Those having the good nutritional properties and most of them are found to be a good source of protein, crude fibre, starch, vitamins and minerals too. Again, corms are good source of micronutrient like Ca, Fe and Zn and hence could be used as supplementary diet for food security. Moreover, the edible corms exhibit good antioxidant property.

ACKNOWLEDGEMENT
The authors are very much thankful to DBT, Govt. of India for providing Instrumentation facilities under Institutional Biotech hub and Principal, Pandu College for permission and necessary laboratory facilities.

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