

Root tuber of *Tacca leontopetaloides* L. (kunze) for food and nutritional security

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Abstract

Tacca leontopetaloides L. (Kunze) is a wild perennial herbaceous and underutilized tuber crop. This study was aimed at analyzing quantitatively the tuber starch of *T. leontopetaloides* L. (Kunze) collected in the wild from Angwan Zam and Ntuer in Shendam Local Government Area (L.G.A) of Plateau State Nigeria for the presence of nutritional and anti-nutritional components. The proximate composition, elemental analyses and phytochemical composition of the tuber starch carried out revealed the presence of moisture, 8.66%, crude protein, 6.79%, crude fibre, 5.44%, crude fat, 0.51%, ash, 0.41%, and NFE (total carbohydrate), 78.19%. The elemental analysis of *T. leontopetaloides* indicated presence of some trace elements including sodium, 34.71 mg/100 g, potassium, 40.18 mg/100 g, calcium, 0.25 mg/100 g, magnesium, 1.40 mg/100 g, iron, 1.37 mg/100 g, zinc, 1.64 mg/100 g, manganese, 0.72 mg/100 g, copper, 0.68 mg/100 g and phosphorus, 0.06 mg/100 g. The results of anti-nutrient composition of *T. leontopetaloides* revealed the presence of tannins, 2.50 mg/100 g, Phytate, 49.77 mg/100 g, oxalate, 15.51 mg/100 g, cyanide, 0.18 mg/100 g, alkaloids, 42.90 mg/100 g, saponins, 14.67 mg/100 g and flavonoids, 1.46 mg/100 g. It was observed that steeping in water for sometimes had effects on the concentration of the anti-nutritional components. This in effect presents the tuber crop a good candidate as food source for humans in a developing country like Nigeria.

Keywords: Proximate composition, Anti-nutritional, *Tacca leontopetaloides*, Root tuber, Phytochemical composition.

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Introduction

Root and tuber crops provide a substantial part of the world food supply and are also an important source of animal feed and industrial products. On a global basic, approximately 45% of root and tuber crop production is consumed as food, with the remainder used as animal feed or for industrial processing for products such as starch, distilled spirit, alcohol and fermented beverages including beer and a range of minor products [1].

Millions of people in many developing countries do not have enough food to meet their daily requirements and many more are deficient in one or more micronutrients. In many cases rural communities depend on wild resources including wild edible plants to meet their food needs in periods of food shortage [1].

The diversity in wild species offers variety in the diet and contributes to household food security. India hold rich genetic diversity in tropical root and tuber crops particularly aroids yams and several minor tuber crops.

Wild edible tuber species are an important source of food in India and other parts of the world and have a significant place in the dietary habits of small and marginal farm families and forest dwelling communities during periods of food scarcity [2]. An edible tuber not only enriches the diet of the people but also possesses medicinal properties. Many tropical tuber species are used in the preparation of stimulants, toning, carminatives and expectorants. These properties need to be

documented to validate, quantify and spread this valuable knowledge [3].

According to Aberoumand and Deokule [4] despite the fact that measures have being taken to boost food production by conventional agricultural activities, there is the need to exploit the vast number of unconventional plants resources that exist in the wild. Akubugwo et al. [5] reported that many of such plants have been identified but lack of data on their chemical composition has limited the prospects of their utilization. Proximate analysis of some wild fruits and seeds indicate that they could be good sources of nutrients for man and livestock [6]. The exploration of indigenous wild food plant is one of the measures that could be taken to avoid hunger and malnutrition. Studies have shown that most rural dwellers depend largely on some of these edible wild plants to meet up with shortages in nutrients like minerals, proteins, lipids, and vitamin A [7].

Apart from the nutritional content of these wild plants, some are known to contained high levels of anti-nutritional components which could be toxic to the body, hence acting as threat to the health and well-being of an individual when consumed. Therefore some knowledge of the nutritional status and the toxic levels of indigenous edible wild plants are imperative in order to encourage their cultivation and consumption [8].

Tacca leontopetaloides (L.) Kuntze is a species of flowering plant from the family Taccaceae. It is commonly known as Polynesian arrow-root (English) or Amura (Hausa) and is a

wild perennial herb. The plant originated from Malaysia and Pacific Islands [9], but is now distributed from western Africa through Southeast Asia to northern Australia. The tubers were known to be a staple foodstuff in Polynesia and also were used as a source of starch.

In Nigeria, the plant is more widely spread in the middle belt [10] and in the south western states. The plant still remains in the wild and is under-utilized in Nigeria. It is found in solitary forms on open fields or under the shade of trees or hill tops. In Plateau State, the tubers are found to be a delicacy to the people of Shendam, Langtang and other members of lower Plateau and are eaten especially when other staple foods are scarce. The tubers are believed to be poisonous and contain a bitter principle, Taccalin and toxic saponins [11]. Ruminants rapidly die as soon as they consume the peels of these tubers. Aside the nutritional content of this plant, it is believed to contain some levels of anti-nutrients which could be toxic to the human body, thereby acting as a threat to the health of an individual if taken. However, Caddick et al. [11] reported that the poisonous component of the tubers could be removed by soaking, washing and rinsing repeatedly in clean water before being processed for food.

Despite the fact that this tuberous crop is gaining acceptance among people of North Central of Nigeria, little or no information about the anti-nutritional composition of *T. leontopetaloides* plant is known. In addition, consumers may face the risk of toxicity due to improper processing.

The present study was then designed to evaluate the nutritional and anti-nutritional composition of *Tacca leontopetaloides* in order to ascertain its suitability for use as food to man.

Materials and Methods

Source of experimental root tubers

The freshly harvested wild Polynesian arrowroot, *Tacca leontopetaloides* tubers used for the experiments were obtained from Angwan Zam and Ntuer in Shendam local government area (L.G.A) Plateau State Nigeria in October 2014. These tuberous materials were collected randomly from the wild.

Preparation of the polynesian arrowroot starch samples

The method for cassava (*Manihot* sp) starch preparation of [12] was adopted with slight modification for the preparation of starch. These include manual peeling, washing (in clean water), cutting the tubers into small size and then homogenization using grinding machine, filtering using muslin cloth, sedimentation, decanting (of watery supernatant), sun drying to brittleness and milling (using millstone) to obtain powdered starch. About 300 g was the weight of the processed tuber. The powdered starch was stored in air tight containers until required for analysis.

Proximate composition analysis of the powdered starch

For the determination of the moisture content, crude protein, crude fibre, crude fat, ash, carbohydrate, standard analytical procedures for food analysis described by AOAC [13] was adopted.

Determination of moisture content

Weight of 2 g of the sample was put into crucibles, dried in an oven at 105°C to a constant weight. The percentage loss in weight was expressed as percentage moisture content on dry weight basis. This was repeated three times to obtain triplicate values.

Protein determination

Total protein content was determined by the Kjeldahl method. A weight of 500 mg of the sample was weighed in triplicate into a Kjeldahl flask, About 10 cm³ of concentrated H₂SO₄ was added, catalyst mixture (1 g) containing sodium sulphate (Na₂SO₄) copper sulphate (CuSO₄) and selenium oxide (SeO₂) in the ratio of 10:5:1 respectively was added to hasten the digestion. Pieces of granulated Zinc or anti-bump granules were added. The sample was then digested in a fume cupboard until the solution became colourless. Distillation was carried out with about 10 cm³ of 40% NaOH solution. The condenser tip was dipped into a conical flask containing 5 cm³ of 4% boric acid in a mixed indicator (containing 5 drops of bromo cresol green methyl red indicator solution) till the boric acid solution turned green. Titration was done in the receiver flask with 0.01 N HCl until the solution turned red. The percentage (%) protein was then calculated.

Determination of crude fibre

The estimation of the crude fibre was done by acid and alkaline digestion methods. Exactly 2 g of sample was defatted. The defatted sample was boiled in 200 ml of 1.25% Tetra Oxo Sulphate (VI) solution under reflux for 30 minutes. After that, the sample was washed with hot water, using a two-fold muslin cloth to trap the particles. The washed sample was transferred quantitatively back to the flask and boiled again in 200 ml of 1.25% sodium hydroxide solution for 30 minutes, and washed before it was transferred to a weighed porcelain crucible and dried in the oven at 105°C for 3 h. After cooling in a desiccator it was re-weighed. The percentage crude fibre was calculated as follows:

$$\% \text{Crude fibre} = \frac{W_2 - W_3}{W_1} \times 100$$

Where:

W₁=weight of sample

W₂=weight of sample+crucible

W₃=weight of crucible+ash

Determination of crude fat

Crude fat was determined from the powder by solvent extraction method. Two grams (2 g) of the starch sample was placed in Whatman extraction thimble and plugged with non-absorbent cotton wool. The fat content of the sample was then extracted with 9% petroleum ether at 60-80°C and transferred into Soxhlet extraction apparatus for 6 h at condensation rate of 5-6 drops.

Determination of ash content

About 2 g of the sample was taken in triplicates and placed in pre-weighed crucibles and ashed in a muffle furnace at 600°C for 3 h. The hot crucibles were cooled in a desiccator and weighed. The percentage residual weight was expressed as ash content.

Carbohydrate determination

The carbohydrate content of the sample was determined by estimation using arithmetic difference. Percentage (%) Carbohydrate = 100 - (%moisture + %protein + % ash + % fat content + % Crude fiber)

Determination of mineral contents

The mineral elements were determined by the modified methods of [14], where sodium and potassium were determined using Jenway Flame Photometer, while calcium, magnesium, iron, zinc, manganese and copper were determined using Buch Model 205 Atomic Absorption Spectrophotometer. Phosphorus level was determined using phosphovanado molybdate colorimetric techniques on JENWAY 6100 Spectrophotometer, blank (control) was also determined in the same manner.

Determination of tannins

Modified method of [15] was adopted for the determination of tannins. A weight of 1000 mg of sample was placed into a centrifuge tube containing 2 ml of sterile distilled water. The tube was centrifuged at 2000 rpm for 10 mins. The content was filtered through Whatman filter paper. A volume of 0.5 ml of the supernatant was made up to 1 ml with distilled water. A volume of 0.5 ml Folin Dennis reagent was added and mixed with 2.5 ml of 20% sodium carbonate solution. The mixture was allowed to stand for 40 mins at room temperature. The absorbance was measured using spectrophotometer.

Determination of phytate

For the phytate determination, modified method of [16] was used. Ten grams of sample was measured into a beaker and 100 mL 0.2 M HCl was used to soak sample for 3 h and then filtered through double layer thick filter papers. A volume of 0.5 mL of extract was pipette into a boiling tube, 1 mL of ferric solution was added and the tube was covered and heated in a water bath for 30 min. The mixture was cooled in ice for 15 min; it was then allowed to adjust to a room temperature. 2 ml of 2, 2-Bipyridine was added and the absorbance of the

mixture was taken at 600 nm against a blank made up of distilled water. Phytic acid solution concentrations from 0-40 µg/ml were used as standards.

Determination of oxalate

The titrimetric method of [17] was used in the determination of oxalate in the samples but with modifications. A weight of 1 g of the sample was weighed into 100 ml conical flask. About 75 cm³ of 1.5 M H₂SO₄ was added and the solution was carefully stirred with a magnetic stirrer for about 1 h then filtered using Whatman No1 filter paper. A volume of 25 cm³ of the sample filtrate (extract) was then collected and titrated hot (80°C-90°C) against 0.1 M KMnO₄ solution to the point when a faint pink color appeared which persisted for at least 30 seconds. This was repeated twice more and the concentration of oxalate in each sample was obtained.

Determination of hydrogen cyanide

The cyanogenic glycoside component was determined by alkaline pictrate method of [18] with slight modifications. A weight of 5 g of the sample was weighed and dissolved in 50 ml of distilled water in corked conical flasks. The mixtures were allowed to stand throughout the whole night and the filtered. A volume of 1ml of the sample was taken in a test tube and then 4 mls of alkaline pictrate was added and then heated in a water bath for 15 minutes. After colour development, the absorbance of colour intensity was measured in a spectrophotometer at 490 nm and was compared with standard cyanide solution.

Determination of alkaloids

The quantitative determination of alkaloids was carried out by the alkaline precipitation through gravimetric method as described by [17]. A weight of 2 g of the sample was measured into a beaker and about 20 cm³ of 10% ethyl acetate was added and was used to soak the sample. The mixture was allowed to stand at room temperature for 4 h. The mixture was filtered through Whatman filter paper no. 40. The filtrate (extract) was concentrated by evaporation over a steam bath. For the alkaloids to be precipitated, concentrated ammonia solution was added in drops to the extract until it was in excess. The resulting alkaloid precipitate was recovered by filtration using a previously weighed filter paper. After filtration, the precipitate was washed with 1% ammonia solution and dried in the oven at 60°C for 60 min, after which it was cooled in a desiccator and reweighed. The experiment was repeated two more times and the average was taken. The weight of alkaloids was determined by difference and expressed as a percentage of the weight of the sample analyzed using the expression.

$$\%Alkaloids = \frac{w_2 - w_1}{\text{weight of sample}} \times 100$$

Where;

w₁=weight of filter paper

w₂=weight of paper+alkaloid precipitated.

Determination of saponin

Modified spectrophotometric method of [19] was adopted for the determination of saponin in the sample. A weight of 1 g of the sample was added to 20 cm³ of 1 M HCl in a beaker and was boiled for 3 h. After cooling it was filtered and a volume of 50 cm³ of petroleum ether was added to the filtrate and the ether layer evaporated to dryness. A volume of 5 cm³ of acetone/ethanol mixture was added to the residue. 0.4 cm³ of each was taken into 3 different test tubes. 6 cm³ of ferrous sulphate reagent was added into each of them followed by 2 cm³ of concentrated H₂SO₄. It was thoroughly mixed and after 10 min the absorbance was taken at 490 nm. Standard saponin was used to establish the calibration curve.

Determination of flavonoids

The method of [17] was used for flavonoid determination. A weight of 5 g of the sample was weighed and repeatedly extracted with 100 cm³ of 80% methanol at room temperature. The mixture was then filtered through filter paper into a 250 cm³ beaker and the filtrate was transferred into a water bath and allowed to evaporate to dryness and weighed. The % flavonoid was calculated using the formula:

$$x = \frac{W_2 - W_1}{W_3} \times 100$$

Where,

x=percentage flavonoids,

w₁=weight of empty beaker,

w₂=weight of empty beaker+flavonoid

w₃=weight of sample.

Statistical analysis

One way analysis of variance (ANOVA) was used to compare means of variables and results were expressed as means of variables.

Results

The proximate composition analysis of *T. leontopetaloides* revealed the presence of moisture, 8.66%, crude protein, 6.79%, crude fibre, 5.44%, crude fat, 0.51%, ash, 0.41%, and NFE (total carbohydrate), 78.19% (Table 1).

The elemental analysis of *T. leontopetaloides* indicated presence of some trace elements including sodium, 34.71 mg/100 g, potassium, 40.18 mg/100 g, calcium, 0.25 mg/100 g, magnesium, 1.40 mg/100 g, iron, 1.37 mg/100 g, zinc, 1.64 mg/100 g, manganese, 0.72 mg/100 g, copper, 0.68 mg/100 g and phosphorus, 0.06 mg/100 g (Table 2).

The results of antinutrient composition of *T. leontopetaloides* revealed the presence of tannins, 2.50 mg/100 g, Phytate, 49.77 mg/100 g, oxalate, 15.51 mg/100 g, cyanide, 0.18 mg/100 g,

alkaloids, 42.90 mg/100 g, saponins, 14.67 mg/100 g and flavonoids, 1.46 mg/100 g (Table 3).

Table 1. Proximate Composition of *T. leontopetaloides*.

Parameter	Concentration (%)
Moisture Content	8.66 ± 0.01
Crude Protein	6.79 ± 0.02
Crude Fibre	5.44 ± 0.03
Crude Fat	0.51 ± 0.04
Ash	0.41 ± 0.04
NFE	78.19 ± 0.05

Values represent mean of three replicates (Mean ± SD)

Table 2. Mineral composition of *T. leontopetaloides*.

Mineral	Concentration (mg/100 g)
Sodium (Na)	34.71 ± 0.55
Potassium (K)	40.18 ± 0.12
Calcium (Ca)	0.25 ± 0.13
Magnesium (Mg)	1.40 ± 0.01
Iron (Fe)	1.37 ± 0.15
Zinc (Zn)	1.64 ± 0.05
Manganese (Mn)	0.72 ± 0.26
Copper (Cu)	0.68 ± 0.04
Phosphorous (P)	0.06 ± 0.02

Values represent mean of three replicates (Mean ± SD)

Table 3. Anti-nutritional composition of *T. leontopetaloides*.

Parameter	Concentration (mg/100g)
Tannins	2.50 ± 0.06
Phytates	49.77 ± 1.09
Oxalates	15.51 ± 0.44
Cyanides	0.18 ± 0.03
Alkaloids	42.90 ± 0.61
Saponins	14.67 ± 0.47
Flavonoids	1.46 ± 0.13

Values represent mean of three replicates (Mean ± SD)

Discussion

The results of the analyses of starch of *T. leontopetaloides* showed that it contains important nutrients including minerals and vitamins as well as other phytochemicals that make the plant a good source of food for man and animals.

The proximate composition analysis of *T. leontopetaloides* revealed the presence of moisture, 8.66%, crude protein,

6.79%, crude fibre, 5.44%, crude fat, 0.51%, ash, 0.41%, and NFE (total carbohydrate), 78.19% (Table 1). The results of these findings are in agreement with the findings of [20] who reported moisture, ash, fats, fibre, crude protein and carbohydrate in the range of 10.83%, 1.93%, 1.06%, 4.42%, 6.12% and 86.07%, respectively in the marc of wild *Tacca involucrata*. The protein contents of the samples varied from 6.82-9.62% and are comparably higher than reported values of 5.15% for white yam, 4.88% for water yam and 3.64% for sweet potato [21]. Substantial fibre content, 5.44% was recorded for the *T. leontopetaloides* tuber starch. Fibre is very important in food as it helps in alleviating problems associated with constipation by expanding the walls of the colon, absorbs water and provides roughage for the bowels for softer and bulkier stool. It helps reduce the risk of cancers and other bowel diseases as well as reducing the cholesterol levels of the blood [22,23].

The carbohydrate content, 78.19% (Table 1) obtained from the tuber starch analysis is comparable to the figures recorded by other workers including [20] who recorded 76% carbohydrate component for *T. involucrata* and Ubwa et al. [20] who recorded 71% carbohydrate for *T. leontopetaloides* peels. The high carbohydrate observed in the sample shows that it will be a good source of energy required for the daily activities of man.

The mineral composition of *T. leontopetaloides* as shown in Table 2 revealed that it contained some minerals that are of beneficial effect to human and animal bodies. Calcium helps in calcification of bones and its deficiency results to syndromes like rickets [24]. Magnesium helps in phosphate transfer in most reactions, its deficiency results to severe migraine, hypertension, stroke and other disease conditions [25,26]. Zinc is very important for protein and nucleic acid synthesis. Manganese is involved in a number of enzyme systems [27]. Iron is very important in production and building of blood cells and is also needed for transporting haemoglobin and for immune responses [28]. Phosphorus is essential for bone and teeth structures [29].

The present study has confirmed the presence of tannins, cyanides, saponins and flavonoids though in small quantities of 2.50, 0.18, 14.67 and 1.46 mg/100 g respectively. Phytates, oxalates and alkaloids were present in appreciable amounts of 49.77, 15.51 and 42.90 mg/100 g respectively (Table 3). These phytochemicals have been known for their various nutritional, pharmacological and physiological uses to man and animals [22]. Tannins as reported by Nwogu et al. [30] are complex phenolic polymers which can bind to proteins and carbohydrates and results to reduction in digestibility and availability of the macromolecules thereby inhibiting microbial growth. Tannins are known to have astringent properties on the mucous membranes and are used in the treatment of wounds emanating from varicose ulcers and haemorrhoids [31,32].

Cyanogenic glycosides (a-hydroxynitrile glycosides) are derived from the five protein amino acids Valine, Isoleucine, Leucine, Phenylalanine and Tyrosine and from the non-proteinogenic amino acid cyclopentenyl glycine. The function of cyanogenic glycosides in plants is dependent on activation

by β -glucosidases to release toxic volatile HCN as well as ketones or aldehydes to put off herbivores and pathogen attacks. Cyanide is poisonous because it binds with cytochrome oxidase and stops its action in respiration in the body [33,34]. The concentration of hydrogen cyanide obtained from this research work, 0.18mg/100g is slightly close to that, 0.16 mg/100 g obtained by Ndouyang et al. [35]. However, Ubwa [22] reported hydrogen cyanide concentration of 43-45 mg/kg in the peels of *T. leontopetaloides*. The reduction in the concentration of hydrogen cyanide could be as a result of the stepping in water during processing. Previous works including that of Chikwendu [36] and Ndouyang et al. [35] reported that processing especially soaking reduces hydrogen cyanide content in food substances such as African Yam bean.

Saponins are structurally diverse molecules that are chemically referred to as triterpene and steroid glycosides. They consist of nonpolar aglycones coupled with one or more monosaccharide moieties with detergent, wetting, emulsifying, and foaming properties [37]. Saponins, in high concentrations, impart a bitter taste and astringency in dietary plants. The bitter taste of saponin is the major factor that limits its use. In the past, saponins were recognized as anti-nutrient constituents, due to their adverse effects such as throat-irritating activity. In addition, saponins were found to reduce the bioavailability of nutrients and decrease enzyme activity which affects protein digestibility and inhibition of various digestive enzymes such as trypsin and chymotrypsin [38]. The saponin content of *T. leontopetaloides* was found to be 14.67 mg/100 g (Table 3) as compared with the findings of [35] who reported saponin content of 67.9 mg/100 g in *T. leontopetaloides* that underwent two steps soaking. Environmental influences and location could account for the differences. Recently, saponins are attracting considerable interest as a result of their beneficial effects in humans. A high saponin diet is known to possess hypocholesterolemic and anti-carcinogenic properties as well as reducing the risk of heart diseases [39].

Flavonoids content of the *T. leontopetaloides* used in this study was found to be 1.46 mg/100 g (Table 3) and was a little higher than that reported by [35] which was 0.38 mg/100 g for *T. leontopetaloides* after two steps soaking. Flavonoids have been reported to be strong antioxidants. They help in preventing the damage caused by free radicals to human cells. Ubwa et al. [22] reported that they slow the proliferation of cancer cells, thereby mediating in most chronic cancer and diabetes cases. Flavonoids have been shown to be able to affect various biological functions: capillary permeability, cellular secretory processes involved in the inflammatory response and inhibition of enzymes, receptors and carriers [40].

The phytates, oxalates and alkaloids contents of *T. leontopetaloides* used in this study were recorded as 49.77, 15.51 and 42.90 mg/100 g respectively. The phytates contents obtained from this research work are similar to 55.7 mg/100 g obtained by [35]. In the same vein, the oxalates contents were similar to 16.2 mg/100 g total oxalates and 14.0 mg/100 g soluble oxalates also reported by [35]. The authors reported that soaking generally is effective in the reduction of anti-nutritional components especially phytates and oxalates. The

soaking of the tubers during processing has been observed to influence the content of the anti-nutrients, thereby presenting the tubers as good sources of food materials. Nwosu [41] reported a significant reduction in phytates, tannins and oxalates contents following soaking which is in agreement with the findings of this research. Phytates and oxalates form complexes with calcium, magnesium, iron, and Zinc and decrease their bioavailability [35].

The values of the phytates, oxalates and alkaloids in the tubers is an indication that utilization of the tubers as food might not have any negative impact that is always connected with utilization of oxalates which is in connection with having negative impact on accessibility of minerals [42].

In general, the anti-nutritional components of *T. leontopetaloides* was considered low with an indication that the tubers can to a great extent be used as food, believing that there would be no interference of the anti-nutrients with the nutrients such as proteins and other minerals in the body.

Conclusion

Anti-nutritional factors are present in most foods of plant origin and are responsible for the harmful effects which are related to absorption of nutrients that interfere with the normal functioning of certain organs. *T. leontopetaloides* when eaten raw is poisonous and lethal but processing it by soaking in water enhances availability of the micronutrient and aids in the reduction of concentration of the anti-nutritional factors. The anti-nutritional factors and their breakdown products possess beneficial health effects if present in minute amounts. This study has shown that *T. leontopetaloides* when processed properly has the potential of a good food source to man as it contains calcium, iron, potassium and other micronutrients needed for the proper functioning of human body. However, physiological and toxicological effects of the plant need to be investigated.

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Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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