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PHYSICAL AND COOKING CHARACTERISTICS OF *BAMBUSA ARUNDINACEA* RETZ AND *DENTROCALAMUS STRICTUS* NESS SEED

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ABSTRACT

Bamboo rice is an all- natural, short-grain, a slight jasmine green tea taste. The detailed information on physical and cooking properties of bamboo seed kernel of Bambusa arundinacea Retz and Dentrocalamus strictus Ness grown in Tamil Nadu and Kerala was explored in the present study. Dentrocalamus strictus Ness variety recorded significantly greater thousand seed weight (g), grain length (mm), grain breadth (mm), thickness (mm), equivalent diameter (mm), sphericity, water uptake ratio and cooking time than Bambusa arundinacea Retz variety. Geographical location did not reveal significant influence on the physical and cooking characteristics of bamboo seed irrespective of its variety. The selected bamboo seeds were round shaped, short and slender.

KEYWORDS: *Bamboo seed, Bambusa arundinacea Retz, Dentrocalamus strictus Ness, Physical properties, Cooking characteristics.*

INTRODUCTION

The grains of the bamboo are locally known as *Mungil Arisee* (in Tamil) that means bamboo rice. When the bamboo seeds are matured, the tribals clean the ground around the plant and patch the floor by using cow dung. Every morning and evening, they collect the seeds that fall from plants on this clean floor. For protecting the seeds from the rodents they use a traditional trap called *Elipori* (Rat trap). Mostly women and children are actively engaged in the collection of bamboo seeds. Excess seeds are sold in the adjoining forest areas. Seeds of *Bambusa arundinacea* collected in Sampaji range of Karnataka by villagers are sold to the forest department, as well as for domestic consumption[1].It helps to empower and improve the economy of the tribal women. Edible bamboo shoots generate self-employment and ultimately reduce the unemployment problems in the North East region of Indian Peninsula[2]. 26 bamboo species are used for edible purposes in pacific region of Asia. Southern Western Ghats of Kanyakumari district;because of its geographical location, stable geological history, favourable agroclimate, heavy rainfall and good soil conditions, support a gregarious growth of two bamboo species, *Bambusa arundinacea* Retz and *Dendrocalamus strictus* Ness[3,4].

The physical properties of agricultural produce are important in designing and constructing equipment and structures for handling, transportation, processing, storage and also for assessing the product quality [5,6]. Physical and mechanical properties of fruit, nut, seed, and kernel are important to design the equipment for dehulling, nut shelling, drying, oil extraction and other processes like transportation and storage[7]. Being a major cereal grain, evaluating the nutritional and cooking qualities of rice has been given highest priority [8,9,10,11]. Cooking characteristics of rice are linked to consumer preferences for rice [12,13] and are very important as rice is consumed almost immediately after cooking[14]. The objective of this study was to determine the physical and cooking characteristics of dehulled bamboo seed of *Bambusa arundinacea* Retz and *Dentrocalamus strictus* Ness grown in Tamil Nadu and Kerala. Recently, a series of studies (very few) has

initiated on the bamboo seed and its characterization to elucidate the factors involved in dictating the quality of bamboo seed and to exploit the possible usage of bamboo seed in other processed food products.

MATERIALS AND METHODS

Bamboo Seed

The bamboo seed of *Bambusa arundinacea* Retz and *Dentrocalamus strictus* Ness grown in Tamil Nadu (coded as Ba-T, Ds-T) and Kerala (coded as Ba-K, Ds-K) were procured from Department of Forest Service at Salem; cleaned, winnowed manually for the removal of dust and other foreign matters. The selected varieties of bamboo paddy were authenticated by the Institute of Herbal Botany, Plant Anatomy Research Center, Chennai, Tamil Nadu. *Bambusa arundinacea* paddy (Ba-T and Ba-K*)* was dehulled at Sri Vinayaka Rice Mill, Salem District, Tamil Nadu, India using a Rubber Roller Dehusker cum Polisher (Satake Corporation, Tokyo, Japan); *Dentrocalamus strictus* variety contain a very hard outer coat of paddy (Ds-T and Ds-K) was dehulled using Wooden Pestle and Mortar (Hand pounding method). The unpolished kernel of both varieties of different geographical origin (Ba-T, Ba-K, Ds-T and Ds-K) were collected to study the physical and cooking properties.

Physical Properties

Thousand Seed Weight

Thousand seed weight of selected bamboo seeds was determined by taking 100 grains randomly from all the samples, weighed in a digital balance and then multiplied by 10 to give the mass of 1000 grains [15].

Length, Breadth and Thickness

The three principle dimensions such as length (L), breadth (B) and thickness (T) of the selected bamboo seeds were measured using a Vernier Caliper with an accuracy of 0.02 mm[15].

Length: Breadth Ratio

Length –breadth ratio (L:B) was determined by dividing the cumulative length of 10 kernels and by the breadth of 10 kernels [17].

Equivalent Diameter

The Equivalent diameter of the selected bamboo seeds was determined by measuring length (L), breadth (B) and thickness (T) of the grain and calculated by the following relationship and the obtained values are represented in mm[18].

D_m = $(LBT)^{1/3}$

D_m = Equivalent diameter or Geometric mean diameter (mm)

L = Length (mm)

B = Breadth (mm)

T = Thickness (mm)

Sphericity

The sphericity of the whole grain was determined by $(\phi) = (LBT)^{1/3}/L$ [18]

L = Length (mm)

B = Breadth (mm)

T = Thickness (mm)

Cooking Characteristics

Water Uptake

Bamboo kernel was cooked in excess water. The 2g of kernel was cooked with 20ml water in a 100ml beaker placed on an electric heater. Samples were removed at cooking time and calculated by equation [19].

$$\text{Water Uptake} = \frac{Weight\,of\,cooked\,rice}{Weight\,of\,raw\,rice} \text{ X } 100$$

Elongation Ratio

Bamboo kernel was cooked in excess water. The 2g of kernel was cooked with 20 ml water in a 100 ml beaker placed on an electric heater. Samples were removed at cooking time to measure its length (before and after cooked) and calculated by equation [20].

$$\text{Elongation Ratio} = \frac{Length\,of\,cooked\,rice}{Length\,raw\,rice}$$

Optimum Cooking Time

Minimum cooking time was determined by weighing 2 g of head kernel of bamboo seed from each variety into a test tube. The samples were cooked in 20 ml distilled water in a boiling water bath. After 10 minute, cooked rice were taken and pressed between two glass plates. Minimum cooking time was recorded when there was no white core left [21].

Alkali Spreading Value

Alkali Spreading Value was estimated according to the standard procedure. The 10 grains of bamboo seed variety of Ba-T, Ba-K, Ds-T and Ds-K were soaked and spaced uniformly in a petri dish , which had 10 ml of 1.7 % potassium hydroxide solution . The petri dish was roofed , undisturbed and kept it at the temperature of 30˚Cfor 23 hours in an incubator. The spreading of each grain was rated visually on a 7- point numerical scale given in Table III and IV[22].

TABLE III

Point – Numerical Scale for the Determination of Alkali Spreading Value

Spreading Scale Rating	Description
1	Kernel not effected
2	Kernel swollen
3	Kernel swollen, collar incomplete and narrow
4	Kernel swollen , collar complete and wide
5	Kernel split or segmented collar complete or wide
6	Kernel dispersed , merging with collar
7	All kernels dispersed and intermingled

TABLE IV

Classification of Alkali Spreading Scale

Rating	Gelatinization temperature
1-2	High
3	High /intermediate
4-5	Intermediate
6-7	low

RESULTS AND DISCUSSION

Physical Characteristics

The marketing values of rice as an agricultural product depend on its physical qualities after the harvesting. The percentage of whole grain is the most important parameter for the rice processing industry [23]. The physical properties of bamboo seed kernel were determined and interpreted in Table 1.

TABLE I
Physical Properties of Bamboo Seed Kernel

Physical Properties	Ba-T	Ba-K	Ds-T	Ds-K
Thousand seed weight (g)[A]	14.53±0.05^{ax}	14.52±0.20^{ax}	23.67±0.50^{by}	23.65±0.50^{by}
Grain length(mm)[B]	1.79±0.37^{ax}	1.75±0.68^{ax}	2.29±0. 46^{by}	2.20±0. 34^{by}
Grain breadth(mm)[B]	1.68±0. .42^{ax}	1.62±0.46^{ax}	2.25±0.44^{by}	2.25±0.54^{by}
Thickness(mm)[B]	1.44±0.33^{ax}	1.44±0.28^{ax}	2.39±0.74^{by}	2.36±0.64^{by}
L:W ratio [B]	1.09±0.34^{ax}	1.03±0.01^{ax}	0.96±0.17^{ax}	0.95±0.02^{ax}
Equivalent diameter(mm)[B]	1.46±0.64^{ax}	1.44±0.79^{ax}	4.03±1.51^{by}	4.03±1.51^{by}
Sphericity[B]	0.79±0.23^{ax}	0.79±0.31^{ax}	1.84±0.81^{by}	1.84±0.76^{by}

A-Values are the average of three determinants. B-Values are the average of ten determinants. Different alphabets in superscript (a, b) indicates significant geographical difference between means at $p<0.05$ using LSD test; (x, y) indicates the significant varietal difference between the means at $p<0.05$using LSD test.

The physical properties such as thousand seed weight (g), grain length (mm), grain breadth (mm), thickness (mm), equivalent diameter (mm), sphericity of bamboo seed kernel were significantly different among the varieties at $p<0.05$, but not among bamboo seeds grown in different geographical locations. The 1000 grain weight is a very important measure of seed quality, which is effective on sprouting, seed potential, seedling growth and plant performance [24,25,26,27,28,29,30,31]. The thousand seed weight of 62.7 % was high in Ds-T, Ds-K compared with Ba-T, Ba-K. This difference may be due to Seed quality and embryo size. This statement was supported by [32] Stated that seed quality is very important to optimum growth and yield production in farm which influenced by many factors such as genetic characteristics, viability, germination percent, vigor, moisture content, storage conditions, survival ability and seed health, but their most important is germination percent and vigor. [33] also stated that the thousand grain weight is one of important scales in seed quality. It depends to embryo size and seed storages for germination and emergence. High thousand seeds weight will increase germination percent, seedling emergence, till erring, density, spike and yield.

The thousand grain weight of different rice varieties and classified according to their weight. The CRI 11, ARCCU12Fa1L6P7-24-1-1-2, CRI-54 and CRI 7 varieties of rice exhibited 21-24 g of thousand grain weight [34]. It was agreed to the thousand kernel weight of the bamboo seed variety of Ds-T and Ds-K. The thousand kernel weight of brown rice cultivar of SKAU-345 (22.92±0.14g) and SR1 (22.73±0.10g) [35] also supported the thousand kernel weight of Ds-T and Ds-K.

The *Dentrocalamus strictus* (Ds-T, Ds-K) variety registered significantly ($p<0.05$) greater length, width and thickness compared with *Bambusa arundinacea* (Ba-T, Ba-K). These principal axial dimensions of the rice grains are important in designing and selecting sieve separators and calculating power during the rice milling operations [36]. The Length (29%) breadth (37%) and thickness (64%) was high in Ds-T, Ds-K compare with Ba-T , Ba-K. The varietal and geographical location did not exhibit significant difference in L: W ratio and Ba-T, Ba-K, Ds-T and Ds-K varieties were round shaped, short and slender seeds based on the classification [37,38] and it was comparable with Salem Samba as medium and slender variety. [39,40] have concluded that the physical dimensions and size related characteristics of the paddy and brown rice were different and it's varied with varieties significantly from short to long grain. The preference for grain size and shape vary from one groups of consumers to the other. Some ethnic groups prefer short bold grains, some have a preference for medium

long grains and long slender grains are highly prized by others[41]. The sphericity and equivalent diameter were also significantly high in Ds-T and Ds-K compared with Ba-T and Ba- K. Rice cultivars in different regions of the world differ in their composition depends on variety, climate, irrigation and fertilizer application [42].

Cooking Characteristics

Being a major cereal grain, evaluating the nutritional and cooking qualities of rice has been given highest priority [43,44,45,46]. It has been opined that variations in composition and cooking quality of rice mainly depends on the genetic as well as surrounding environmental factors where they are grown [42].

TABLE II
Cooking properties of Bamboo Seed Kernel

Cooking Characteristics	Ba-T	Ba-K	Ds-T	Ds-K
Water uptake ratio(g)^{B}	1.53±.05^{ax}	1.53±.05^{ax}	2.00±0.00^{by}	2.00±0.00^{by}
Cooking time (min)^{B}	20.66±2.88^{ax}	20.00±0.00^{ax}	40.00±0.00^{by}	40.00±0.00^{by}
Elongation ratio(mm)^{A}	1.15±0.12^{ax}	1.13±0.12^{ax}	1.12±0.10^{ax}	1.11±0.92^{ax}

A-Values are the average of three determinants. B-Values are the average of the ten determinants. Different alphabets in superscript (a,b) indicates significant geographical difference between means at $p<0.05$ using LSD test; (x, y) indicates the significant varietal difference between the means at $p<0.05$ using LSD test.

In this study, the water uptake and cooking time of bamboo seed kernel (Table 2) was significantly different and greater in *Dentrocalamus strictus* Ness variety at $p<0.05$ irrespective of its geographical location. It's may be due to fibrous bran layer in *Dentrocalamus strictus* Ness. Similar longest 'minimal cooking time' of 31.67 min was observed in brown rice and justified that presence of fibrous bran layer requires longer time for the starchy endosperm to cook [47]. According to[48] for rice, high amylose and long chain amylopectin can lead to hard texture, while the vice-versa can have a softer texture on cooking. Disorganized cellular structure can enhance the probabilities for high water absorption during cooking and can contribute to longer cooking time [49]. Positive correlation exists among optimum cooking time with water uptake ratio and kernel breadth after cooking; kernel length and negative correlation with elongation ratio and cooking time [50]. Similar correlation was noted between water uptake ratio and cooking time; elongation ratio and cooking time in the studied bamboo seed. Increase in either length or breadth can occur depending on the increase in volume during cooking as and when water is absorbed. Generally, breadth wise increase on cooking of rice is considered undesirable trait, while high quality rice varieties are characterized and preferred based on increase in length during cooking [51]. The cooking and eating characteristics of rice starch are controlled by the rice starch source, genotype and amylose: amylopectin ratio [52]. According to [53] the cooking and pasting characteristics are varied among the rice varieties.

Elongation ratio was not significantly different among the varieties but significantly different among bamboo seeds grown in different geographical locations at $p<0.05$. The maximum elongation ratio was observed in Ba-T followed by Ba-K, Ds-T and Ds-K. The table III showed the variation in values of long cooking time (40min) but low elongation value of Ds-T and Ds-K was due to result of the variation in rice consistency, seen in the bursting of the grains during and after cooking. [54] proposed that parboiling of rice grain reduces the rate of disintegration during cooking than the corresponding raw rice. Grain size and shape largely determine the market value and consumer acceptance of rice, while cooking quality is influenced by the properties of starch. Some varieties expand more in size than others upon cooking. Length-wise expansion without increase in girth is considered a highly desirable trait of high quality rice [55].The greater length wise elongation ratio of Ba-T variety suggested its high quality than Ba-K, Ds-T and Ds-K. Similar elongation characteristic was also observed in E4197:IR68 variety studied by [56].

Alkali spreading value

Alkali spreading value (ASV) of whole kernel (milled rice) measures the gel type of rice. It also allows an estimation of the gelatinization temperature and is partly associated with the amylose content of the starch. The gelatinization temperature of the endosperm starch refers to the cooking temperature at which water is absorbed and the starch granule swell irreversibly with a simultaneous loss of crystalline. Alkali spreading value is indirectly correlates with the gelatinization temperature [57]. The result of alkali spreading value of bamboo seed variety showed in figures 1-4. Bamboo seed varieties of Ba-T and Ba-K Shows high gelatinization; whereas Ds-T and Ds-K was intermediate gelatinization.

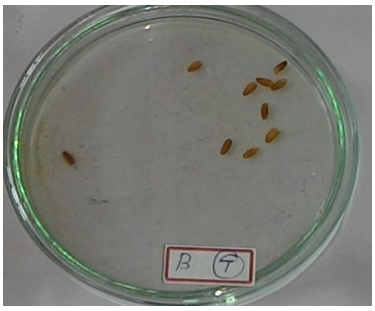

Fig.1: Ba-T -High gelatinisation, Kernel swollen (Alkali value 2)

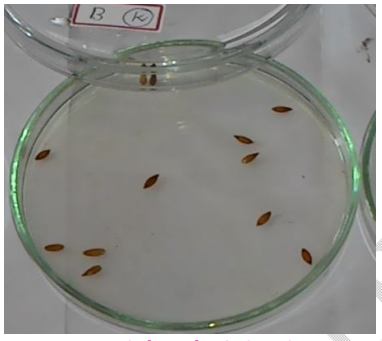

Fig.2 Ba-K- High gelatinisation, Kernel swollen (Alkali value 2)

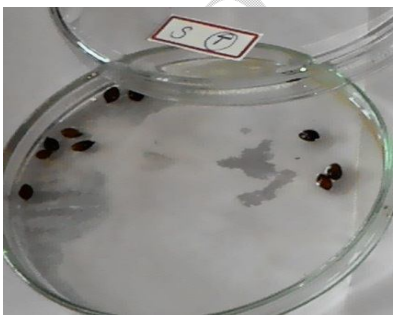

Fig.3: Ds-T- Intermediate gelatinization,Kernel swollen, collar complete and wide (Alkali value 4)

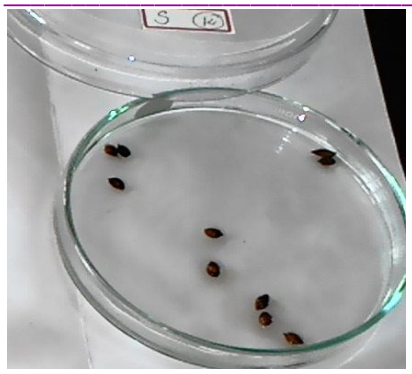

Fig. 4: Ds-K- Intermediate gelatinization,Kernel swollen, collar complete and wide (Alkali value 4)

SUMMARY AND CONCLUSION

Bamboo seed varieties could be classified as round, short and slender variety. This information was useful for optimizing milling operations, designing the storage structures and machinery, which would help to avoid the postharvest and milling losses and to find the end use of the particular bamboo seed. The *Bambusa arundinacea* Retz variety observed to have shorter cooking time with less physical dimensions, water uptake ratio and greater elongation ratio signifying the high demand of selected bamboo seed for the preparation of mostly preferred non-sticky short and slender rice while *Dentrocalamus strictus* Ness revealed the characteristic of long and slender non sticky rice with greater physical dimensions, water uptake ratio and less elongation ratio.

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