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Investigating Biochemical Characteristics of Key Finger Millet (*Eleusine coracana* L.) Varieties/ Genotypes

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***Abstract*— During the 2022-23 research conducted at the Department of Agricultural Biochemistry, C. S. Azad University of Agriculture and Technology in Kanpur, a comprehensive investigation was undertaken to analyze the physical parameters, functional properties, and biochemical parameters of 20 varieties/genotypes of finger millet. The study employed a Completely Randomized Design (CRD), and all findings were deemed statistically significant. Among the varieties assessed, IC0321712 exhibited the highest value in terms of test weight, indicating its potential for robust grain yield. Notably, IC0475978 demonstrated exceptional functional characteristics, particularly in dispersibility and water absorption capacity, suggesting its suitability for various food applications. Furthermore, variety IC0476418 emerged as biochemically superior, boasting elevated levels of carbohydrates and proteins. Additionally, it contained significant amounts of essential amino acids such as methionine and tryptophan, which are crucial for human health. These findings hold significant implications for breeding programs and the promotion of finger millet consumption. By identifying varieties/genotypes with superior nutritional profiles and specific health-promoting properties, this research contributes to the advancement of agriculture and the diversification of nutritious grain sources.*

***Keywords*— Dispersibility, millets, Tryptophan, ragi, seed colour**

I. INTRODUCTION

The grass family *Poaceae* encompasses a remarkable member known as finger millet (Eleusine coracana) with a chromosome count of 2n=36. Around 5000 years ago, a wild variant of finger millet, flourishing in the highlands of Ethiopia and Uganda, underwent the transformative process of domestication. Subsequently, domesticated finger millet found its way to the lowlands of Africa. Roughly three millennia in the past, this invaluable grain journeyed to India, establishing the nation as a secondary hub of finger millet diversity (FAO, 2023). Widely recognized as "ragi" in India, it stands as a dietary cornerstone for many in economically disadvantaged segments of society. In the Indian context, finger millet ranks as the third most vital millet. Its primary consumption base lies within underdeveloped regions globally, often earning the monikers "crop for the poor" or "famine food." Yet, its nutritional and therapeutic prowess has elevated it to the status of a "super cereal" (Vietmeyer, 1996).

According to the World Food Programme, almost 1.2 billion people are estimated to routinely consume millet. The production of millet has been relatively stable in the past several years, and in 2020, 28 million metric tons are expected to be produced. Asia is the second-largest producer of millet, behind Africa. The top three nations in the world that produce millet are China, Niger, and India. Further notable millet-producing countries are Senegal, Mali, and Burkina Faso. India ranks among the top 5 exporters of millet worldwide. Millet exports increased from $400 million in 2020 to $470 million in 2021, based on the ITC trade map. India exported $64.28 million worth of millets in 2021–2022, compared to $59.75 million in 2020–2021.

The mature plant may grow up to 150 cm in height. Among other things, the seeds—which might be white, light brown, or dark brown—are used to produce unleavened bread from milled flour. With many tillers and nodule branches, the leaves are grass-like and thin. The panicle is composed of fingers, which are a group of digitally ordered spikes.

A culture of "refined" eating and growing worries about lifestyle illnesses have led to a gradual but steady shift in consumer behavior toward nutrient-rich millets as a viable alternative to wheat and rice. Customers in both urban and rural regions are increasingly favoring millets to improve their immunity and nutrition as a consequence of the COVID-19. The Government of India designated certain millets as Nutri-Cereals in April 2018 to promote the production and consumption of millets. These include Sorghum (Jowar), Pearl Millet (Bajra), Finger Millet (Ragi/Mandua), and Minor Millets, such as Foxtail Millet (Kangani/Kakun), Proso Millet (Cheena), Kodo Millet (Kodo), Barnyard Millet (Sawa/Sanwa/ Jhangora), Little Millet (Kutki), and two Pseudo-millets, Buckwheat (Kuttu) and Amaranthus (Chaulai). In an effort to boost demand for millets both domestically and internationally and to provide people with nutrient-dense meals, the Indian government has asked the UN to declare 2023 the International Year of Millets (IYoM-2023). The United Nations General Assembly (UNGA) declared March 20, 2023, to be the International Year of Millets after 72 countries granted India's proposal. Consequently, the Honourable Union Finance Minister declared the following budget on February 1st, 2022: It has been announced that 2023 will be the International Year of Millets. Post-harvest value addition, increasing local consumption, and national and international branding of millet products will all receive support. (NABARD 2023). It is also a nutritious grain that is high in fiber and other minerals. These elements will guarantee millet's continued importance as a food crop in the years to come. Most Indian millets are cultivated in arid and semi-arid regions and belong to a class of nutrient-rich, drought-tolerant cereals. They are an essential part of India's economic and ecological security and a major source of food and fodder for millions of farmers who lack resources. They are ideal for anyone with diabetes or celiac disease because they are also gluten-free and have a low glycemic index.

All other millets have at least twice as much calcium as rice, but finger millet contains thirty times more than rice. Rice is not even in the race since foxtail and little millet are so rich in iron. Millets contain large amounts of Carotene, a vitamin that most of us only find in pharmaceutical tablets and capsules. Additionally, ragi contains a sizable amount of essential amino acids (EAA), which are necessary for human health. Eleusine coracana, the primary protein portion of finger millet, has strong levels of valine, methionine, isoleucine, tryptophan, and threonine, making it a biologically valuable food. In addition to aiding in the body's nitrogen balance, valine is necessary for metabolism, muscular coordination, tissue healing, and muscle balance. Additionally, it enhances and maintains mental vigor and tranquility. Isoleucine has a critical role in maintaining blood formation and controlling blood sugar levels. It also helps to mend and rebuild skin, bones, and muscular tissue. The body uses threonine to maintain its levels of protein. It also inhibits the production of fat in the liver and aids in the development of tooth enamel. Tryptophan is a naturally occurring relaxant that helps prevent anxiety, melancholy, and sleeplessness. They also lessen overindulgence in food and produce growth hormones, which aid in the treatment of migraine headaches. Methionine is an amino acid with a sulphur base that the body needs for a number of functions. It's said to support healthy skin and hair growth. Finger millet is consumed to fulfil customary needs and as a dietary supplement. The food items are given to sick people, infants, breastfeeding mothers, and expecting women as a nutritious supplement. Leprosy is treated internally in southern Africa by drinking a mixture of finger millet leaves and leaves.

In addition to the primary nutrients, 100 grams of finger millet includes 290 mg of phosphorus, 410 mg of calcium, and 12.6 mg of iron. Patients with diabetes are also advised to consume it due to its high fiber content and low glycaemic index. Eating finger millet reduces cholesterol and keeps constipation at bay. The seed of finger millet is used medicinally as a dysentery prophylactic. Ragi has the highest levels of phytic acid (685 mg/100g), total polyphenols (298 mg/100g), tannins (18.75 mg/100g), flavonoids (23.68 mg/100g), and trypsin inhibitors (102.6 mg/100g). Its high carbohydrate content (72%), proteins (7.3%), fat (1.4%), and minerals (2.7%) account for its nutritive value. (Kumar et al., 2013).

finger millet's medical applications and its well-known therapeutic qualities, even for the average person. gives the body elasticity and strength, allows for the preservation of strength without fatigue, raises body warmth, and causes increased urine; for these reasons, it is typically used in heavy physical labor. Finger millet bran causes indigestion, thus in order to avoid this issue, it must be soaked, pulverized, and the bran/husk removed before drying and eating. Additionally, millets include folic acid and the vitamins "B" complex, particularly niacin. Minerals including calcium, iron, potassium, magnesium, and zinc are also present in finger millet. It has been shown that eating enough calcium helps to regulate blood-lipid levels and guards against osteoporosis, colon cancer, and kidney stones. For youngsters to gain bone, the ideal calcium to protein ratio is required. Patients with diabetes are given finger millet grain to help lower their blood glucose levels. Those with heart problems can also benefit from this grain. (Et al., Rajalakshmi 2014). The United Nations Organization is observing 2023 as International Millets Year to encourage the use and processing of millets in light of their utility, at the request of the Indian government. Coarse grains can also significantly lessen the prevalence of hunger and malnutrition in African nations. Given the significance of this, the current study has been designed to accomplish the goals. The study seeks to identify those with superior biochemical profiles, which could potentially contribute to enhanced nutritional value, health benefits, or other desirable characteristics. The research may also explore correlations between biochemical composition and agronomic traits to provide insights into the underlying genetic and physiological mechanisms governing these traits. Additionally, the findings could inform breeding programs aimed at developing improved finger millet varieties with optimized biochemical attributes for food, nutrition, and agricultural sustainability.

II. MATERIALS AND METHODS

The current study was conducted at the laboratories of the Department of Agricultural Biochemistry at Chandra Shekhar Azad University of Agriculture and Technology in Kanpur, India, during the 20222–2023 season. The Chandra Shekhar Azad University of Agriculture and Technology in Kanpur's Department of Genetics and Plant Breeding will provide the seed sample for each of the twenty finger millet varieties/genotypes listed below. The Department of Agricultural Biochemistry, Laboratory of Biochemistry, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, India is the site of all experiments and research. Longitude: 80.307251, Latitude: 26.491150.

Seed colour:

Seed coat colour of ragi millet germplasm was determined on the bases of visual observation

Test weight:

The weight of a thousand seed was calculated by weighing, writing down the weight, then manually counting the samples. With a precision of 0.01 g, the grain samples were weighed using a digital electronic balance.

Dispersibility: -

A total of 10 g of the flour sample was weighed into 100 mL measuring cylinder and distilled water was added. The set up was stirred vigorously and allowed to stand for 3 h. The volume of settled particle was recorded and subtracted from 100. Olopade, *et.al*., (2014).

$$\% \text{ Dispersibility } = 100 - \text{volume of settled particles}$$

Water absorption capacity: -

One gram of flour was divided into three identical 50 mL centrifuge tubes, to which 10 mL of distilled water was added. The mixture was then thoroughly mixed with a glass rod and allowed to sit in a water bath at 30 degrees Celsius for half an hour. A centrifuge was used to centrifuge the centrifuge tubes for 15 minutes at 3,000 rpm. After discarding the supernatants, the remnants were weighed. Sawant et al. (2013) used Equation 11 to determine the water absorbance of two distinct centrifuge tube weights.

$$\text{Water absorption capacity} = \frac{V1-V2}{V2} X100$$

Where: V1 = initial volume of the liquid

V2 = final volume of the liquid

Carbohydrate

Estimation of carbohydrate is done by anthrone method. (Ludwig & Goldberg 1956)

Protein content:

Protein content of the sample was determined by biuret method as described by Williams P. C. (1961).

Methionine content:

Methionine content of the sample was determined by Calorimetric method as reported by Horn et al., (1946).

Tryptophan content:

Tryptophan content of the sample was determined by the Spies and Chambers (1949).

III. RESULT AND DISCUSSION

Seed colour:

Table 1 provides information on the color of the seed in several ragi Millet germplasms. There have been reports of radish brown, dark red, light brown, and brick red colors in different germplasm. One of the main elements influencing the color of the ragi millet grains is the presence of pigments, which improve the product's visual quality. Color variation within the germplasm is prevalent and evident in nearly all minor millets. (2011) Krishna et al. Variations in the color of ragi millet seeds might be due to the genetic composition of the germplasm. According to reports, the dehulled ragi millet grain ranges in colour from drab cream to chocolate. while the colours of the grains of ragi millet are light brown, dark brown, dark red, brick red, and purple. **(Rajasekharan 2004).**

Test weight:

Results on finger millet test weight as impacted by certain finer millet varieties/genotypes is shown in table 1 and visually represented in fig 1. The data made it clear that finger millet test weights varied between 2.22 and 4.23 grams depending on the variety and genotype. In variety IC0321712, the significantly highest test weight of 4.23g was obtained. 2.22g was the lowest in IC0475978. The test weight varied from 2.22 g to 4.23 g in different ragi millet grains. The germplasm of all the ragi millets was found to be significant in terms of test weight. Ramappa *et al.* (2010) showed a similar range of test weight in Ragi Millet germplasm when obtaining the yield factors.

Table 1. Physical characteristics of certain varieties/genotypes of finger millet.

S.N.	Varieties/Genotypes	Colour of seeds	Test weight (gm)
1	**VL324**	Dark red	3.35
2	**VL379**	Dark red	3.37
3	**VL376**	Radish brown	2.45
4	**VL352**	Dark red	3.02
5	**IC0475654**	Light brown	2.38
6	**IC0474887**	Radish brown	3.05
7	**IC0475697**	Light brown	3.21
8	**IC0478760**	Dark red	2.99
9	**IC0321712**	Brick red	**4.23**
10	**IC0475457**	Dark red	4.03
11	**IC0283451**	Radish brown	3.03
12	**IC0476418**	Light brown	3.81
13	**IC0476092**	Brick red	2.32
14	**IC0474910**	Dark red	3.97
15	**IC0476818**	Radish brown	3.76
16	**IC0475654**	Light brown	2.47
17	**IC0474887**	Dark red	3.12
18	**IC0475978**	Brick red	**2.22**
19	**IC0347251**	Light brown	3.16
20	**IC0474089**	Dark red	3.04
	Mean		**2.48**
	S.E.(d)		**0.075**
	C.D. at 5%		**0.152**

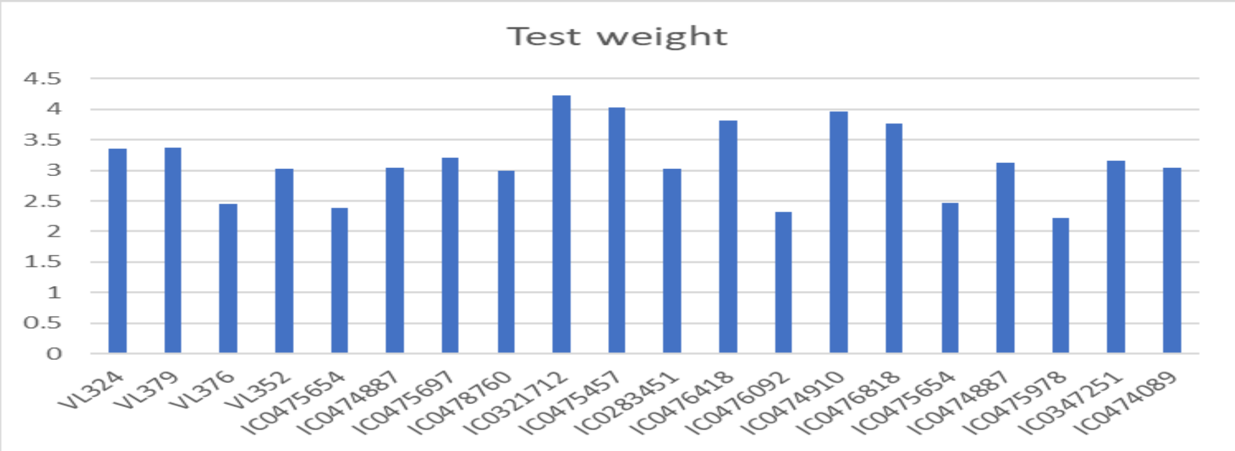


Fig.1 .test weight of finger millet

Dispersibility:

Table 2 presents data on the dispersibility of several finger millet varieties and genotypes, whereas Figure 2 provides a visual representation of the data. The data made it clear that finger millet's dispersibility varied between 75.66% and 90.66% depending on the variety and genotype. In variety IC0475978, the dispersibility was much higher at 90.66%. Finally, 75.66% in IC0475697 was the lowest.The dispersibility of different ragi millet grains varies from 75.66% to 90.66%. It was discovered that all ragi millets have high dispersibility. The results of this investigation were in line with those of Ramashia et al. (2017), who found that finger millet flours had dispersibilities ranging from 87% to 92%. When mixing, the dispersibility levels could contribute to the production of fine component dough.

Water absorption capacity:

Table 2 provides information on the water absorption capacity of several finger millet varieties and genotypes, whereas Figure 3 provides a visual representation of the data. The chart made it clear that finger millet of various kinds and genotypes had a water absorption capacity ranging from 0.91 to 1.15 milliliters per gram. Significantly, variety IC0475978 had the highest WAC of 1.15 mg/g. And in VL352, the lowest were 0.91 ml/g. The results of this investigation were in line with those of Ramashia et al. (2017), who found that finger millet flours had dispersibilities ranging from 0.93 to 1.23 ml/g.

Table 2. Functional characteristics of certain varieties/genotypes of finger millet.

S.N.	Varieties/Genotypes	Dispersibility (%)	Water absorption capacity (ml/g)
1	**VL324**	86.33	1.02
2	**VL379**	90.33	0.99
3	**VL376**	80.66	0.96
4	**VL352**	90.65	**0.91**
5	**IC0475654**	85.00	0.97
6	**IC0474887**	82.33	1.01
7	**IC0475697**	**75.66**	1.04
8	**IC0478760**	82.33	0.94
9	**IC0321712**	82.00	1.05
10	**IC0475457**	87.33	1.02
11	**IC0283451**	84.66	0.97
12	**IC0476418**	87.33	1.08

13	**IC0476092**	89.66	0.95
14	**IC0474910**	85.66	0.90
15	**IC0476818**	85.66	0.98
16	**IC0475654**	85.33	0.93
17	**IC0474887**	83.00	1.05
18	**IC0475978**	**90.66**	**1.15**
19	**IC0347251**	84.33	0.94
20	**IC0474089**	88.66	0.95
	Mean	81.091	0.99
	S.E.(d)	2.095	0.032
	C.D. at 5%	4.250	0.065

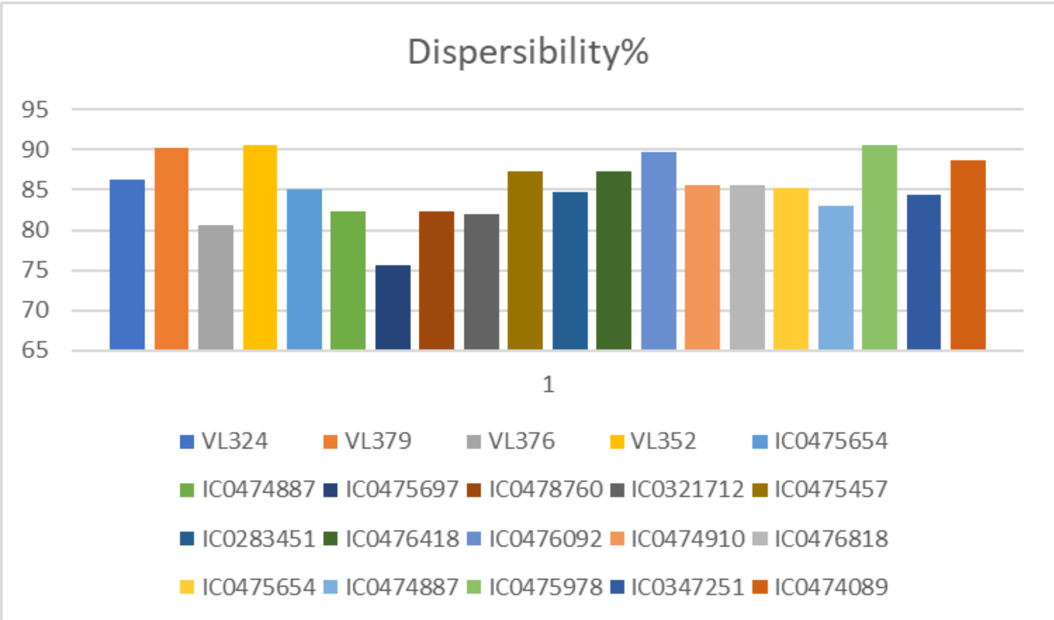


Fig.2. Dispersibility of finger millet.

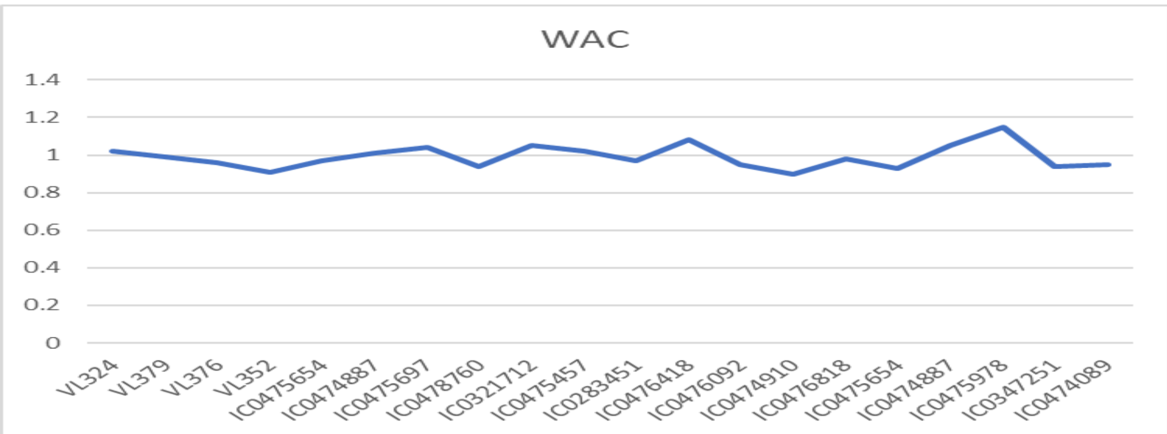


Fig.3. Water absorption capacity (ml/g) of finger millet.

Biochemical characteristics:

Carbohydrate content

Table 3 presents statistics on finger millet's performance with regard to its carbohydrate content, while Figure 4 provides a graphic illustration of the data. The chart made it clear that finger millet of various kinds and genotypes had a carbohydrate content that ranged from 69.87% to 74.78%. The variety IC0476418 had the significantly greatest carbohydrate content (74.78%), whereas IC0474910 had the lowest (69.87%). Depending on its genetic composition, different germplasms may have greater or lower carbohydrate levels. In 2013, Amadou et al. observed a similar range of carbs in their study on the nutritional value of several genotypes of ragi millet.

Protein content

Table 3 presents statistics on the protein content of finger millet, while Figure 4 provides a visual illustration of the same. The table showed that the protein content of finger millet varied in varieties and genotypes, ranging from 7.14% to 9.23%. In variety IC0476418, the protein content was found to be much higher at 9.23%. And in IC0474887, the lowest were 7.14. It was discovered that the protein composition of the germplasm was all significant. Verma and Patel (2013). The protein content and energy value were assessed using actual digestibility, biological value, net protein utilisation, and the observation of a similar range of protein. When Bhosale et al. (2020) examined the biochemical properties of finger millet, they discovered that the protein range was comparable, ranging from 5.78 to 10.96%.

Methionine content

Table 3 presents the data on the methionine content of finger millet, while Figure 4 provides a graphic illustration of the same. The data showed that the methionine concentration of finger millet varied in varieties and genotypes was between 22.15 to 30.13 mg/g protein. The variety IC0476818 had the significantly highest methionine content (30.13), while IC0475654 had the lowest (22.15). superior quality of vital amino acids, particularly cysteine and methionine.

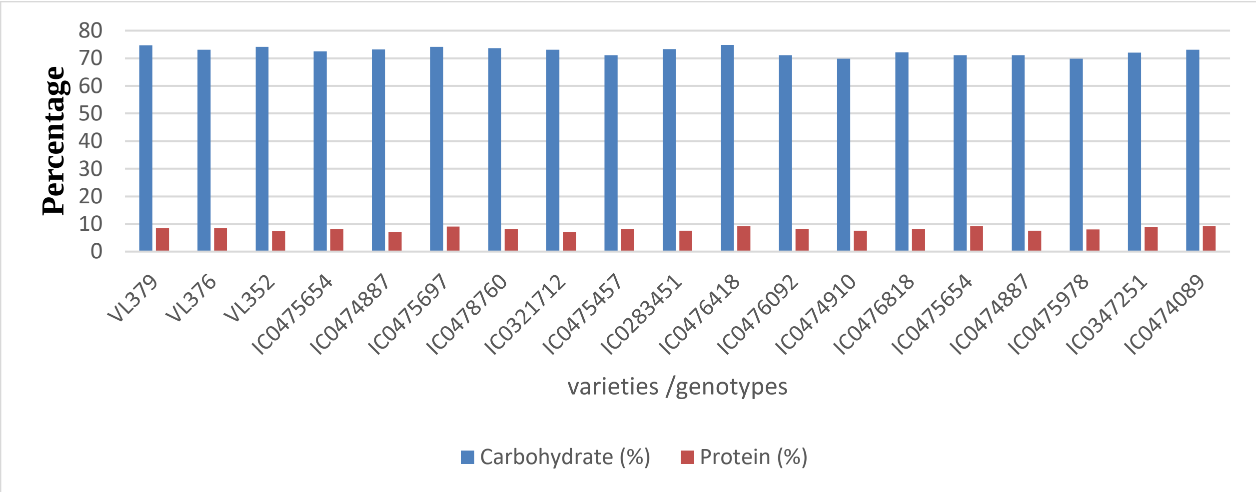
Tryptophane content

Table 3 presents the facts on the tryptophane content of finger millet, while Figure 4 provides a graphic illustration of the same. The data made it clear that the tryptophane content of finger millet varied in varieties and genotypes was between 11.27 and 19.87 mg/g protein. Variety IC0475654 had the noticeably highest tryptophane concentration, 19.87 mg/g protein. And 11.27 in IC0475457 was the lowest.Tryptophan is an essential amino acid that is involved in several metabolic activities, chief among them being the production of nicotinamide, a vitamin B6. Every germplasm has a noticeable distinction from one another. Obilana and Manyasa (2002) suggested that the variation in tryptophane content between finger millet germplasm was probably caused by changes in protein synthesis and its function in the production of aromatic amino acids. Amadou et al. (2013) provided information on the tryptophan content of several finger millet germplasm samples.

Table 3. Biochemical characteristics of certain varieties/genotypes of finger millet.

S.N.	Varieties/Genotypes	Carbohydrate (%)	Protein (%)	Methionine (mg/g protein)	Tryptophane (mg/g protein)
1	**VL324**	70.88	7.54	26.33	19.54
2	**VL379**	74.65	8.53	27.14	17.12
3	**VL376**	73.11	8.51	26.13	18.42
4	**VL352**	74.11	7.46	28.03	13.52
5	**IC0475654**	72.53	8.13	**22.15**	**19.87**
6	**IC0474887**	73.16	**7.14**	26.33	14.52
7	**IC0475697**	74.15	9.09	22.50	17.47
8	**IC0478760**	73.69	8.11	23.02	16.96
9	**IC0321712**	73.04	7.05	28.31	19.34
10	**IC0475457**	71.12	8.14	27.16	**11.27**
11	**IC0283451**	73.30	7.53	26.19	16.69
12	**IC0476418**	**74.78**	**9.23**	29.47	18.97
13	**IC0476092**	71.07	8.21	27.52	16.53

14	**IC0474910**	**69.87**	7.54	26.54	14.97
15	**IC0476818**	72.15	8.14	**30.13**	17.57
16	**IC0475654**	71.15	9.21	24.54	18.49
17	**IC0474887**	71.08	7.52	27.03	17.23
18	**IC0475978**	69.90	8.03	25.17	16.69
19	**IC0347251**	72.10	8.95	24.15	15.98
20	**IC0474089**	73.14	9.15	23.16	17.83
	Mean	68.76	8.16	26.04	16.94
	S.E.(d)	0.124	0.069	0.135	0.075
	C.D. at 5%	0.252	0.141	0.274	0.152



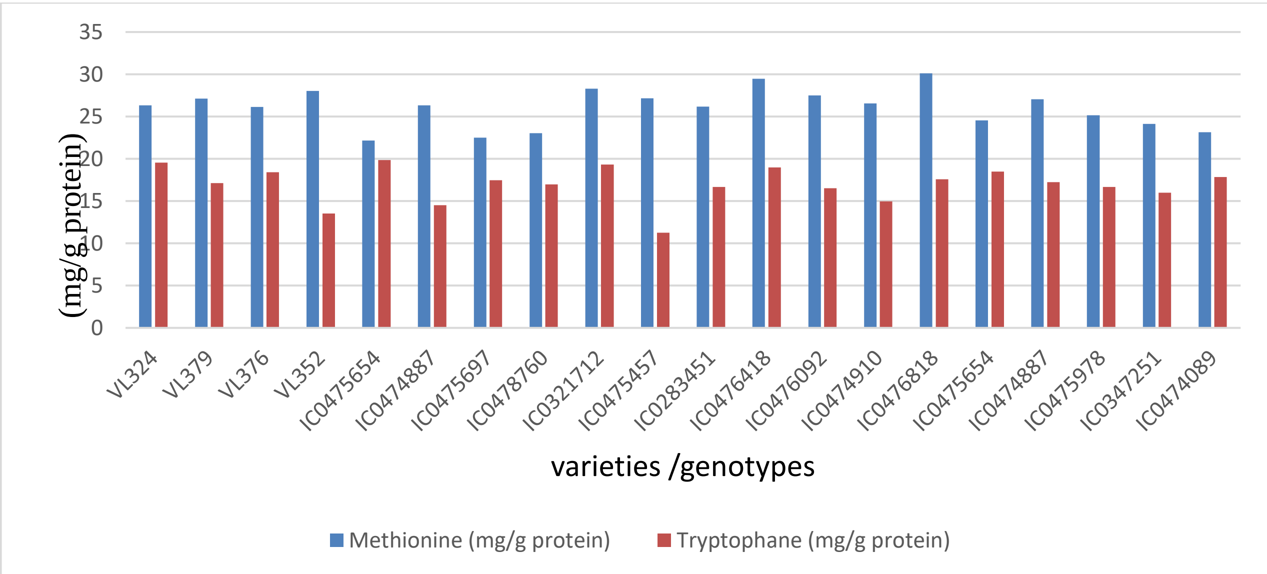


Fig.4. Biochemical properties of finger millet.

IV. CONCLUSIONS

The variety IC0321712 delivered the greatest value in test weight based on physical attributes, according to the aims and conclusions of the experiment. Dispersibility and water absorption capacity are two functional attributes where the variation IC0475978 excels greatly. Biochemically, the variety IC0476418 is outstanding. It has the greatest protein and carbohydrate content along with a sizable dose of tryptophane and methionine. Variety ICO476418 was discovered to be superior in biochemical parameters and to have important physical and functional features based on the overall observation. The findings underscore the importance of genetic diversity in finger millet and the potential for targeted breeding efforts to develop improved varieties with enhanced nutritional value, health benefits, and agronomic traits. These insights have practical implications for food security, nutrition, and agricultural sustainability, providing a foundation for further research, breeding programs, and the promotion of finger millet as a valuable crop for human consumption and agricultural development.

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