International Scientific Journal of Engineering and Management ISSN: 2583-6129
Volume: 03 Issue: 12 | Dec – 2024 DOI: 10.55041/ISJEM02158
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

Thermogravimetric Analysis (TGA) Of Starch Extracted from Banana Pseudo-Stem

***Dr. Priya D. Patil**

***Department of Botany, Vivekanand College, Kolhapur (An Empowered Autonomous Institute)**

***E-mail: ppriya.patil@vivekanandcollege.ac.in / ppriya.patil@rediffmail.com**

Abstract: The study investigates the thermal decomposition behavior of starch extracted from banana pseudo-stem using Thermogravimetric analysis (TGA). In banana pseudo-stem starch, TGA reveals a multi-stage degradation process. The gelatinization temperature of starch was between 54.04° C – 112.16° C. The results from this finding show that the starch obtained from pseudo-stem could be a potential source of starch that can be commercialized, and thus increase the sources of starch in the food industry. The results provide insight into the thermal stability and degradation profile, supporting potential industrial applications of banana pseudo-stem starch in bioplastics and biodegradable materials. The TGA results indicate three major weight loss stages related to moisture evaporation, starch decomposition and carbonization.

Keywords: *Banana pseudo-stem, starch, Thermogravimetric analysis, thermal stability, biodegradable materials etc.*

Introduction:

The most affordable, abundant, and nearly nourishing fruit is the banana. It has all the necessary nutrients, provides a number of therapeutic benefits and contains vitamins and minerals. A ripe banana has 70% moisture, 0.5% crude fiber, 1.2% proteins, 27% carbohydrates, 0.3% lipids, 0.9% minerals, 29 mg of phosphorus, 8 mg of calcium, 0.6 mg of iron, 0.5 mg of b-carotene, 0.7 mg of niacin, 12 mg of ascorbic acid, 0.05 mg of riboflavin, and 104 cal/100 g of energy [1].

Increased environmental concern has spurred interest in biodegradable materials derived from renewable sources. The growing interest in biodegradable materials has directed attention towards non-conventional sources of starch. Banana pseudo-stem, an agricultural waste by-product, is a promising raw material for starch extraction due to its high polysaccharide content. Understanding the thermal behavior of this starch is critical for evaluating its suitability in thermal processing applications [2, 3]. The banana pseudo-stem is made up of tightly packed leaf sheaths that thicken as a result of the lower midrib being modified until the plant reaches its maximum height. It began when the reproductive organ started to take shape. The pseudo-stem of bananas is said to be red, reddish-green, and yellowish in colour [4]. The increase in the area planted to bananas can serve as a gauge for the increase in waste. The banana plant is within the category of annual agricultural wastes. The pseudo-stem is chopped off when the banana fruits are picked, and as they cannot bear fruit twice, the majority are either left in the soil plantation or disposed of somewhere else to decompose. Pollution of the environment would result from this crop waste that was abandoned [5]. It is possible to use banana pseudo-stem as a feedstock for energy production [6].

International Scientific Journal of Engineering and Management
Volume: 03 Issue: 12 | Dec – 2024
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata
ISSN: 2583-6129
DOI: 10.55041/ISJEM02158

Material and Methods:

Sample Preparation: Starch was extracted from banana pseudo-stem through a wet extraction method involving maceration, filtration and drying [7].

Theromogravimetric Analysis (TGA): TGA was performed using a Thermogravimetric analyzer (Model: SDT Q600) under a nitrogen atmosphere. Approximately 10 mg of the starch sample was heated from 25° C to 600° C at a rate of 10° C/min.

Results and Discussion:

The results of DSC analysis of starch isolated from the banana pseudo-stem starch is summarized in Table 1. The transition temperatures (T_O), range 2($T_p - T_O$), enthalpies of gelatinization (ΔHG), and peak height indices (PHI) of starch of banana pseudo-stem differ significantly (Figure: 1). This is because of their qualitative and quantitative make up as well as their physico-chemical and functional properties [8].

Table 1: Gelatinization properties of Banana pseudo-stem starch

Sr. No.	Starch source	T_{OG}	T_{PG}	T_{CG}	T_{PG}-T_{OG}	ΔHG	R_G $2(T_{PG} - T_{OG})$	PHI
1.	Banana Pseudo-stem	54.04	80.98	112.16	31.18	16.52	62.36	0.53

T_{0G}, onset temperature, T_{PG}, peak temperature, T_{CG}, conclusion temperature, ΔHG, enthalpy of gelatinization, RG, gelatinization range; PHI, peak height index ΔHG/ (T_{PG} - T_{0G}) .

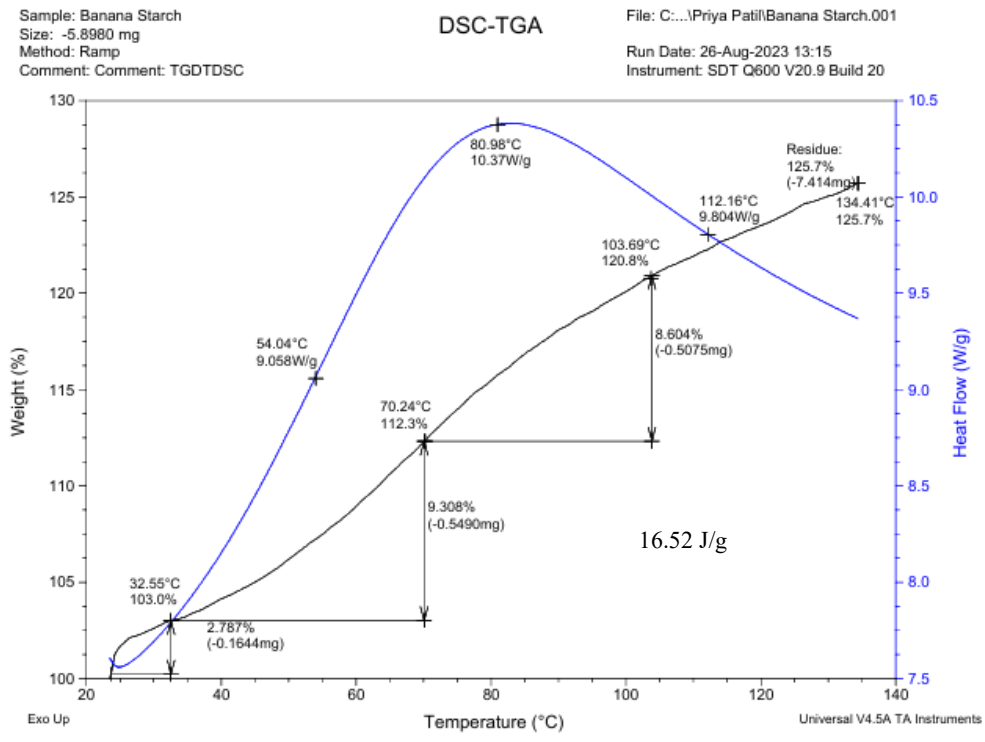

Figure 1: DSC thermogram of gelatinization of banana pseudo-stem starch

ISSN: 2583-6129
DOI: 10.55041/ISJEM02158

Peak Height Index (PHI), is a parameter which represents the uniformity of gelatinization. Isolated starch of banana pseudo-stem showed the lowest ΔHG value 16.52 J/g. Starch showed significantly lower onset temperature (T_O), peak temperature (Tp) and conclusion temperature (Tc). This variation in transition temperatures is related to the granule size, microstructure, proportion, form of crystalline organization and the ratio of amylose and amylopectin [9, 10]. PHI, a measure of uniformity in gelatinization, was found to be lower in isolated starch of banana pseudo-stem (0.53). The transition temperatures observed for the Banana starch was higher than those earlier observed for corn, wheat, potato and rice [11]. Banana pseudo-stem starch with low To, broad R, low peak height index (PHI) has irregular and large sized granules. Low To, broad R and low PHI of starches might have irregularity shaped granules or granules of many different sizes [12].

The TGA showed three district weight loss stages:

Temperature °C	**Weight** %	**Heat Flow** W/g	**Temperature Difference** °C/mg
0	-	-	-
10	-	-	-
20	-	-	-
30	102.6	7.692	0.8042
40	104.1	8.151	0.8217
50	106.2	8.784	0.8601
60	108.9	9.496	0.9049
70	112.3	10.09	0.937
80	115.5	10.37	0.9333
90	118.1	10.32	0.8977
100	120.1	10.1	0.8474
110	121.9	9.856	0.7984
120	123.5	9.634	0.7536
130	125	9.443	0.7148

Stage I (30-100°C): An initial weight loss of ~10% was observed, attributed to moisture and physically absorbed water.

Stage II (110-120°C): A major degradation phase occurred, accounting for approximately ~60 to 70% weight loss. This phase corresponds to the thermal decomposition of starch components such as amylose and amylopectin. Maximum degradation occurred near 310° C.

Stage III (>120°C): Gradual weight loss continued, likely due to degradation and char formation.

These finding are consistent with the degradation patterns of starches from other botanical sources [13]. The thermal decomposition data **suggest** that banana pseudo-stem starch exhibits thermal stability comparable to other plant-based starches, making it suitable for thermoplastic applications and biopolymer development [14].

Conclusion:

The composition and other characteristics of starch were significantly influenced by botanical sources. Thermogravimetric analysis reveals that starch derived from banana pseudo-stem undergoes a typical thermal degradation pattern with good thermal stability. Its decomposition profile supports its potential use in the development of biodegradable materials, such as bioplastics and packaging applications. The results of this study should assist develop new commercially viable sources of starch and boost the food industry's economy.

Acknowledgment:

The author acknowledges DST supported 'Sophisticated Analytical Instrument Facilities (SAIF) in Shivaji University, Kolhapur, Maharashtra" For providing with "Differential Scanning Calorimetry model SDT Q600, TA Instruments, USA" facility accessed through I-STEM (Indian Science, Technology and Engineering Facilities Map) portal, supported by the Office of the Principal Scientific Adviser to the Govt. of India. Also, Author would like to thank Principal, Vivekanand College, Kolhapur (An Empowered Autonomous Institute) for funding for this work under seed money scheme for Research.

References:

1. Bello-Perez, (1984). Isolation and partial characterization of banana starches. *J Agric. Food Chem*., 47:854-857.
2. Zuraida, A. R. (2020). Characterization of starch from banana (*Musa paradisica*) pseudo-stem waste. *Journal of Polymers and the Environment*, 28: 2355-2364.
3. Hoover, R. (2001). Composition, molecular structure and physic-chemical properties of tuber and root starches: a review. *Carbohydrate Polymers*, 45 (3): 253-267.
4. Sumardi I. and Wulandari M. (2010). Anatomy and morphology character of five Indonesian banana cultivars (Musa spp.) of different ploidy level. *Biodiversitas,* 11: 167–175.
5. Li K., Fu S., Zhan H., Zhan Y. and Lucia L. A. (2010). Analysis of the chemical composition and morphological structure of banana pseudo-stem. *Bioresources*, 5: 576–585
6. Abdullah N, Sulaiman F., Miskam M. A. and Mohd Taib R. (2014). Characterization of banana (Musa spp.) pseudo-stem and fruit-bunch-stem as a potential renewable energy resource. *World Acad. Sci. Eng. Technol.*, 8: 815–819.
7. Patil, P. D. (2022). Morphological, structural and physic-chemical properties of starch extracted from Banana pseudo-stem: A Novel Source. International Journal of food and nutritional sciences, 11(12): 15212-15222.
8. Patil, P. D. and Chavan, N. S. (2015). Studies on thermal behavior and properties of starch isolated from Bruguiera species. *Advances in Biomedicine and Pharmacy*, 2 (2): 100-114.
9. Singh S.K., Johnson L.A., White P.J., Jane J.L. and Pollak L.M., "Thermal properties and paste and gel behaviors of starch recovered from accessions used in the germplasm enhancement of maize project", Cereal Chem., 78: 315-321, 2001.
10. Banks W., Greenwood C.T. and Muir D.D., "Studies on the biosynthesis of starch granules. Properties of the starch granules of normal barley, and barley with starch of high amylose-content, during growth", *Starke*, 25: 225–230, 1973.
11. Singh N., Singh J., Kaur L., Sodhi N.S. and Gill B.S. (2003). "Morphological, thermal and rheological properties of starches from different botanical sources—a review", *Food Chem.,* 81: 219–231.
12. Bagley E.B. and Christiansen D.D. (1982). "Swelling capacity of starch and its relationship to suspension viscosity: effect of cooking time, temperature and concentration", *J. Texture Studies,* 13: 115-126.
13. Wang, S. and Copeland, L. (2012). Effect of acid hydrolysis on starch structure and functionality: A review. *Critical Reviews in Food Science and Nutrition*, 52(5): 440-452.
14. Arulrajah, A. (2014). Feasibility study of utilization of banana pseudo-stem as raw material for biodegradable plastic. *Materials Today*: Proceedings, 1(1): 159-165.