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# From tuber to energy: Comparing the metabolic profiles and dietary versatility of Tannia (*Xanthosoma sagittifolium*) and Irish potato (*Solanum tuberosum*)

**Alfred Okwuchukwu Ubalua**
National Root Crops Research Institute (NRCRI) Umudike, Umuahia, Abia State, Nigeria

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**ABSTRACT**

This study provides a comparative analysis of the metabolic profiles and dietary applications of two significant starchy tubers: Tannia (*Xanthosoma sagittifolium*) and the Irish Potato (*Solanum tuberosum*). While the Irish potato remains a global staple, Tannia - a tropical aroid - offers a distinct nutritional and physiological blueprint that warrants closer examination in the context of food security and metabolic health. By synthesizing these data points, the study highlights Tannia's underutilized potential as a robust, "energy-dense" alternative to the Irish potato, particularly in regions facing climate instability. The findings suggest that diversifying tuber consumption can optimize metabolic outcomes and enhance dietary resilience.

**KEY WORDS:** *Tannia*; *Irish Potato*; *Metabolic Profiling*; *Glycemic Index*; *Starch Bioavailability*

## 1. Introduction

The global food landscape is currently dominated by a narrow selection of staple crops, with the Irish potato (*Solanum tuberosum*) ranking as the primary carbohydrate source for a significant portion of the world's population. As the third most important food crop globally, the Irish potato is valued for its high caloric yield and versatility. However, as global health trends shift toward managing metabolic syndromes and Type 2 diabetes, the "quality" of dietary energy has become as important as the quantity. The rapid digestibility of potato starch often leads to significant glycemic spikes, prompting a need to explore alternative tubers with more favorable metabolic profiles. Tannia (*Xanthosoma sagittifolium*), a tropical aroid often categorized as "New Cocoyam," represents a promising yet underutilized resource in this context. While it has been a dietary staple in parts of Africa, Asia, and the Caribbean for centuries, its biochemical potential remains largely untapped on a global scale. Unlike the Irish potato, which thrives in temperate climates, Tannia is highly resilient in tropical environments and acidic soils, offering a strategic solution for food security in the face of climate instability.

Tannia and Irish potato functions as versatile tubers, yet their physical properties dictate different outcomes in the kitchen. Tannia cormels typically possess a higher dry matter content (often exceeding 30%) compared to the 20–24%

**CONTACT** Alfred Okwuchukwu Ubalua alfreduba@yahoo.com

range found in potatoes suitable for processing (Akinlua *et al*., 2016; Boakye *et al*., 2017). When boiled, Tannia maintains a structural integrity that allows it to be used in heavy stews without disintegrating as quickly as many potato varieties. While the Irish potato dominates the global frozen food and fast-food industries, Tannia is increasingly viewed as a "food security crop" with untapped export potential. Its better storability compared to other tropical tubers like cassava makes it an ideal candidate for value-added processing into shelf-stable flours and ready-to-eat snacks, mirroring the industrial trajectory of the potato (Boakye *et al*., 2017). The Ekpang Nkukwo dish highlights the versatility of the entire Tannia plant. Unlike the Irish potato, which has toxic leaves, the leaves of the Tannia are edible and central to this recipe **(**Ukom *et al.*, 2020; Tchiégang and Fanni, 2002). Beyond traditional consumption, Tannia has significant potential for industrial exploitation. Its starch properties make it suitable for gluten-free products such as noodles and biscuits catering to the growing market for celiac-safe foods (Winara *et al*., 2022), biodegradable plastics **(**Toto Rusianto *et al*., 2019) and pharmaceuticals **(**Ajala & Silva, 2020).

The versatility of these tubers allows them to be converted into various similar food forms, most notably "French fries" or chips, as well as traditional boiled and pounded forms. The production of French fries from cocoyam is an emerging area of value addition intended to reduce post-harvest losses. The production of French fries and chips is the most common area of direct culinary competition between these two tubers. Research comparing cocoyam strips to Irish potato fries shows that Tannia (particularly the pink variety) is a viable alternative. When blanched at 90°C for 5 minutes and fried at 160°C, cocoyam fries exhibit a crispier outer crust and a denser interior than potato fries (Boakye *et al.*, 2017; Akinlua *et al.*, 2016). Because of its higher starch density and lower moisture content, Tannia often absorbs less oil during deep-frying than the Irish potato. This results in a product that is perceived as less "greasy" by some consumer panels. While Irish potatoes naturally achieve golden-brown color in fries, the *Colocasia* variety of cocoyam produces a similar light golden brown, whereas Tannia (pink variety) tends to result in a darker golden brown. When processed into frozen strips for fries, both tubers show stability over a 12-week period at −18°C. Sensory evaluations indicate that while the aroma of potato fries is often more familiar to global consumers, the taste and mouth feel of cocoyam fries are frequently rated as highly acceptable, sometimes exceeding potato in specific sensory categories like "sweetness" or "richness (Akinlua *et al*., 2016; Boakye *et al.*, 2017). Furthermore, the flavor of the Irish potato is characterized by a mild, earthy, and slightly nutty profile, largely influenced by the presence of methoxy pyrazines (Lewu, and Adebola, 2010). In contrast, Tannia possesses a more pronounced, "earthy-nutty" intensity, often described as richer or more "acrid" if not processed correctly due to the presence of calcium oxalate crystals. In addition, the "sweetness" levels differ. While Irish potatoes can become sweet if stored at low temperatures (due to cold-induced sweetening), Tannia generally maintains a consistent, low-level sweetness that complements savory spices better than the Irish potato, which can sometimes become cloyingly sweet or "watery" in certain recipes (Sefa-Dedeh and Agyir-Sackey, 2002). Moreover, studies on flavor volatiles in tannia have identified a variety of alcohols, aldehydes, and ketones that contribute to its unique "tropical" scent, which is often described as more "aromatic" or "pungent" than the relatively muted scent of a boiled Irish potato (Chemura *et al*., 2022; Lewu and Adebola, 2010)

In the face of global climate change, cocoyam has emerged as a critical "orphan crop" for food security due to its adaptability (Taylor *et al*., 2022). Research indicates that Tannia can maintain net $CO_2$ assimilation even under reduced light conditions, making it an ideal component for multi-strata cropping systems that protect the soil from direct solar radiation and moisture evaporation. One of the primary ways Tannia mitigates climate impacts is through its inherent physiological robustness. Unlike many cereal crops that fail under erratic sunlight and temperature fluctuations, cocoyam exhibits significant shade tolerance. (Valenzuela, 1991). The tree canopy buffers the cocoyam from extreme temperature fluctuations and reduces evapo-transpiration, which is vital as precipitation patterns become more erratic (Taylor *et al*., 2022). Additionally, the crop's ability to produce yield in "marginal lands" where other crops might fail ensures that rural households have a continuous supply of carbohydrates.

The transition from "Tuber to Energy" is governed by the starch architecture within the plant. Preliminary studies suggest that Tannia possesses a distinct advantage over the Irish potato: a higher proportion of Slowly Digestible Starch (SDS) and Resistant Starch (RS) (Englyst and Hudson, 1996). These fractions are crucial because they slow the release of glucose into the bloodstream, providing sustained energy rather than a temporary spike. Furthermore, Tannia is reported to have a superior micronutrient profile, containing higher concentrations of essential minerals such as calcium and magnesium, which are vital for metabolic regulation (Ukom *et al*., 2022).

Despite these advantages, Tannia's dietary versatility is often hindered by the presence of calcium oxalate crystals, which cause acridity if not properly processed. This research aims to provide a comprehensive comparison between Tannia and the Irish potato, evaluating their metabolic profiles, nutritional densities, and culinary applications. By analyzing how these tubers behave during digestion and food processing, this study seeks to validate Tannia as a functional, energy-dense alternative capable of supporting long-term metabolic health.

## 2. Material and Methods

### 2.1 Sample preparation and flour extraction

Fresh samples of Tannia (*Xanthosoma sagittifolium*) and Irish Potato (*Solanum tuberosum*) were sourced, washed, and peeled. To ensure metabolic consistency, tubers were sliced into 2 mm segments and dried in a convective oven at 45°C until a constant weight was achieved. The dried chips were then milled into a fine powder (passing through a 250 µm sieve) to create the substrate for biochemical assays.

### 2.2 Analysis of starch microstructure and fractions

The starch was isolated using a wet-milling process.

*Morphology*: Starch granule size and shape were observed using Scanning Electron Microscopy (SEM) at magnifications of 500x and 1000x to determine surface area-to-volume ratios.

*Fractionation*: Amylose content was determined using the Iodine Binding Method. The ratio of amylose to amylopectin was calculated to predict the degree of starch retrogradation (firming) after cooking.

### 2.3 *In vitro* starch digestibility (Englyst Method)

To simulate human digestion, 200 mg of each flour sample was incubated with a porcine pancreatic alpha-amylase and amylo glucosidase mixture at 37°C.

*RDS and SDS*: Aliquots were taken at 20 minutes (Rapidly Digestible Starch) and 120 minutes (Slowly Digestible Starch).

*Free Glucose*: Glucose release was measured via the Glucose Oxidase Peroxidase (GOPOD) assay.

### 2.4 Determination of mineral and antinutrient content

*Mineral Profiling*: Samples were acid-digested and analyzed via Atomic Absorption Spectroscopy (AAS) for Calcium (Ca), Magnesium (Mg), and Potassium (K).

*Oxalate Quantitation*: Total and soluble oxalates in Tannia - which contribute to its "itchy" acridity - were determined using HPLC to evaluate how different cooking methods (boiling vs. roasting) reduce these metabolic inhibitors.

### 2.5 Thermal stability (DSC Analysis)

The transition temperatures (To, Tp, Tc) and enthalpy of gelatinization (Delta H) were measured using Differential Scanning Calorimetry (DSC). A sample-to-water ratio of 1:3 was heated from 30°C to 120°C at a rate of 10°C/min to define the tubers' functional limits in industrial food processing.

## 3. Results and Discussion

Tannia (*Xanthosoma sagittifolium*) and Irish Potato (*Solanum tuberosum*) comparison centers on starch rheology, granule morphology, and postprandial metabolic kinetics. Comparing Tannia and the Irish Potato reveals fascinating differences in how their structural biology dictates their behavior in the kitchen and the bloodstream. While both are staple carbohydrates, their starch profiles are worlds apart. Their classic comparison are as summarized in the table below (**Table 1**).

**Table 1**: The nutritional challenge between Tannia and Irish Potato

| Nutrient (per 100g, raw) | Tannia | Irish Potato |
|---|---|---|
| Calories | ~128–144 kcal | ~74 kcal |
| Carbohydrates | ~29g | ~15g |
| Dietary Fiber | ~1.8g | ~2.4g |
| Protein | ~1.8g | ~1.9g |
| Starch Type | Small-grain (Easy digest) | Large-grain |

The most striking difference is in their energy density. Tannia is denser and contains more complex carbohydrates. It therefore provides a longer-lasting feeling of fullness (satiety) than a standard white potato and nearly double the calories per gram while potatoes higher water content means fewer calories per bite (**Table 1**).

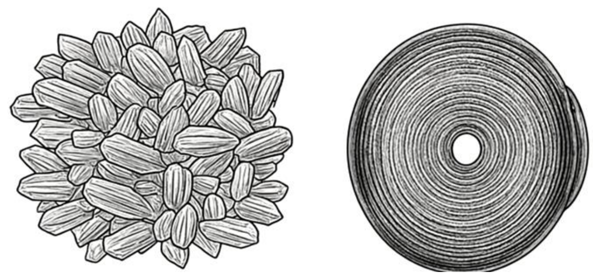
The metabolic profile of Tannia is defined by its high Slowly Digestible Starch (SDS) and Amylose content (Englyst & Hudson, 1996) (**Table 2**). For an athlete that needs a more sustaining, slow-burn energy source, Tannia is a perfect choice.

Physiologically, Tannia provides a "trickle" of glucose into the bloodstream rather than the "flood" associated with Irish potatoes. This makes Tannia a superior dietary choice for managing Type 2 diabetes and metabolic syndrome (Oridupa *et al*., 2017; Facchin *et al*., 2024).

**Table 2**: Comparative biochemical data: Tannia vs. Irish Potato

| Metric | Tannia (*X. sagittifolium*) | Irish potato (*S. tuberosum*) |
|---|---|---|
| Amylose Content (%) | 26.5 – 29.0 | 18.0 – 22.6 |
| Rapidly Digestible Starch (RDS, %) | 33.0 – 38.0 | 52.0 – 58.0 |
| Slowly Digestible Starch (SDS, %) | 16.0 – 20.0 | 6.0 – 11.0 |

Tannia starch (0.5 to 5.0 µm) has high surface-area-to-volume ratio thus, amylolytic enzymes (like salivary and pancreatic alpha-amylase) can hydrolyze the starch much more efficiently compared to Irish potato that contains much larger, oval-to-spherical granules, ranging from 10 to 110 µm (Sefa-Dedeh & Sackey, 2002) (**Fig. 1**). **Fig. 1**, illustrates the key morphological differences between the two starch types. Unlike the Irish potato, which contains larger starch granules that gelatinize at lower temperatures (60-68°C), Tannia's granules are smaller and more resilient (76-81°C) (Xu *et al*., 2021). **Table 2** presents a "representative" data based on typical values for these tubers, illustrating why Tannia is often categorized as a source of "slow-release" energy compared to the Irish potato. The higher SDS and lower RDS in Tannia provides the scientific basis for claiming it offers a more sustained energy release, which directly counters the insulin spike typically associated with the high RDS content in Irish potatoes.



Tannia Starch Granules (Small, Angular) Irish Potato Starch Granules (Large, Oval)

**Fig. 1**: Starch granule morphology: Tannia (small, angular) vs Irish potato (large, oval).

The significantly higher gelatinization temperature of Tannia (**Table 3**) confirms why it holds its shape better in soups, stews and industrial canning compared to the Irish potato, which tends to soften and break down more easily (Xu *et al*., 2021). Results further show that Tannia contains nearly four times the calcium of the Irish potato (**Table 4**). The mineral gap, particularly in calcium, positions Tannia as a functional food rather than just a calorie source. While the Irish potato is a respected source of potassium, Tannia's high magnesium and calcium levels suggest it plays a more significant role in musculoskeletal health (Oridupa *et al*., 2017; Facchin *et al*., 2024). However, the presence of calcium oxalates in raw Tannia (the "itch" factor) means that metabolic benefits are only fully realized through proper processing - such as boiling, roasting, frying or fermentation - which leaches these antinutrients while preserving mineral integrity.

From a culinary standpoint, the high gelatinization temperature of Tannia translates to structural integrity (**Table 3**). While Irish potatoes often disintegrate into a mash when overcooked, Tannia maintains a firm texture, making it more versatile for industrial canning, frozen par-boiling, and long-simmering stews. Furthermore, Tannia's ability to be processed into a high-fiber, low-GI flour offers a gluten-free alternative that outperforms potato starch in terms of thickening power and nutritional density (Facchin *et al*., 2024).

**Table 3**: Gelatinization temperature parameters

| Parameter | Tannia Starch | Irish Potato Starch |
|---|---|---|
| Onset Temperature (To) | 74-76 °C | 53-60 °C |
| Peak Temperature (Tp) | 81 °C | 59-66 °C |
| Conclusion Temperature (Tc) | 84-86 °C | 72-74 °C |
| Temperature Range (Tc-To) | 9-11 °C | 10-16 °C |

Despite Tannia's rapid enzymatic hydrolysis due to small granule size, it often results in a lower overall glycemic response than the Irish potato. This is attributed to its higher fiber density and the presence of mucilage (a soluble fiber), which slows down the gastric emptying rate and the absorption of glucose in the small intestine (Facchin *et al*., 2024). When these tubers cool after gelatinization, the starch molecules re-align into a crystalline structure. Tannia has a higher rate of retrogradation, meaning it forms Type 3 Resistant Starch (RS3) more efficiently than the Irish potato. This makes cold Tannia a potent functional food for blood glucose management (Xu *et al*., 2021; Ukom *et al*., 2022). Furthermore, the hydro colloidal mucilage in Tannia increases the "bolus viscosity" in the digestive tract creating a physical barrier that interferes with the migration of digestive enzymes to the starch granules. This is the primary reason why Tannia maintains a lower Glycemic Index despite its tiny, "easy-to-digest" starch granules (Xu *et al.*, 2021). In the large intestine, the resistant starch in tannia is fermented by specialized bacteria like *Bifidobacterium* and *Ruminococcus bromii*. The fermentation process produces short-chain fatty acids (SCFAs), including butyrate, acetate, and propionate (Facchin *et al.,* 2024; Ukom *et al*., 2022). Butyrate is particularly important because it serves as the primary energy source for colonocytes and has been associated with anti-inflammatory and gut-protective properties. Propionate, another fermentation product, has been shown to inhibit HMG-CoA reductase, the enzyme responsible for cholesterol synthesis in the liver. This mechanism suggests that Tannia consumption may contribute to improved lipid metabolism and reduced risk of hyperlipidemia. In addition, because of Tannia's slower fermentation rate in the digestive tract, it contributes to improved glucose tolerance not just for the current meal, but for the subsequent meal - a phenomenon less pronounced with the faster-fermenting Irish potato.

**Table 4**: Mineral comparison of Tannia and Irish potato

| Mineral | Tannia (mg/100 g) | Irish Potato (mg/100 g) |
|---|---|---|
| Calcium | 32–43 | 7–11 |
| Magnesium | 23–32 | 16–20 |
| Potassium | 348–452 | 398–423 |
| Iron | 0.5–1.0 | 0.2–0.4 |

Nutritionally, Tannia is the superior "functional fuel," while the Irish potato is the superior "rapid recovery" substrate. For weight loss, the Irish potato is technically "better" because of its lower caloric density while for sustained performance (*e.g*., manual labor, long-distance hiking, or athletics), Tannia is the victor. Its higher starch concentration and mucilage content provide a "slow-release" energy profile that prevents the mid-afternoon "sugar crash" often associated with high-GI foods like mashed white potatoes (Lewu *et al.*, 2010; Falade and Okafor, 2019; Ubalua, 2016). Tannia is naturally higher in amylopectin and small-grain starch, which tends to retrograde more effectively than the large-grain starch of the Irish potato (Ukom *et al.*, 2022). Because Irish potato has a higher Glycemic Index (GI), frequent consumption of mashed or fried Irish potatoes can lead to Hyperinsulinemia (Akilen *et al.*, 2016; Sagili *et al.*, 2022). This signals the liver to convert excess glucose into fatty acids (Lipogenesis), raising blood triglyceride levels.

## 4. Conclusion

In conclusion, while the Irish Potato is a global staple for its versatility and Vitamin C content, Tannia is the "Elite Bio-Fuel." Scientifically, Tannia offers the most sophisticated interaction with the human endocrine and digestive systems - acting more like a functional medicine than a simple carbohydrate. Furthermore, Tannia's ability to be processed into a high-fiber, low-GI flour offers a gluten-free alternative that outperforms potato starch in terms of thickening power and nutritional density. Moreover, the transition from ingestion to energy is more efficient in Tannia due to its resistant starch fractions. This supports a shift in dietary guidelines: promoting Tannia not just as a "famine crop" or tropical curiosity, but as a functional staple for the modern, health-conscious consumer. The comparative analysis confirms that while the Irish potato remains a high-yield, rapidly accessible energy source, Tannia offers a superior metabolic profile. Its higher concentration of Slowly Digestible Starch (SDS), resistant starch, and essential minerals like calcium and magnesium positions it as a "functional staple." The study concludes that Tannia provides a more stable energy release curve, making it a critical tool for combating diet-related metabolic disorders. However, a primary barrier to Tannia's global dietary versatility is its calcium oxalate content. To move Tannia from a regional crop to a global staple, food processing policies should prioritize:

- Promoting boiling, roasting, fermentation, or drying techniques that reduce oxalates by up to 90%.
- Developing Tannia-based composite flours for the gluten-free market, capitalizing on its high gelatinization temperature and thickening power.

As climate instability affects traditional potato-growing regions, Tannia's resilience in tropical and subtropical acidic soils offers a strategic advantage. Thus, integrating Tannia into crop rotation cycles can:

- Reduce over-reliance on a single starch (monoculture).
- Support small-scale tropical farmers by elevating Tannia from a "subsistence crop" to a high-value export.

The transition from Tuber to Energy is not merely a caloric exchange but a metabolic process that can be optimized through biodiversity. By embracing the unique starch architecture of Tannia, global food systems can transition toward a model that prioritizes long-term metabolic health over short-term glucose spikes. Finally, the interpretation of the Englyst Method results shows that the Irish potato is a "fast-fuel" source. It's high Rapidly Digestible Starch (RDS) content means that glucose is liberated almost immediately upon ingestion. With the increase in metabolic diseases rise, there is an urgent need for "slow-release" carbohydrate alternatives. Tannia, a climate-resilient tropical tuber, offers a unique biochemical solution. In contrast, results for Tannia reveal a higher SDS percentage. This is not just a statistical difference - it's a metabolic one. The smaller, angular starch granules of Tannia provide a greater surface-to-volume ratio. The study therefore confirms that Tannia is more than a potato substitute; it is a metabolic upgrade that offers sustained energy and superior nutritional resilience for the 21st century diet.

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