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biomolecules

MDPI

The effect of heat-moisture treatment (HMT) on the structural, functional properties and digestibility of citric acid-modified *Plectranthus rotundifolius* (Hausa potato) starch

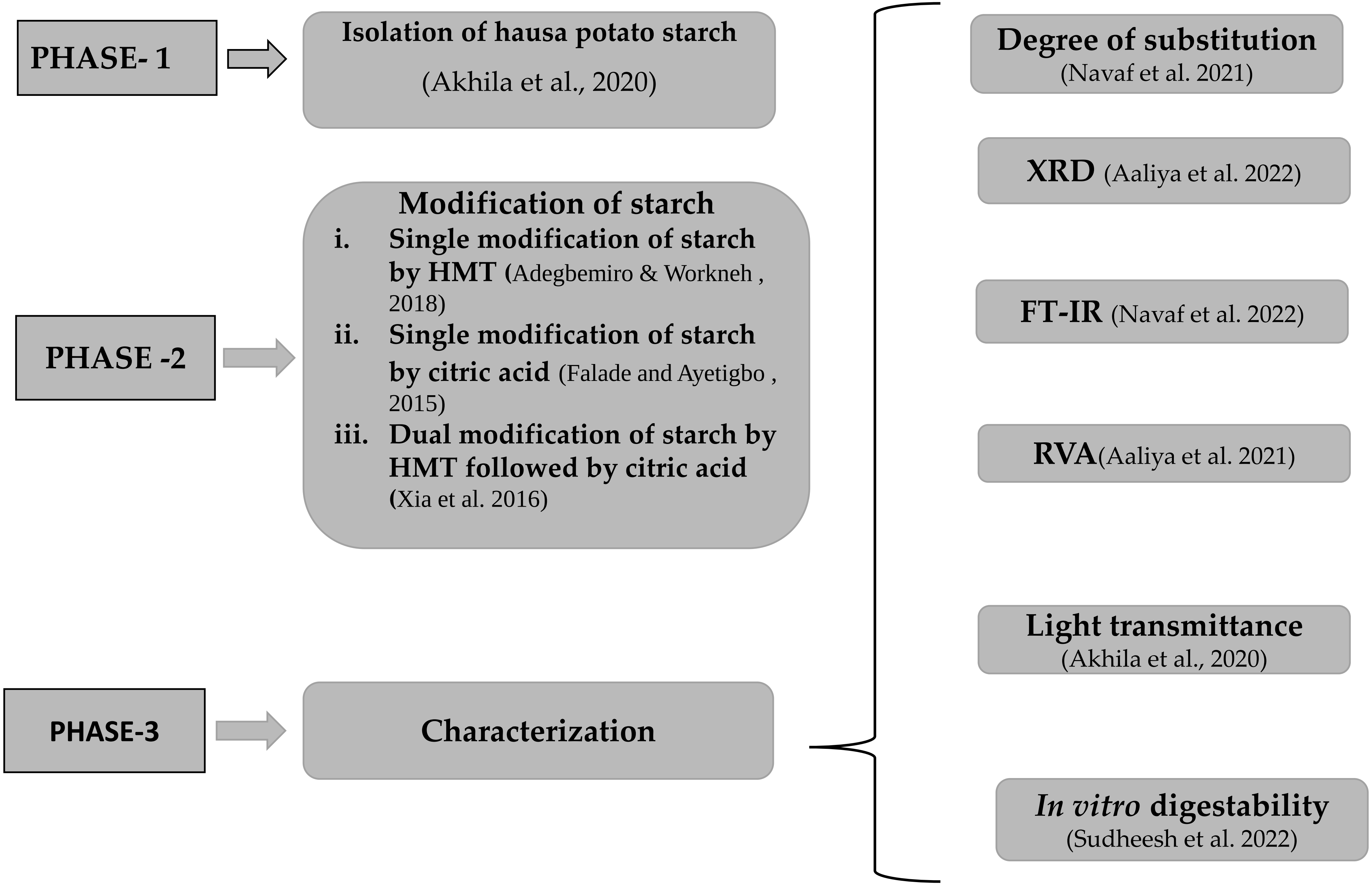
Introduction

- Starch is a naturally abundant biopolymer found in the plant
- Hausa potato (*Plectranthus rotundifolius*) tuber is a non-conventional source of starch.
- Starch has been modified to achieve its industrial need by physical, chemical, and enzymatic methods.
- HMT is the cheapest method that alters the crystalline and amorphous area of starch by treating it at high temperature (90–120 °C) with a moisture content of 20–35 % for a specific period to starch
- Citric acid esterification promotes the usage of green chemicals and confers unique physicochemical properties to starches

Objectives

- To isolate Hausa potato starch from Hausa potato (*Plectranthus rotundifolius*)
- To modify the Hausa potato starch by HMT and citric acid
- To dual modify the Hausa potato starch by HMT-citric acid.
- To study the physicochemical characterization of modified starch

Plan of work



PHASE- 1
Isolation of hausa potato starch
(Akhila et al., 2020)
PHASE -2
Modification of starch
i. Single modification of starch by HMT (Adegbemiro & Workneh , 2018)
ii. Single modification of starch by citric acid (Falade and Ayetigbo , 2015)
iii. Dual modification of starch by HMT followed by citric acid (Xia et al. 2016)
PHASE-3
Characterization
Degree of substitution
(Navaf et al. 2021)
XRD (Aaliya et al. 2022)
FT-IR (Navaf et al. 2022)
RVA(Aaliya et al. 2021)
Light transmittance
(Akhila et al., 2020)
In vitro digestability
(Sudheesh et al. 2022)

Result and discussion

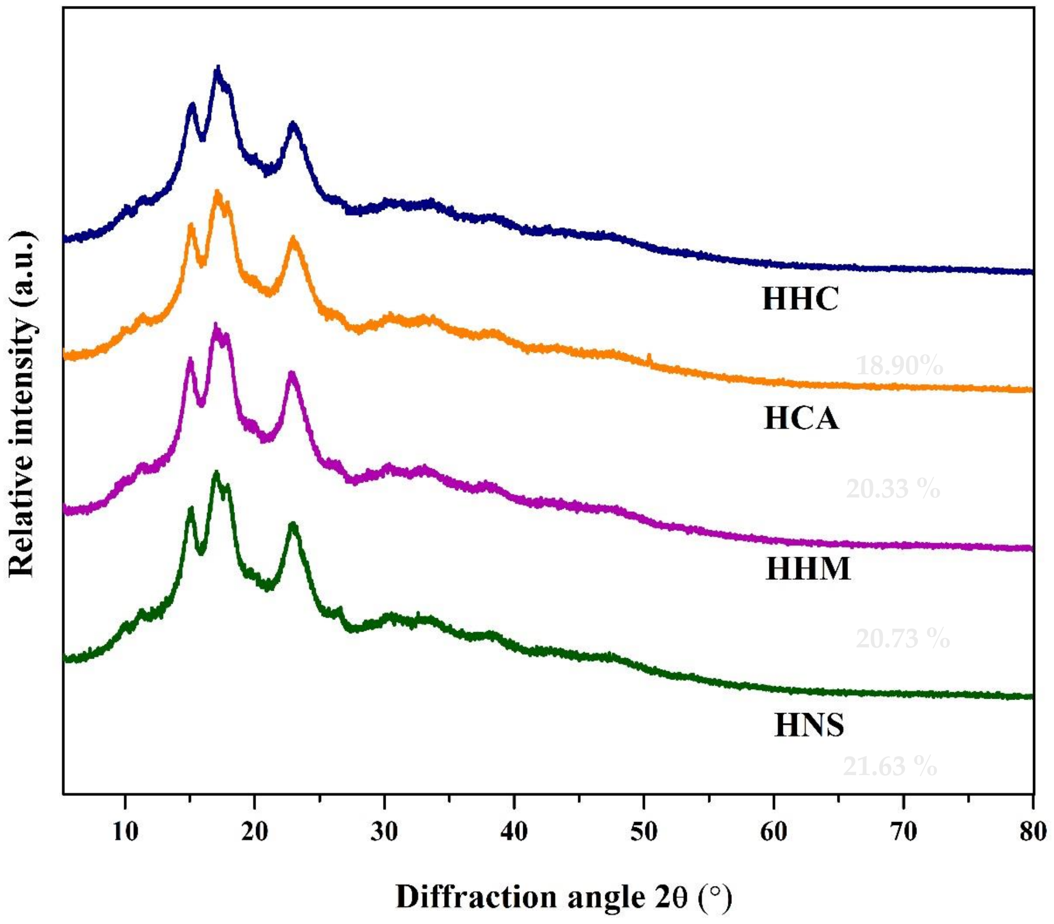
Degree of substitution

Samples	Degree of substitution
HNS	--
HHM	--
HCA	0.112 ± 0.013[a]
HHC	0.135± 0.051[b]

HNS- native Hausa potato starch, HHM- HMT modified Hausa potato starch, HCA- citric acid modified Hausa potato starch, HHC– HMT-citric acid-modified Hausa potato starch.

- The DS describes the number of substituted functional groups that exist per unit of anhydrous glucose.
- HHC showed a significantly ($p \leq 0.05$) higher DS compared to HCA

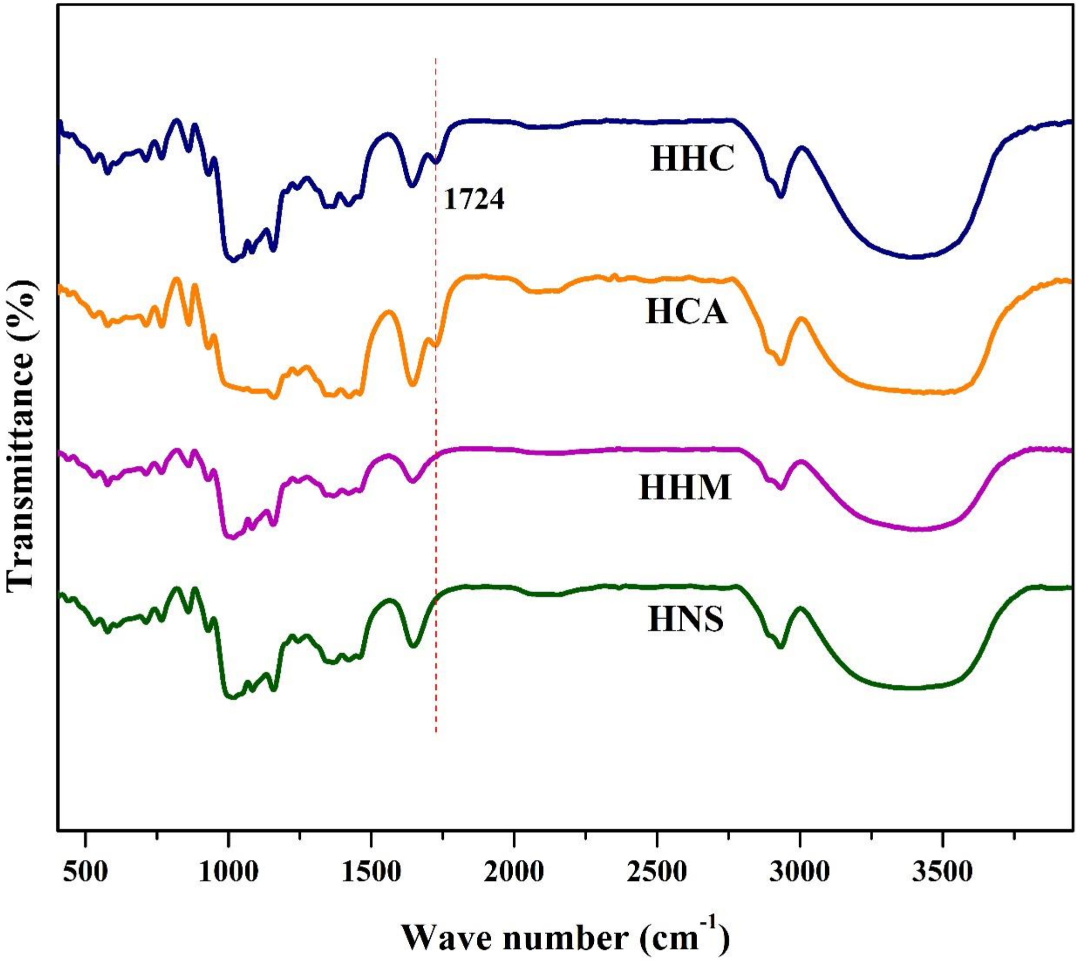
X-ray diffraction and relative crystallinity



Samples	Relative crystallinity (%)
HNS	21.63 ± 0.21[d]
HHM	20.73 ± 0.15[c]
HCA	20.33 ± 0.06[b]
HHC	18.90 ± 0.08[a]

- ❖ A-type diffraction pattern
- ❖ All modification significantly decreases the RC %

Fourier transform infrared spectroscopy (FT-IR)



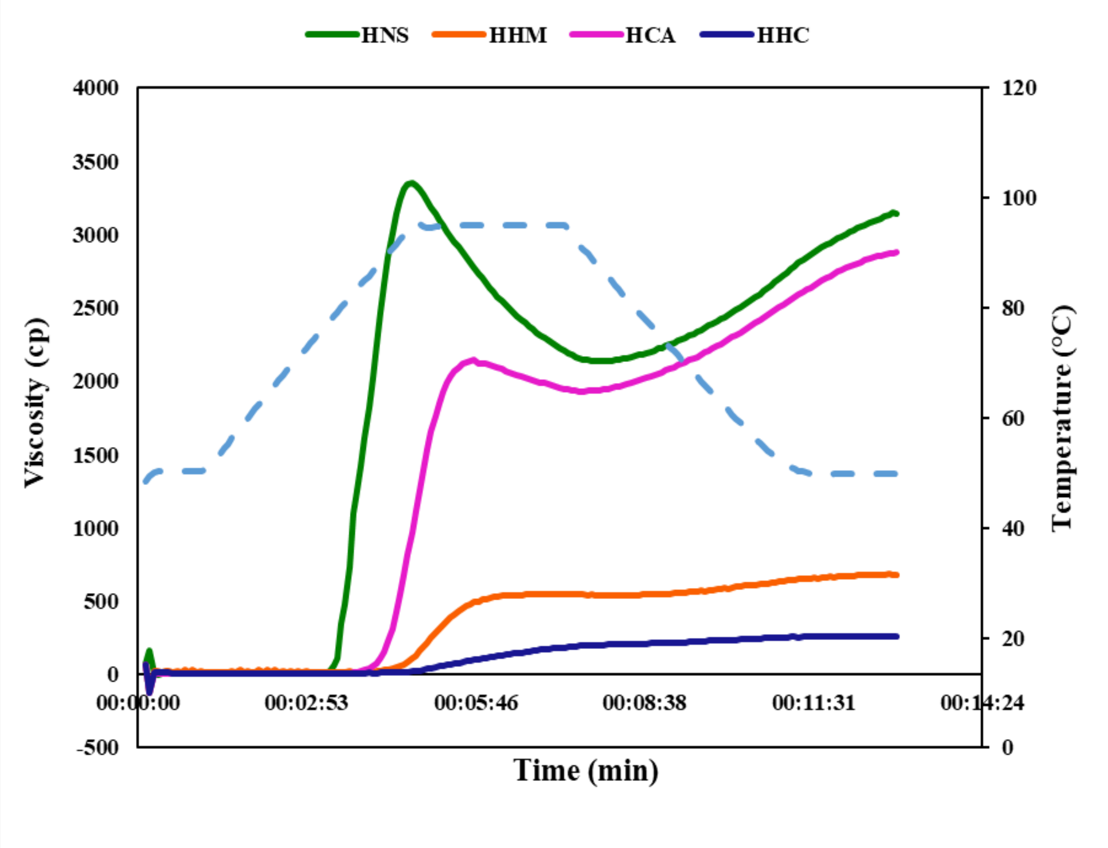
- Hausa potato starch showed Major peaks including
  O–H group broad peak at 3365 cm^{-1}
  C–H_2 group 2931 cm^{-1}
  H–O–H bending vibration at 1646 cm^{-1}
- The peaks at 921 cm^{-1}, 1018 cm^{-1}, 1084 cm^{-1}, and 1160 cm^{-1}, representing the contraction and expansion of the C–O–C bond in the glucose pyranose ring
- HCA and HHC exhibited a new peak at 1724 cm^{-1}, representing the C=O stretching group

Thermal properties

Samples	T_o (°C)	T_p (°C)	T_c (°C)	ΔH (J/g)
HNS	68.18 ± 0.02^a	73.04 ± 0.19^a	88.23 ± 0.03^a	11.12 ± 0.15^d
HHM	68.89 ± 0.10^b	74.22 ± 0.23^b	89.41 ± 0.19^b	10.78 ± 0.02^c
HCA	69.53 ± 0.06^c	74.81 ± 0.04^c	90.22 ± 0.07^c	8.76 ± 0.09^b
HHC	70.18 ± 0.15^d	75.06 ± 0.07^d	90.94 ± 0.04^d	6.57 ± 0.05^a

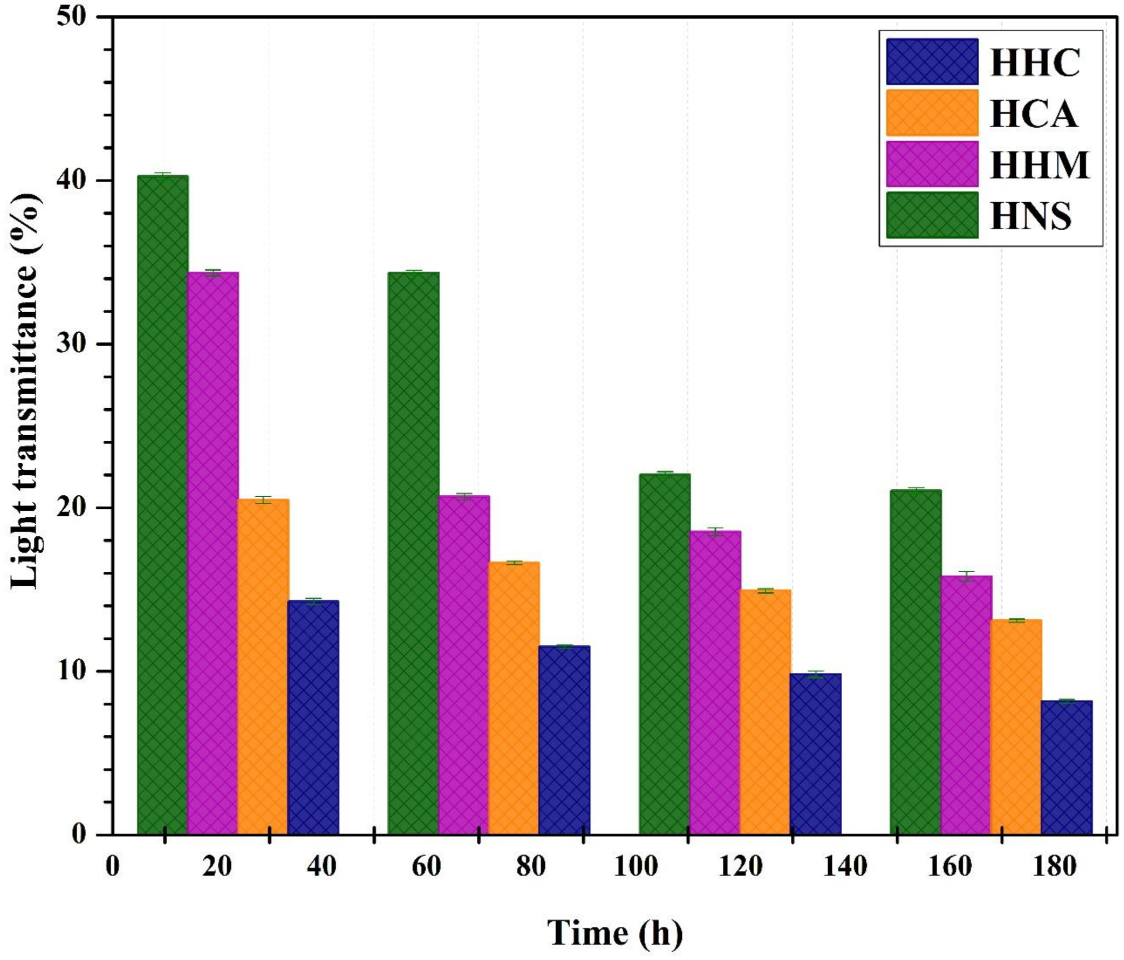
- After citric acid treatment, the enthalpy of gelatinization was significantly reduced ($p \leq 0.05$) and increased gelatinization transition temperature for HCA and HHC.

Pasting profile



- Native Hausa potato starch exhibited remarkably higher ($p \leq 0.05$) peak, breakdown, final, and setback viscosities than modified starches.
- HHM starches had a higher PT (85.8 °C) than HNS starches (78.40 °C).
- The substitution of citrate prevents starch from swelling and gelatinizing during RVA analysis in HCA and HHC samples

Light transmittance



- ❖ All the Hausa potato starch samples showed a decreased light transmittance percentage with storage time due to the turbidity formation in the starch gel
- ❖ The HHC samples exhibited the lowest light transmittance among the samples due to the higher number of bulkier citrate group

In vitro digestibility

Samples	RDS (%)	SDS (%)	RS (%)
HNS	29.31 ± 0.24[d]	33.61 ± 0.15[a]	37.07 ± 0.11[a]
HHM	26.12 ± 0.12[c]	34.03 ± 0.08[b]	39.82 ± 0.15[b]
HCA	25.24 ± 0.18[b]	34.89 ± 0.09[c]	40.12 ± 0.21[c]
HHC	20.16 ± 0.11[a]	36.10 ± 0.14[d]	44.05 ± 0.03[d]

- ❖ Retrogradation mechanism by purposeful alteration or processing of the HHM led to a significantly higher RS compared to HNS
- ❖ Citric acid-modified starches, HCA and HHC showed improved SDS and RS and a decrease in RDS
- ❖ Crosslinking and steric hindrance of the bulker citrate group led to resistance to the enzymatic hydrolysis, thereby increasing digestion time and high RS and SDS percentage

Conclusion

- The study of Hausa potato starch properties was affected differently by HMT, citric acid, and dual-modified starches.
- DS, thermal analysis, and FT-IR study suggested that citrate esterification significantly improved by HMT in HHC.
- The citrate esterified single and dual modified samples had a lower enthalpy of gelatinization, and light transmittance than that of native and HMT-modified starches.
- Reduced viscosities resulting from all the starch modifications are significant quality considerations that can encourage their use in processed meats, sweets, and imitation cheese.
- The study enables safe and green modification of starches with improved characteristics and can be easily applied in food and pharmaceutical.
- The increased DS and RS content of the HHC suggests that the HMT served as a pre-treatment and favored the production of the citrate starch. The dual-modified Hausa potato having a high amount of RS can easily be exploited in food and non-food sectors.

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