ATATÜRK ÜNİVERSİTESİ YAYINLARI
ATATURK UNIVERSITY PUBLICATIONS

Research Article *Araştırma Makalesi* DOI: 10.5152/AUAF.2023.23069

Development of Instant *Wasa-Wasa* from White-Fleshed Yam Tuber

Beyaz Etli Yam Yumrusundan Hazır Wasa-Wasa'nın Geliştirilmesi

Wasiu AWOYALE
Sekinat Oyinlola SHITTU
Kazeem K. OLATOYE

Department of Food Science and Technology, Kwara State University Malete, Ilorin, Kwara, Nigeria

ABSTRACT

Wasa-wasa is a steamed granule-like product produced from fermented yam flour and consumed immediately after production with salad, spaghetti, beans, and fish/meat pepper sauce. To extend the shelf life of w*asa-wasa*, there is a need to dry the steamed yam flour granules produced at a specific temperature and time, hence the need to produce instant w*asa-wasa* from white-fleshed yam tuber (*Dioscorea rotundata*). Instant *wasa-wasa* was produced using different steaming temperatures and times generated using a central composite rotatable design of the Design expert software, before drying. The functional and pasting properties, chemical composition, and sensory attributes of the instant *wasa-wasa* were evaluated using standard methods. The mean functional properties of the instant *wasa-wasa* are bulk density 68%, water absorption capacity 373%, solubility index 2%, swelling power 4%, oil absorption capacity 154%, least gelation concentration 9%, and dispersibility 74%. The pasting properties are peak viscosity 33 RVU, trough viscosity 18 RVU, breakdown viscosity 14 RVU, final viscosity 65 RVU, setback viscosity 47 RVU, peak time 4 minutes, and pasting temperature 54°C. The chemical composition is crude fiber 2%, starch 38%, sugar 11%, amylose 18%, moisture 5%, and ash 4%. All the sensory attributes of the cooked instant *wasa-wasa* were within the likeness range and not significantly different ($p > .05$). However, the optimum steaming temperature and time combination that will produce an acceptable and quality instant *wasa-wasa* is 60°C for 16 minutes.

Keywords: Fermented yam flour, quality attributes, steaming temperature and time, wasa-wasa

ÖZ

Wasa-wasa, fermente edilmiş yam ununda üretilen ve üretimden hemen sonra salata, spagetti, fasulye ve balık/et biber sosu ile tüketilen buharda pişirilmiş granül benzeri bir üründür. *Wasa-wasa*'nın raf ömrünü uzatmak için, buharda pişirilmiş yam unu granülünün belirli bir sıcaklık ve sürede kurutulması gerekmektedir, bu nedenle beyaz etli yam (*Dioscorea rotundata*) kullanılarak çabuk hazırlanan *wasa-wasa* (IW) ürünü geliştirilmiştir. Kurutma aşamasından önce IW, Design expert yazılımının döndürülebilir merkezi kompozit tasarımı kullanılarak oluşturulan farklı buharlama sıcaklıkları ve süreleri kullanılarak üretilmiştir. IW'nin fonksiyonel ve çirişlenme özellikleri, kimyasal bileşimi ve duyusal nitelikleri standart yöntemler kullanılarak değerlendirilmiştir. IW' nin kütle yoğunluğu %68, su emme kapasitesi %373, çözünürlük indeksi %2, şişme gücü %4, yağ emme kapasitesi %154, en düşük jelleşme konsantrasyonu %9 ve dağılabilirliği %74' tür. Çirişlenme özellikleri ise; pik viskozite 33 RVU, incelme sonrası viskozite 18 RVU, karıştırma ile viskozite azalması 14 RVU, son viskozite 65 RVU, katılaşma değeri 47 RVU, pik süresi 4 dak ve çirişlenme sıcaklığı 54 °C dir. Kimyasal bileşim %2 ham lif, %38 nişasta, %11 şeker, %18 amiloz, %5 nem ve %4 kül' den oluşmuştur. Pişmiş *wasa-wasa*'nın tüm duyusal özellikleri benzerdir ve önemli ölçüde farklı değildir ($p > ,05$). Bununla birlikte, kabul edilebilir ve kaliteli bir *wasa-wasa* üretecek optimum buharlama sıcaklığı ve zaman kombinasyonu 60°C ve 16 dakika olarak belirlenmiştir.

Anahtar Kelimeler: Fermente yam unu, kalite özellikleri, buharda pişirme sıcaklığı ve süresi, wasa-wasa

Received/Geliş Tarihi: 12.01.2023
Accepted/Kabul Tarihi: 07.09.2023
Publication Date/Geliş Tarihi: 28.09.2023

Corresponding Author/Sorumlu Yazar: Wasiu AWOYALE
E-mail: wawoyale0101@gmail.com

Cite this article as: Awoyale, W., Shittu, S. O., & Olatoye, K. K. (2023). Development of instant *Wasa-Wasa* from white-fleshed Yam tuber. *Research in Agricultural Sciences*, 54(3), 143-152.

Content of this journal is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

Introduction

From handling, marketing, and distribution to processing, postharvest losses of 10–60% of the total crop have been reported at various stages of yam production (Agbo et al., 2016). Physical damage, rodent attacks, fungal and bacterial diseases, physiological processes like sprouting, dehydration, and



Figure 1.
Wasa-wasa Produced from Dioscorea rotundata Fermented Flour.

respiration, as well as losses in tuber quantity and quality are examples. Yam tubers are processed to overcome the problem of perishability caused by their seasonality and high moisture content (Agbo et al., 2016).

In countries like Nigeria, Ghana, and the Republic of Bénin in West Africa, yam tubers are processed into dry yam tubers/slices or flour. Yam can be eaten in a variety of ways, most commonly boiled, fried, or baked. It is made into unfermented flour used to produce *poundo* (a flour-based food product that is reconstituted in boiling water to produce a cooked dough that is eaten with a favorite soup) or high-quality yam flour for baking. The tubers are also made into fermented flour to be used for *amala* (Awoyale et al., 2010), and *wasa-wasa* (Figure 1).

Wasa-wasa is a staple food produced by steaming fermented yam flour and consumed with salad, spaghetti, beans, and different types of sauces like fish sauce, meat sauce, and pepper sauce. *Wasa-wasa* is rich in carbohydrates and proteins. It also provides vitamins and roughage because it is accompanied by vegetables like cabbage, carrots, and sliced potatoes (Zulaiha, 2018). There are a variety of ingredients that can be used to prepare *wasa-wasa* dish. Though these ingredients may be dependent on the choices of the beneficiaries, the most common or primary ingredients include yam flour, salt, freshly ground pepper, water for steaming, onions, and groundnut or shea butter oil (Ayitey, 2016). It is cooked in a pot and steamed until it is ready. It usually turns black after cooking. However, there is a dearth of information on the best-steaming temperature and time to produce *wasa-wasa*, which is consumed in different parts of West African countries.

It is envisaged that the production of instant *wasa-wasa* will not only extend the shelf life of *wasa-wasa* but also diversify the utilization of fermented yam flour. Therefore, this study is aimed at producing instant *wasa-wasa* (IW) from white-fleshed yam tuber (*Dioscorea rotundata*).

Methods

Material

About 100 kg of *Dioscorea rotundata* tubers was purchased from the Malete market in Nigeria's Kwara state. The processing equipment required for the present study was obtained from the Food Processing Laboratory of the Department of Food Science and Technology, Kwara State University (Malete).

Method

Yam Flour Production

The fresh yam tuber was manually sliced using a stainless-steel knife for 2–3 days in water before being decanted and dried for 8 hours at 60°C in a cabinet dryer. The dried slices were then milled into flour using a dry hammer mill, sieved with a sieve of 0.5 mm, cooled, and packaged (Figure 2) for processing into *wasa-wasa* (Awoyale et al., 2010).

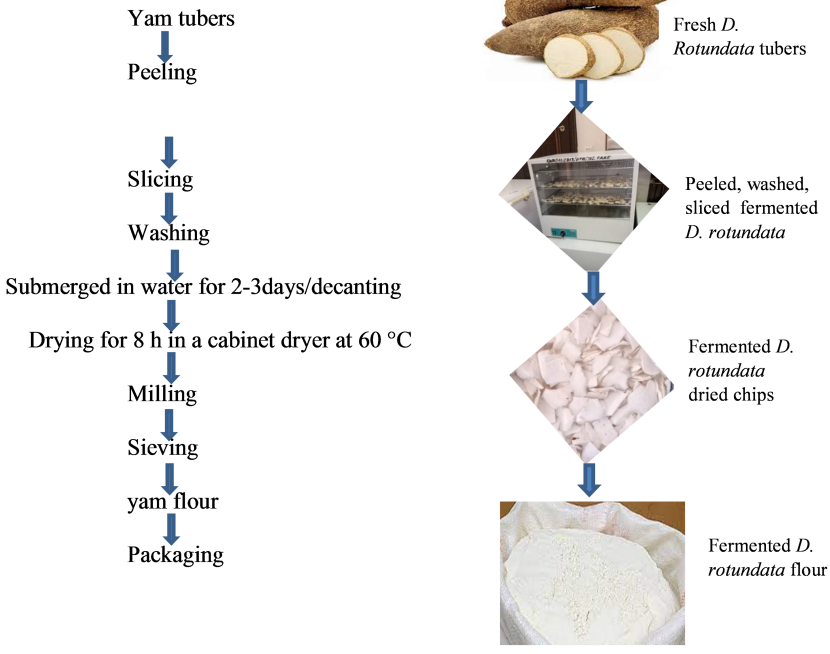


Figure 2.
Fermented Yam Flour Production (Awoyale et al., 2010).

Table 1.
Steaming Temperatures and Times Used to Produce Instant Wasa-Wasa

Runs	Steaming Temperature (°C)	Steaming Time (Minutes)
1	62.00	20.00
2	60.50	17.50
3	58.38	17.50
4	60.50	21.04
5	60.50	17.50
6	60.50	13.96
7	60.50	17.50
8	62.00	15.00
9	60.50	17.50
10	59.00	15.00
11	62.62	17.50
12	60.5	17.5
13	59.0	20.0

Steaming temperatures and times used to produce wasa-wasa

The steaming temperature and amount of time required to produce the instant *wasa-wasa* were determined using the Central Composite Rotatable Design of the Design-Expert Software (version 6.0) (Table 1). This was done using the highest and lowest values of steaming temperature of 62°C and 59°C and steaming time of 20 minutes and 15 minutes, respectively.

Production of *Wasa-Wasa*

In order to moisten the yam flour to produce w*asa-wasa,* 250 mL of water was sprinkled on it at intervals and partially kneaded into it. The kneading process went on until the moistened flour all came together into granules with a diameter of about 2 mm. Using the steaming temperatures and durations listed in Table 1, the granules were then steamed to obtain fully cooked w*asa-wasa*. The w*asa-wasa* was dried for 5 hours at 60°C in a cabinet dryer, cooled, and packaged in a high-density polyethylene bag for further analyses.

Determination of Functional Properties

Bulk Density

An Ohaus weighing balance (PA214, Switzerland) was used to weigh the sample (7 g) into a graduated measuring cylinder of 50 mL volume. The bulk density (BD) was determined by gently tapping the cylinder against the palm until a constant volume was obtained, and calculated as shown in Equation 1 (AOAC, 2010).

$$BD = \frac{\text{Weight of sample}}{\text{The volume of the sample after tappng}} \quad (1)$$

Water and Oil Absorption Capacity

The method reported by Awoyale et al. (2021) was used to determine the samples' oil absorption capacity (OAC) and water absorption capacity (WAC). To determine the WAC and the OAC, the samples (each 1 g) were blended for 30 seconds with 10 mL of sunflower oil and 10 ml of distilled water, respectively. After that, the samples were centrifuged at 3500 rpm for 30 minutes at room temperature using a centrifuge (Gallenkamp model 90-1, England). The supernatant was then decanted, and the WAC and OAC, which stands for the weight of oil and water absorbed by the sample, were calculated.

Swelling Power

The swelling power was determined following the method reported by Awoyale et al. (2021) with slight changes. A sample of 0.1 g was weighed into a test tube; 10 mL of distilled water was added and heated in a water bath (Thelco, model 83, USA) of 60°C for 30 minutes with ceaseless shaking during the heating time frame. Eventually, the test tube was centrifuged with a centrifuge at 2200 rpm for 15 minutes to work with the expulsion of the supernatant. The supernatant was carefully decanted, and the weight of the starch paste was taken. The swelling power was then calculated using Equation 2.

$$\text{Swelling power} = \frac{\text{Weight of the starch paste}}{\text{Weight of the dry starch sample}} \times 100 \quad (2)$$

Least Gelation Concentration

The least gelation concentration (LGC) was calculated using the method described by Awoyale et al. (2016). To create 220% (w/v) suspensions, appropriate sample suspensions were individually weighed into 5 mL of distilled water. These suspensions were placed in test tubes that were heated for one hour in a boiling water bath before being quickly cooled with water from a running faucet. The LGC was calculated as the concentration at which the sample did not fall or slip from the inverted test tube after being further chilled for an additional hour under running water.

Dispersibility

The samples (10 g) were weighed into a 100 mL measuring cylinder. Distilled water was added to reach a volume of 100 mL. After 3 hours of vigorous stirring, the mixture was allowed to settle. On the measuring cylinder, the volume of settled particles was observed, recorded, and subtracted from 100. The difference was then reported as percentage dispersibility (Awoyale et al., 2021).

Pasting Properties

A Rapid Visco Analyzer (RVA) (Model RVA-4C, Newport Scientific, Warriewood, Australia) was used to analyze the samples' pasting properties and was connected to a computer running Thermocline Software from the same manufacturer (Awoyale et al., 2019). Three-gram samples were weighed into a canister, where 25 mL of distilled water was added to make a slurry. The RVA received this canister, which was covered with a stirrer. The following was the programming of the cooling and heating cycles: The slurry was kept at 50°C for 1 minutes, then heated to 95°C for 3 minutes, and kept at 95°C for 2 minutes. After that, it was cooled to 50°C for 3 minutes, and the rotation speed of 160 rpm was kept at that temperature for 2 minutes. Rapid viscosity unit (RVU) was used to describe the viscosity. The following parameters are automatically recorded by the instrument: peak viscosity (the maximum viscosity attained during pasting), breakdown viscosity (the difference between peak viscosity and minimum viscosity attained during pasting), setback viscosity (the difference between maximum viscosity attained during cooling and minimum viscosity attained during pasting), final viscosity (viscosity attained after the RVA run), pasting temperature (the temperature at which a sharp increase in the viscosity of the flour suspension after the commencement of heating) and peak time (the time taken for the paste to reach peak viscosity).

Chemical Composition

Crude Fiber Content

The AOAC (2010) method was used to determine the crude fiber content of the samples. About 100 mL of 0.255N H_2SO_4 was added to 2 g of the sample inside the fiber flask (W). The heating

mantle was used to heat the mixture for one hour under reflux, and the hot mixture was then filtered through a cloth made of fibers. After the filtrate was removed, the residue was returned to the flask, where 100 mL of 0.313 N NaOH was added, the mixture was heated under reflux for an additional 1 hour, and 10 mL of acetone was added to dissolve any organic components. Before being finally transferred into a crucible, the residue was cleaned on the sieve cloth with approximately 50 mL of hot water. To remove moisture, the crucible and the residue were dried overnight in an oven at 105°C. The weight W_1 was measured after the oven-dried crucible containing the residue was cooled in a desiccator. The crucible with the weight W_1 was then moved to the muffle furnace for ashing for four hours, after which the crucible containing the white or grey ash (free of carbonaceous material) was cooled in the desiccator and weighed as W_2. The difference between W_1 and W_2 gives the fiber weight . The percentage crude fiber content was obtained using Equation 3.

$$\% \text{ Crude fiber} = \frac{W_1 - W_2}{W} \times 100 \quad (3)$$

Ash Content

The AOAC (2010) method was used to determine the sample's ash content. This involves burning 3 g of the sample for 5 hours in a VULCANTM furnace model 3-1750 at 600°C to remove all organic components and moisture. After incineration, the weight of the residue was recorded and the ash content calculated as shown in Equation 4.

$$\% \text{ Ash content} = \frac{W_3 - W_1}{W_2} \times 100 \quad (4)$$

W_3 = Weight of crucible + ash
W_2 = Weight of the sample only
W_1 = Weight of the crucible

Moisture Content

Approximately 3 g of the sample was weighed into a dish that had already been weighed, cleaned, and dried. The dish was then placed in a draft-air oven (Fisher Scientific, 655F, USA) that was kept at 103°C for 24 hours. The sample was taken, put in a desiccator to cool to room temperature, and weighed after it had dried. The moisture content was calculated as shown in Equation 5 (AOAC, 2010).

$$\text{Percentage moisture content} = \left(\frac{M_1 - M_2}{M_1 - M_o}\right) \times 100 \quad (5)$$

where M_o = weight in grams of dish

M_1 = weight in grams of dish and sample before drying
M_2 = weight in grams of dish and sample after drying
$M_1 - M_o$ = weight of sample prepared for drying

Starch and Sugar Content

Approximately 0.020 g of the finely ground sample was weighed before it was put into centrifuge tubes and wetted with 1 mL of 95% ethanol. After adding 10 mL of hot ethanol to the 1 mL of 95% ethanol, 2 mL of distilled water was added. The mixture was vortexed and centrifuged for 10 minutes at approximately 2000 rpm using a centrifuge. The residue was analyzed for starch, while the supernatant was collected for free sugar analysis as reported by Awoyale et al. (2021). About 7.5 mL of perchloric acid was added to the residue and allowed to hydrolyze for 1 hour to determine the amount of starch present. Perchloric acid and residue were hydrolyzed, and the mixture was then diluted to 25 mL with distilled water and then filtered using Whatman No. 2 filter paper. A 0.05 mL of the filtrate was taken, increased to 1 mL with distilled water, and vortexed. The color was created by mixing 2.5 mL of concentrated H_2SO_4 with 0.5 mL of phenol. After going through a vortex, the mixture was left to cool to room temperature. At 490 nm, the absorbance was measured. on a spectrophotometer (Milton Roy Company, USA, Model Spectronic 601). After that, 2.5 mL of concentrated H_2SO_4 and 0.5 mL of phenol were added to about 0.2 mL of the aliquot that was taken from the supernatant and made up to 20 mL with distilled water. The absorbance was measured at 490 nm after it was allowed to cool. A 100 mL volumetric flask containing 0.01 g of D-glucose was weighed to produce the standard glucose solution. After the contents were dissolved and mixed with distilled water to a volume of 100 mL, test tubes containing 0.1, 0.2, 0.3, 0.4, and 0.5 mL each were filled with the stock solution (100 mg/mL glucose). This is equivalent to glucose levels of 10, 20, 30, 40, and 50 mg/mL. After that, 2.5 mL of concentrated H_2SO_4 and 0.5 mL of phenols containing 5%t were added. The solution was cooled by vortexing and the absorbance was measured at 490 nm. The slope was plotted on a standard glucose curve of absorbance against concentration, and the intercept was used to calculate the sugar and starch contents as shown in Equations 6 and 7, respectively.

$$\text{Percentage sugar content} = \left(\frac{\text{Abs.} - \text{Intercept} \times \text{Dilution factor} \times \text{Volume}}{\text{Weight of sample} \times \text{slope} \times 10000}\right) \times 100 \quad (6)$$

where

Abs. = Absorbance; Dilution factor = 5; Volume = 20 mL

$$\text{Percentage starch content} = \left(\frac{\text{Abs.} - \text{Intercept} \times \text{Dilution factor} \times \text{Volume} \times 0.9}{\text{Weight of sample} \times \text{slope} \times 10000}\right) \times 100 \quad (7)$$

where

Dilution factor = 20; Volume = 25 mL.

Note: The slope and intercept used for the calculations were from the standard glucose curve.

Amylose Content

The approach taken by Pereira et al. (2017) was used to figure out how much amylose was in the samples. Approximately 0.1 g of the starch sample was solubilized in 1 mL of 95% ethanol and 9 mL of 1M NaOH and heated in a water bath for 10 minutes. Up to 10 mL of the extract were produced from 1 mL using distilled water. To produce a dark blue color, 0.5 mL of the diluted extract, 0.1 mL of N acetic acid, and 0.2 mL of iodine solution (0.2 g I_2 + 2.0 g KI_2 in 100 mL of distilled water) were added. For complete color development, the colored solution was made up to 10 ml in distilled water and left to stand for 20 minutes. A spectrophotometer (Milton Roy Company, USA, Model Spectronic 601) was used to measure the solution's absorbance at 620 nm after it had been vortexed. To determine the amount of amylose in the

sample, the absorbance of standard corn amylose at a concentration that was previously known was used, as shown in Equation 8.

$$\%\text{Amylose} = \left(\frac{\%\text{Amylose of standard} \times \text{Absorbance of sample}}{\text{Absorbance of standard}}\right) \times 100 \quad (8)$$

Sensory Properties

Preparation of Sample and Sensory Evaluation

In a stainless-steel pot, about 100 g of the sample were added to 500 mL of boiling water, allowed to stand for 5 minutes, and then steamed for 10 minutes. For the purpose of sensory evaluation, the cooked *Wasa-wasa* was appropriately packaged, coded, and kept in a warmer. Twelve trained panelists from the Gbawojo market in Saki were chosen for their interest and ability to distinguish food sensory properties. The color, smell, appearance, texture, taste, and overall acceptability of the samples were evaluated by the panelists using a 9-point hedonic scale, with 9 denoting extreme liking and 1 denoting extreme dislike (Awoyale et al., 2010).

Statistical Analysis

The Statistical Package for the Social Sciences Statistics version 21 (IBM SPSS Corp., Armonk, NY, USA) was utilized to analyze the generated data's analysis of variance (ANOVA). Design-Expert's response surface central composite rotatable design (version 6.0) was utilized for the optimization.

Results

Functional Properties of Instant Wasa-Wasa

Awoyale et al. (2019) reported that functional properties reveal how the food materials interact with other food components, thus influencing processing applications, food quality, and final acceptability. The functional properties of IW are shown in Table 2 as a result of the various steaming temperatures and durations. Bulk density (BD) of 68.0%, water absorption capacity (WAC) of 373%, oil absorption capacity (OAC) of 154%, solubility index (SI) of 2.06%, dispersibility of 73.69%, swelling power (SWP) of 4.22%, and least gelation concentration (LGC) of 8.62% is the average functional properties of the IW. The IW's functional properties all show significant differences ($p < .05$).

According to Oppong et al. (2015), the BD is utilized to evaluate the flour's heaviness, the need for handling, and the kind of packaging materials suitable for storing and transporting food materials. The IW's BD ranged from 64 to 72%. The IW produced under steaming at 60.5°C for 20.5 minutes had the lowest BD, while the IW produced under steaming at 59°C for 20 minutes had the highest BD (Table 2). According to Komolafe and Arawande (2010), it has been established that the lower the BD value, the greater the quantity of product that can be packaged in each container volume, thereby reducing the amount of space required as well as the cost of packaging and transportation. According to Komolafe and Arawande (2010), this indicated that in comparison to the IW produced from the steaming condition of 59°C for 20 minutes, a greater quantity of the IW produced from the steaming condition of 60.5°C for 20.5 minutes could be packaged in each volume of the container, thereby reducing the costs of packaging and transportation. The relationship between the BD and the IW's trough viscosity ($p < .01$, $r = -.82$) and amylose content ($p < .05$, $r = -.56$) is both significant and negative (Table 3). However, the relationship between the BD and the IW's starch content is positive and significant ($p < .05$, $r = .70$) (Table 3). This suggests that a higher BD of the IW is associated with a higher starch content, whereas a higher BD of the IW is associated with a lower trough viscosity and amylose content.

The WAC represents a product's capacity to associate with water in circumstances lacking it (Awoyale et al., 2019). The IW's WAC was between 349% and 401%. The WAC of the IW produced under steaming at 59°C for 20 minutes was the highest, while the WAC of the IW produced under steaming at 60.5°C for 17.5 minutes was the lowest (Table 2). The result of the WAC was higher compared to that of yam flour reported by Omeire et al. (2014). The IW's subsequent drying and steaming may be the cause of this. However, a significant and positive correlation ($p < .05$, $r = .68$) exists between the WAC and the amylose content of the IW, so the WAC of the IW is proportional to the amylose content (Table 3). According to Onimawo and Akubor (2012), the OAC, on the other hand, measures the capacity of food materials to absorb oil. This ability is primarily attributed to the physical entrapment of oils. The OAC of the IW ranged from 144 to 163%, with the IW produced at 62°C for 20 minutes having the highest OAC and the IW produced at 59°C for 15 minutes having the lowest (Table 2). Due to its high

Table 2.
Effect of Different Steaming Temperatures and Times on the Functional Composition of Instant ***Wasa-Wasa***

Steaming Temperature (°C)	Steaming Time (Minutes)	Swelling Power	Water Absorption Capacity (%)	Least Gelation Concentration (%)	Dispersibility (%)	Oil Absorption Capacity (%)	Bulk Density (%)	Solubility Index (%)
62.00	15.00	4.37 ± 0.03^{f}	372.00 ± 0.00^{d}	8.00 ± 0.00^{b}	72.00 ± 0.00^{d}	162.00 ± 0.00^{ab}	64.00 ± 0.02^{e}	2.01 ± 0.00^{f}
60.50	17.50	4.30 ± 0.01^{e}	349.00 ± 0.01^{e}	8.40 ± 0.84^{b}	75.20 ± 0.42^{a}	154.00 ± 0.05^{bc}	70.00 ± 0.01^{ab}	2.11 ± 0.00^{b}
58.70	17.50	4.21 ± 0.00^{d}	380.00 ± 0.00^{c}	10.00 ± 0.00^{a}	72.00 ± 0.00^{d}	154.00 ± 0.01^{bc}	68.00 ± 0.01^{bcd}	1.93 ± 0.01^{h}
60.50	20.50	4.22 ± 0.01^{d}	379.00 ± 0.01^{c}	10.00 ± 0.00^{a}	73.00 ± 0.00^{c}	153.00 ± 0.00^{cd}	62.00 ± 0.01^{e}	2.04 ± 0.00^{d}
60.50	14.50	4.08±0.01^{b}	399.00 ± 0.01^{a}	8.00 ± 0.00^{b}	75.00 ± 0.00^{a}	146.00 ± 0.01^{de}	68.00 ± 0.01^{d}	2.10 ± 0.00^{c}
62.00	20.00	4.28 ± 0.03^{e}	372.00 ± 0.01^{d}	8.00 ± 0.00^{b}	73.00 ± 0.00^{c}	163.00 ± 0.01^{a}	67.00 ± 0.00^{d}	2.03 ± 0.00^{e}
59.00	15.00	3.95 ± 0.01^{a}	400.00 ± 0.00^{a}	10.00 ± 0.00^{a}	73.00 ± 0.00^{c}	144.00 ± 0.03^{e}	69.00 ± 0.00^{bc}	1.97 ± 0.00^{g}
62.30	17.50	4.20 ± 0.00^{d}	394.00 ± 0.02^{b}	10.00 ± 0.00^{a}	74.00 ± 0.00^{b}	153.00 ± 0.00^{cd}	62.00 ± 0.00^{e}	2.04 ± 0.00^{d}
59.00	20.00	4.11 ± 0.01^{c}	401.00 ± 0.01^{a}	6.00 ± 0.00^{c}	70.00±0.00^{e}	160.00 ± 0.00^{ac}	72.00 ± 0.01^{a}	2.12 ± 0.00^{a}
Mean		4.22	373	8.62	73.69	154	68	2.06
p		***	***	***	***	***	***	***

Note: ^{a,b,c,d,e,f,g,h}Means with different letters within the same column are significantly different ($p < .05$).***$p < .001$.

Table 3.
Correlation Between the Functional and Pasting Properties and the Chemical Composition of instant Wasa-Wasa

	Swelling Power	Water Absorption Capacity	Least Gelation Concentration	Dispersibility	Oil Absorption Capacity	Solubility Index	Bulk Density	Crude Fiber	Starch	Sugar	Amylose	Moisture	Ash
Swelling power	1.00	−0.80**	−0.14	0.30	0.58*	0.28	−0.07	−0.22	0.15	0.14	−0.50	0.58*	0.73**
Water absorption capacity	−0.80**	1.00	0.08	−0.62*	−0.25	−0.44	−0.37	0.24	−0.50	−0.40	0.68*	−0.53	−0.63*
Least gelation concentration	−0.14	0.08	1.00	0.25	−0.50	−0.58*	−0.52	0.02	−0.22	−0.07	0.58*	−0.04	0.10
Dispersibility	0.30	−0.62*	0.25	1.00	−0.39	0.47	0.18	−0.52	0.61*	0.49	−0.29	0.01	0.48
Oil absorption capacity	0.58*	−0.25	−0.50	−0.39	1.00	0.07	−0.02	0.27	−0.21	−0.32	−0.28	0.34	0.19
Solubility index	0.28	−0.44	−0.58*	0.47	0.07	1.00	0.46	−0.30	0.58*	0.48	−0.67*	0.00	0.23
Bulk density	−0.07	−0.37	−0.52	0.18	−0.02	0.46	1.00	0.12	0.70**	0.48	-0.56*	0.05	−0.23
Peak viscosity	0.15	−0.10	0.24	−0.13	0.00	−0.55	−0.10	0.26	−0.05	−0.15	0.15	0.28	0.13
Trough viscosity	0.17	0.15	0.45	−0.09	0.18	−0.37	−0.82**	−0.01	−0.55	−0.55*	0.48	−0.09	0.24
Breakdown viscosity	0.12	−0.14	0.15	−0.11	−0.04	−0.49	0.08	0.27	0.07	−0.03	0.05	0.31	0.08
Final viscosity	0.25	−0.08	−0.37	−0.14	0.47	0.11	0.02	0.07	−0.06	−0.45	0.10	−0.26	−0.09
Setback viscosity	0.23	−0.12	−0.49	−0.12	0.46	0.20	0.19	0.08	0.05	−0.36	0.01	−0.26	−0.15
Peak time	0.16	0.05	−0.19	−0.10	0.29	0.42	−0.22	−0.13	−0.19	0.02	−0.17	0.06	0.07
Pasting temp	0.07	0.02	−0.25	−0.03	0.21	0.44	0.11	0.23	0.11	−0.07	0.01	−0.02	−0.25

Note: *$p < .05$, **$p < .01$.

OAC, this suggests that the IW produced by steaming at 59°C for 15 minutes may consume more oil than the IW produced by steaming at 62°C for 20 minutes.

The extent of the granules' associative forces can be seen in the SWP of starchy foods. As a result, the associative forces decrease with increasing SWP (Awoyale et al., 2019). The IW's SWP ranged from 3.95 to 4.37%. The SWP of the IW produced under steaming at 62°C for 15 minutes was the highest, while the SWP of the IW produced under steaming at 59°C for 15 minutes was the lowest (Table 2). This suggested that the starch granules in the IW produced by steaming at 59°C for 15 minutes had higher associative forces than those in the IW produced by steaming at 62°C for 15 minutes. The high moisture content of the IW may be the cause of its high SWP after 15 minutes of steaming at 62°C. This is because the SWP and the IW's moisture content have a positive and significant correlation (Table 3). Starch or starch blends' reconstitutability in water is measured by their dispersibility.

Starch reconstitutes better in water when its dispersibility is higher (Awoyale et al., 2019). The IW's dispersibility ranged from 70.0 to 75.2%. It may be easy to reconstitute the IW produced from the steaming temperature of 60.5°C for 17.5 minutes, because of its high dispersibility (Table 2). There is a positive and significant correlation ($p < .05$, $r = .61$) between the dispersibility and the starch content of the IW (Table 3), suggesting that this high dispersibility is related to the high starch content of the IW. According to Awoyale et al. (2016), the LGC measures the minimum quantity of flour required to form a gel in a specified volume of water. This quantity varies from flour to flour based on the relative ratios of their structural constituents, such as protein, carbohydrates, and lipids. The IW produced under steaming conditions of 58.7°C for 17.5 minutes, 60.5°C for 20.5 minutes, 59°C for 15 minutes, and 62.3°C for 17.5 minutes had the highest LGC, while the IW produced under steaming conditions of 59°C for 20 minutes had the lowest LGC (Table 2).

According to Awoyale et al. (2016), the amount of starchy food required to form a gel increases with the LGC. Due to its low LGC, this indicates that only a small amount of IW produced by steaming at 59°C for 20 minutes may be required to form a gel in hot water. The high LGC of the IW that results from the steaming conditions of 58.7°C for 17.5 minutes, 60.5°C for 20.5 minutes, 59°C for 15 minutes, and 62.3°C for 17.5 minutes may be due to the high amylose content of the IW. This is because the LGC and the IW's amylose content have a positive and significant correlation ($p < .05$, $r = .58$) (Table 3).

Pasting Properties of Instant Wasa-Wasa

Table 4 depicts the IW's pasting properties. According to Oluwalana et al. (2011), food products' pasting properties are crucial for predicting their behavior during and after cooking. The IW's average pasting properties are as follows: peak viscosity 32.58 RVU, trough viscosity 18.36 RVU, final viscosity 61.21 RVU, setback viscosity 46.85 RVU, breakdown viscosity 14.22 RVU, peak time 4.30 minutes, and pasting temperature 52.04°C. Peak viscosity, which contributes to the paste's good texture (Ikegwu et al., 2009), is the maximum viscosity that develops during or shortly after the heating portion. The IW's pasting properties ranged from 19.17 to 49.75 RVU, with the IW produced at 58.7°C for 17.5 minutes having the highest pasting properties and the IW produced at 59°C for 20 minutes having the lowest (Table 4). Thus, consumers who prefer good texture products may consume cooked IW prepared from the steaming condition of 58.7°C for 17.5 minutes, while those who like low texture products may use the IW made from the steaming condition of 59°C for 20 minutes.

Table 4.
Effect of Different Steaming Temperatures and Times on the Pasting Properties of Instant Wasa-Wasa

Steaming Temperature (°C)	Steaming Time (Minutes)	Peak Viscosity (RVU)	Trough Viscosity (RVU)	Breakdown Viscosity (RVU)	Final Viscosity (RVU)	Setback Viscosity (RVU)	Peak Time (Minutes)	Pasting Temperature (°C)
62.00	15.00	36.17 ± 5.42^{abc}	19.83 ± 3.18^{abc}	16.33 ± 2.24^{ab}	73.25 ± 16.38^{b}	53.42 ± 13.20^{b}	4.73 ± 3.02^{abc}	50.35 ± 0.21^{a}
60.50	17.50	30.68 ± 12.80^{abc}	17.12 ± 1.62^{abc}	13.56 ± 12.50^{ab}	64.34 ± 9.28^{b}	47.23 ± 8.02^{bc}	4.34 ± 2.71^{abc}	52.38 ± 2.24^{a}
58.70	17.50	49.75 ± 16.26^{a}	16.88 ± 3.71^{bc}	32.88 ± 19.98^{a}	49.58 ± 8.60^{b}	32.71 ± 4.89^{c}	1.87 ± 0.75^{bc}	50.35 ± 0.28^{a}
60.50	20.50	30.58 ± 7.19^{abc}	22.46 ± 5.24^{a}	8.13 ± 1.94^{b}	53.46 ± 8.90^{b}	31.00 ± 3.65^{c}	6.53 ± 0.66^{ab}	50.83 ± 0.46^{a}
60.50	14.50	23.75 ± 2.00^{ab}	16.58 ± 0.35^{bc}	7.17 ± 1.65^{b}	57.04 ± 8.43^{b}	40.46 ± 8.07^{bc}	3.57 ± 0.71^{abc}	50.55 ± 0.00^{a}
62.00	20.00	48.04 ± 0.18a^{b}	22.38 ± 4.07^{a}	25.67 ± 3.89^{ab}	95.83 ± 22.98^{a}	73.46 ± 18.92^{a}	1.97 ± 0.14^{bc}	52.03 ± 2.16^{a}
59.00	15.00	36.58 ± 13.44^{abc}	18.17 ± 1.30^{abc}	18.42 ± 14.73^{ab}	63.08 ± 9.66^{b}	44.92 ± 8.37^{bc}	1.57 ± 0.52^{c}	50.68 ± 0.67^{a}
62.30	17.50	26.17 ± 0.59^{abc}	21.21 ± 2.06^{ab}	4.96 ± 1.47^{b}	62.83 ± 3.77^{b}	41.63 ± 1.71^{bc}	6.93 ± 0.09^{a}	55.08 ± 6.97^{a}
59.00	20.00	19.17 ± 0.12^{c}	15.63 ± 0.88^{c}	3.54 ± 1.00^{b}	70.96 ± 1.59^{b}	55.33 ± 2.47^{b}	7.00 ± 0.00^{a}	54.80 ± 0.35^{a}
Mean		32.58	18.36	14.22	65.21	46.85	4.30	52.04
p level		NS	*	NS	*	**	NS	NS

Note: NS = Not significant.
*$p < .05$, **$p < .01$.^{a,b,c}Means with different letters within the same column are significantly different ($p < .05$).

Consequently, high peak viscosity is an essential criterion for producing IW with good textural properties.

The starch paste's capacity to withstand breakdown during cooling is measured by its trough viscosity (Adegunwa et al., 2017). The IW that was produced by steaming at 60.5°C for 20.5 minutes had the highest trough viscosity (22.46 RVU), while the IW that was produced by steaming at 59°C for 20 minutes had the lowest (15.63 RVU) (Table 4). The trough viscosity decreased as more starch granules and amylose leached into the solution (Sanni et al., 2017). This suggested that, after cooking, the starch granules and amylose in the IW produced by steaming at 59°C for 20 minutes might leach into the solution, giving it a soft texture. The low sugar content may be the cause of the high trough viscosity of the IW that results from steaming at 60.5°C for 20.5 minutes. This is because the IW's sugar content has a significant and negative correlation with the trough viscosity ($p < .05$, $r = -.55$) (Table 3).

The ability of a material to form a gel after cooking is indicated by the final viscosity, which is the most common pasting parameter for determining the quality of a starch-based sample (Awoyale et al., 2019). The final viscosity was higher in the IW produced from the steaming condition 62°C for 20 minutes (95.83 RVU) and lower in the steaming condition 58.7°C for 17.5 minutes (49.58 RVU) (Table 4). This means that the IW made from the steaming condition of 62°C for 20 minutes may form gel quickly during cooking compared to the steaming condition of 58.7°C for 17.5 minutes with the lowest final viscosity. However, due to its low final viscosity, the IW produced by steaming at 58.7°C for 17.5 minutes may be resistant to shear stress during cooking (Asaam et al., 2018).

A flour paste's retrogradation tendency can be measured by its setback viscosity (Assam et al., 2018). Greater resistance to retrogradation is indicated by a lower setback viscosity during cooling (Awoyale et al., 2019). The setback viscosity ranged between 31.00 RVU in the IW produced from the steaming condition of 60.5°C for 20.5 minutes and 73.46 RVU in the IW made from the steaming condition of 62°C for 20 minutes (Table 4). This suggested that cooked IW produced by steaming at 60.5°C for 20.5 minutes might not easily retrograde due to its lower setback viscosity compared to cooked IW produced by steaming at 62°C for 20 minutes, which has a high setback viscosity.

The flour's ability to withstand cooking heat and shear stress is measured by its breakdown viscosity (Awoyale et al., 2019). The IW's breakdown viscosity was between 3.54 RVU and 32.88 RVU. The breakdown viscosity of the IW produced under steaming at 58.7°C for 17.5 minutes was the highest, while the breakdown viscosity of the IW produced under steaming at 59°C for 20 minutes was the lowest (Table 4). An expanded breakdown consistency shows a lower capacity of the sample to endure heating and shear pressure during cooking (Sanni et al., 2017). This indicates that the IW produced by steaming at 59°C for 20 minutes may withstand heating and shear stress during cooking due to its low breakdown viscosity; however, the IW produced by steaming at 58.7°C for 17.5 minutes may not withstand heating due to its high breakdown viscosity.

According to Awoyale et al. (2019), the pasting temperature is a measure of the minimum temperature required to cook a specific food sample. This temperature has an impact on the stability of other components in a formulation and indicates energy costs. The pasting temperature was higher in the IW produced from the steaming time of 17.5 minutes and temperature of 62.3°C (55.08°C) and lower in the IW made from the steaming time of 15.0 minutes at 62°C and 17.5 minutes at 58.7°C (50.35°C) (Table 4). This suggested that, due to their low pasting temperatures, the IW produced from the steaming condition of 15.0 minutes at 62°C and 17.5 minutes at 58.7°C may require less energy than the IW made from the steaming condition of 62.3°C for 17.5 minutes. However, a paste may form on all IW samples below the boiling point of water (100°C). As a result, cooked IW produced from the samples may consume less energy.

According to Table 4, the IW produced from the steaming condition of 59°C for 15 minutes (1.57 minutes) has a lower peak time, which is a measure of the cooking time. The IW produced from the steaming condition of 59°C for 20 minutes (7 minutes) has a higher peak time. This demonstrates that the entire IW can be cooked in less than 8 minutes.

Table 5.
Effect of Different Steaming Temperatures and Times on the Chemical Composition of Instant Wasa-Wasa

Steaming Temperature (°C)	Steaming Time (Minutes)	Crude Fiber Content (%)	Starch Content (%)	Sugar Content (%)	Amylose Content (%)	Moisture Content (%)	Ash Content %
62.00	15.00	2.47 ± 0.01^{ab}	32.49 ± 0.00^{d}	8.17 ± 0.01^{c}	18.24 ± 0.00^{b}	4.96 ± 0.01^{ab}	3.89 ± 0.78^{a}
60.50	17.50	2.46 ± 0.11^{ab}	40.21 ± 0.71^{a}	11.89 ± 0.68^{a}	16.57 ± 0.85^{c}	5.28 ± 0.53^{ab}	3.98 ± 0.27^{a}
58.70	17.50	2.62 ± 0.01^{a}	38.64 ± 0.01^{b}	12.14 ± 0.01^{a}	18.27 ± 0.03^{b}	5.76 ± 0.01^{a}	3.93 ± 0.00^{a}
60.50	20.50	2.51 ± 0.00^{ab}	34.94 ± 0.01^{d}	10.82 ± 0.01^{b}	17.43 ± 0.01^{bc}	5.44 ± 0.00^{ab}	4.19 ± 0.88^{a}
60.50	14.50	2.41 ± 0.01^{b}	40.56 ± 0.00^{a}	12.91 ± 0.01^{a}	17.63 ± 0.01^{bc}	4.08 ± 0.01^{c}	3.93 ± 0.50^{a}
62.00	20.00	2.48 ± 0.01^{ab}	38.10 ± 0.00^{bc}	8.44 ± 0.01c	18.41 ± 0.00^{b}	4.86 ± 0.01^{bc}	4.00 ± 0.10^{a}
59.00	15.00	2.54 ± 0.01^{ab}	35.14 ± 0.01d	8.29 ± 0.01c	20.15 ± 0.00a	4.07 ± 0.01c	3.28 ± 0.73a
62.30	17.50	2.42 ± 0.00b	35.25 ± 0.01^{d}	8.54 ± 0.02^{c}	20.21 ± 0.00^{a}	5.06 ± 0.01^{ab}	3.75 ± 0.07^{a}
59.00	20.00	2.62 ± 0.01^{a}	37.43 ± 0.00^{c}	10.48 ± 0.01^{b}	17.21 ± 0.00^{bc}	4.77 ± 0.01^{bc}	3.45 ± 0.49^{a}
Mean		2.49	37.97	10.71	17.72	5.03	3.87
p level		NS	***	***	***	**	NS

Note: NS = not significant.
^{a,b,c}Means with different letters within the same column are significantly different ($p < .05$).***$p < .001$, **$p < .01$.

Chemical Composition of Instant Wasa-Wasa

Table 5 depicts the chemical composition of the IW. Except for the amounts of ash and crude fiber, which were not significantly different ($p > .05$), the chemical composition of the IW differs significantly ($p < .05$). The means chemical composition of the IW is crude fiber 2.49%, ash 3.87%, moisture 5.03%, amylose 17.72%, total sugar 10.71%, and starch 37.97%.

Even though a product's high ash content may indicate high contamination, the ash content reflects the mineral status (Baah et al., 2009). According to Table 5, the ash content was lower in the IW produced from a steaming condition of 59°C for 15 minutes (3.28%) and higher in the IW produced from a steaming condition of 60.5°C for 20.5 minutes (4.19%). According to Omohimi et al. (2014), one of the most significant factors in determining shelf stability is the moisture content of the samples. The IW's moisture content ranged from 4.07 to 5.78%, with the IW produced at 58.7°C for 17.5 minutes having the highest moisture content and the IW produced at 59°C for 15 minutes having the lowest moisture content (Table 5). If properly packaged, the IW samples' may guarantee adequate storage. This is because the moisture content is below the 10% standard for dried foods (Sanni et al., 2005). According to Jimoh and Olatidoye (2009), the IW's moisture content was within the range of 4.07 to 5.72% which has been reported for yam flour. Although crude fiber does not contain any nutrients or energy, it is a source of the dietary fiber that is necessary for a healthy bowel movement and aids in the prevention of obesity, diabetes, colon cancer, and other diseases of the gastrointestinal tract (Awoyale et al., 2016). The IWs crude fiber content ranges from 2.42 to 2.62%. The IW with the highest crude fiber content was produced by steaming at 58.7°C for 17.50 minutes and 59°C for 20 minutes, while the IW with the lowest crude fiber content was produced by steaming at 60.5°C for 14.5 minutes. According to Umoh and Iwe (2014), the range of values is greater than that of yam flour (0.29 to 1.51%).

Starch is the predominant fraction of yam tubers (Awoyale et al., 2016). According to Table 5, the IW that was made by steaming at 60.5°C for 17.5 minutes had a higher starch content (40.21%) than the IW that was made by steaming at 62°C for 15 minutes (32.49%). Starch granule comprises a straight chain of glucose (amylose) and a branched chain (amylopectin). Functionally,

Table 6.
Effect of Different Steaming Temperatures and Times on the Sensory Properties of Instant Wasa-Wasa

Steaming Temperature (°C)	Steaming Time (Minutes)	Taste	Appearance	Color	Texture	Smell	Mouthfeel	Overall Acceptability
62.00	15.00	8.00 ± 0.85^{ab}	8.67 ± 0.78^{a}	8.75 ± 0.62^{a}	7.67 ± 0.98^{a}	8.75 ± 0.62^{a}	7.33 ± 1.07^{a}	8.17 ± 0.58^{a}
60.50	17.50	7.68 ± 1.53^{abc}	7.37 ± 2.60^{a}	8.90 ± 0.35^{a}	6.98 ± 2.19^{a}	8.53 ± 1.17^{a}	6.93 ± 2.08^{a}	7.25 ± 1.80^{a}
58.70	17.50	7.00 ± 1.35^{bc}	8.17 ± 1.40^{a}	8.92 ± 0.29^{a}	7.17 ± 1.40^{a}	8.75 ± 0.62^{a}	6.83 ± 1.11^{a}	7.67 ± 0.89^{a}
60.50	20.50	6.75 ± 1.86^{c}	8.33 ± 0.89^{a}	9.00 ± 0.00^{a}	7.33 ± 0.49^{a}	8.67 ± 0.65^{a}	7.58 ± 1.08^{a}	7.83 ± 0.72^{a}
60.50	14.50	7.67 ± 0.98^{abc}	8.58 ± 1.00^{a}	8.83 ± 0.58^{a}	6.67 ± 1.07^{a}	8.50 ± 0.90^{a}	7.25 ± 1.06^{a}	7.92 ± 0.67^{a}
62.00	20.00	7.92 ± 1.08^{abc}	8.58 ± 0.79^{a}	8.92 ± 0.29^{a}	6.67 ± 1.07^{a}	8.17 ± 1.40^{a}	6.67 ± 1.30^{a}	7.41 ± 0.51^{a}
59.00	15.00	7.42 ± 1.00^{abc}	8.33 ± 0.89^{a}	8.75 ± 0.62^{a}	6.42 ± 1.16^{a}	8.67 ± 0.65^{a}	6.67 ± 1.30^{a}	7.25 ± 0.87^{a}
62.30	17.50	7.5 ± 1.38^{abc}	8.42 ± 1.16^{a}	8.83 ± 0.39^{a}	7.83 ± 0.83^{a}	8.75 ± 0.62^{a}	6.83 ± 1.70^{a}	7.58 ± 1.16^{a}
59.00	20.00	8.33 ± 0.65^{a}	7.58 ± 2.11^{a}	8.83 ± 0.39^{a}	7.67 ± 1.15^{a}	8.5 ± 0.79^{a}	7.33 ± 1.30^{a}	7.67 ± 0.98^{a}
Mean		7.62	7.96	8.87	6.95	8.57	7.01	7.52
p level		NS	NS	NS	NS	NS	NS	NS

Note: NS = Not significant.
^{a,b,c}Means with different letters within the same column are significantly different ($p < .05$).

Table 7.
Criteria for the Optimization of Instant Wasa-Wasa Quality and Solutions

Quality Attributes	Goal	Lower Limit	Upper Limit	Importance	Solution
Steaming temperature	Is in range	59.00	62.00	3	59.77
Steaming time	Is in range	15.00	20.00	3	15.00
Swelling power	Maximize	3.95	4.37	3	4.11
Water absorption capacity	Maximize	348.40	400.75	3	378.73
Least gelation concentration	Maximize	6.00	10.00	3	8.62
Dispersibility	Maximize	70.00	76.00	3	74.68
Oil absorption capacity	Minimize	144.35	162.90	3	148.11
Solubility index	Maximize	1.93	2.12	3	2.04
Bulk density	Maximize	61.50	71.50	3	69.27
Peak viscosity	Maximize	19.17	53.92	3	32.58
Trough viscosity	Minimize	15.42	22.46	3	18.36
Breakdown viscosity	Maximize	3.54	36.42	3	14.22
Final viscosity	Maximize	49.58	95.83	3	60.69
Setback viscosity	Minimize	31.00	73.46	3	43.62
Peak time	Minimize	0.13	0.58	3	0.20
Pasting temperature	Minimize	4.20	4.59	3	4.23
Crude fiber	Maximize	2.26	2.62	3	2.50
Starch	Maximize	32.49	40.82	3	38.97
Sugar	Minimize	8.17	12.91	3	11.27
Amylose	Maximize	16.01	20.21	3	18.04
Moisture	Minimize	4.07	5.76	3	4.49
Ash	Maximize	3.28	4.19	3	3.87
Overall acceptability	Maximize	4.42	8.75	3	7.52
Desirability	–	–	–	–	0.58

amylose is the starch fraction that retrogrades more rapidly due to the tendency of the linear molecule to associate rapidly but amylopectin retrogrades slowly (Awoyale et al., 2019). Nutritionally, high-amylose starch exhibits lower digestibility, thus releasing glucose slowly into the bloodstream and hence resulting in low incidence of diabetes (Zhong et al., 2018). The amylose content was higher in the IW produced from the steaming condition of 59°C for 15 minutes (20.21%) and lower in the IW made from the steaming condition of 60.5°C for 17.5 minutes (16.57%) (Table 5). Therefore, the IW produced under steaming conditions of 60.5°C for 17.5 minutes at a low amylose content may undergo a more rapid retrograde than the IW produced under steaming conditions of 59°C for 15 minutes (Awoyale et al., 2019). Additionally, individuals with diabetes may benefit from the high amylose content of the IW produced by steaming at 59°C for 15 minutes as opposed to the low amylose content of the IW produced by steaming at 60.5°C for 17.5 minutes (Syahariza et al., 2013; Zhong et al., 2018).

Sensory Evaluation of Cooked Instant Wasa-Wasa

Due to human biological variation and how people perceive sensory attributes, sensory evaluation is an expression of an individual's likes or dislikes for a product (Iwe, 2010). The cooked IW's sensory properties are shown in Table 6. The findings show that all of the cooked IW's sensory characteristics were comparable to one another ($p > .05$) and did not significantly differ from one another.

Optimization of Instant Wasa-Wasa Quality

The models for the functional properties (SWP, WAC, OAC, LGC, dispersibility, SI, and BD), the pasting properties (peak viscosity, setback viscosity, breakdown viscosity, peak time, and pasting temperature), the chemical composition (moisture, crude fiber, ash, starch, sugar, and amylose contents), and the overall acceptability of the IW (not shown) were useful for indicating the directions in which the independent variables needed to change to maximize the quality to produce acceptable IW. The criteria that were used for the numerical optimization of the variables are shown in Table 7. These responses were used. The overall acceptability of the IW, crude fiber, starch, amylose, and ash, as well as the response values of SWP, WAC, LGC, dispersibility, SI, and BD, were maximized while the OAC, and the trough and setback viscosities, peak time, pasting temperature, and sugar and moisture contents were minimized. While optimizing the dependent variables, the steaming temperature and time were kept within a range as independent variables. The desirability value of 0.58 was chosen because it represented the best combination of steaming temperature and time that could produce quality and an acceptable IW, which is 60°C for 15 minutes.

Conclusion and Recommendations

Since *wasa-wasa* is a steamed granule produced from yam flour, with no consistent steaming temperature and time, which may affect the quality and acceptability of the product, this study

showed that steaming yam flour at 60°C for 15 minutes will produce an acceptable *wasa-wasa* of good quality.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - W.A., S.S., K.O.; Design - W.A., S.S., K.O.; Materials - A.W., S.S.; Data Collection and/or Processing - W.A., S.S., K.O.; Writing Manuscript - W.A., S.S., K.O.

Acknowledgment: The authors would like to acknowledge Mrs Kudirat Ajao of the Department of Food Science and Technology Food Processing Laboratory, Kwara State University Malete, for her role in this study.

Declaration of Interests: The authors have no conflicts of interest to declare.

Funding: The authors declared that this study has received no financial support.

Hakem Değerlendirmesi: Dış bağımsız.

Yazar Katkıları: Fikir – W.A., S.S., K.O.; Tasarım – W.A., S.S., K.O.; Malzemeler – A.W., S.S.; Veri Toplanması ve/veya İşlemesi – W.A., S.S., K.O.; Yazıyı Yazan – W.A., S.S., K.O.

Teşekkür: Yazarlar Bayan Kudirat'a teşekkür etmek isterler.Ajao, Gıda Bilimi ve Teknolojisi Gıda İşleme BölümüBu çalışmadaki rolü nedeniyle Malete Kwara Eyalet Üniversitesi Laboratuvarı'na teşekkür ederiz.

Çıkar Çatışması: Yazarlar çıkar çatışması bildirmemişlerdir.

Finansal Destek: Yazarlar bu çalışma için finansal destek almadıklarını beyan etmişlerdir.

References

Adegunwa, M. O., Adelekan, E. O., Adebowale, A. A., Bakare, H. A., & Alamu, E. O. (2017). Evaluation of nutritional and functional properties of plantain (Musa paradisiaca L.) and tiger nut (Cyperus esculentus L.) flour blends for food formulations. *Cogent Chemistry*, *3*, 1–15.

Agbo, T. O. O., Ekele, G. E., & Amonjenu, A. (2016). Evaluation of harvest and post-harvest skills in yam (*Doiscorea spp*) production possessed by agricultural education students in Colleges of Education in north-central Nigeria. *Scholarly Journal of Agricultural Sciences*, *6*(6), 162–168.

AOAC. (2010). *Official methods of analysis* (18th ed.). Association of Official Analytical Chemists.

Asaam, E. S., Adubofuor, J., Amoah, I., Apeku, O. D., & Yildiz, F. (2018). Functional and Pasting Properties of Yellow Maize – Soya Bean – Pumpkin composite flours and acceptability Study on their breakfast cereals. *Cogent Food and Agriculture*, *4*, 1–15.

Awoyale, W., Kawalawu, W. K. C., Asiedu, R., Maziya-Dixon, B., Abass, A., & Edet, M. (2019). Evaluation of the chemical and functional properties of gari from Liberia. *Croatian Journal of Food Science and Technology*, *11*(2), 1–11.

Awoyale, W., Maziya-Dixon, B., Sanni, L. O., & Shittu, T. A. (2010). Nutritional and Sensory properties of amala supplemented with distillers spent grain (DSG). *Journal of Food, Agriculture and Environment*, *8*(3 & 4), 66–70.

Awoyale, W., Maziya-Dixon, B., Sanni, L. O., & Shittu, T. A. (2016). Effect of water yam (*Dioscorea alata*) flour fortified with distiller's spent grain on nutritional, chemical, and functional properties. *Food Science and Nutrition*, *4*(1), 1–3. [CrossRef]

Awoyale, W., Oyedele, H., Adenitan, A. A., Alamu, E. O., & Maziya-Dixon, B. (2021). Comparing the functional and pasting properties of gari and the sensory attributes of the eba produced using backslopped and spontaneous fermentation methods. *Cogent Food and Agriculture*, *7*(1), 1, 1883827. [CrossRef]

Ayitey, C. (2016). 5 delicious Ghanaian meals with strange names. *Yen.com.gh – Ghana News*.

Baah, F. D., Maziya-Dixon, B., Asiedu, R., Oduro, I., & Ellis, W. O. (2009). The nutritional and biochemical composition of D. alata (Dioscorea spp.) tubers. *Journal of Food, Agriculture and Environment*, *7*(2), 373–378.

Ikegwu, O. J., Nwobasi, V. N., Odoh, M. O., & Oledinma, N. U. (2009). Evaluation of the pasting and some functional properties of starch isolated from some improved cassava varieties in Nigeria. *African Journal of Biotechnology*, *8*, 2310–2315.

Iwe, M. (2010). Handbook of sensory methods and analysis. *Rojoint Communication Services Ltd Enugu*, 78.

Jimoh, K. O., & Olatidoye, O. P. (2009). Evaluation of physicochemical and rheological characteristics of soybean fortified yam flour. *Journal of Applied Biologicalsciences*, *13*, 703–706.

Komolafe, E., & Arawande, J. (2010). Evaluation of the quantity and quality of gari produced from three cultivars of cassava. *Journal of Research in National Development*, *8*, 15–23.

Oluwalana, I. B., Oluwamukomi, M. O., Fagbemi, T. N., & Oluwafemi, G. I. (2011). Effects of temperature and period of blanching on the pasting and functional properties of plantain (*Musa Parasidiaca*) flour. *Journal of Stored Products and Postharvest Research*, *2*, 164–169.

Omeire, G. C., Umeji, O. F., & Obasi, N. E. (2014). Acceptability of noodles produced from blends of wheat, acha, and soybean composite flour. *Nigerian Food Journal*, *32*(1), 31–37. [CrossRef]

Omohimi, C. I., Sobukola, O. P., Sarafadeen, K. O., & Sanni, L. O. (2014). Effect of ucuna-extrusion process parameters on selected quality attributes of meat analogue from ucuna bean seed flour. *Nigerian Food Journal*, *32*(1), 21–30. [CrossRef]

Onimawo, I. A., & Akubor, P. I. (2012). Food Chemistry (Integrated Approach with Biochemical background). 2nd ed. Joytal printing press, Agbowo, Ibadan, Nigeria

Oppong, D., Arthur, E., Kwadwo, S. O., Badu, E., & Sakyi, P. (2015). Proximate composition and some functional properties of soft wheat flour. *International Journal of Innovative Research in Science, Engineering and Technology*, *4*, 753–758.

Pereira, C. R., Resende, J. T. V., Guerra, E. P., Lima, V. A., Martins, M. D., & Knob, A. (2017). Enzymatic conversion of sweet potato granular starch into fermentable sugars: Feasibility of sweet potato peel as an alternative substrate for α-amylase production. *Biocatalysis and Agricultural Biotechnology*, *11*, 231–238. [CrossRef]

Sanni, L. O., Maziya-Dixon, B., Akanya, J. N., Okaro, C., Alaya, Y., Egwuonwu, C. Y., Okechukwu, R. U., Ezedinma, C., Akoroda, M., Lemchi, J., Ogbe, F., Okaro, E., Tarawali, G., Mkumbira, J., Patino, M., Ssemakula, G., & Dixon, A. (2005). *Standards for cassava products and guidelines for export* (p. 96). IITA.

Sanni, L. O., Tomlins, K., Owo, H. O., Sobukola, O. P., Obadina, O. A., & Kajihausa, O. E. (2017). Influence of storage conditions and packaging materials on some quality attributes of water yam flour. *Cogent Food and Agriculture*, *10*, 1–26.

Syahariza, Z. A., Sar, S., Hasjim, J., Tizzotti, M. J., & Gilbert, R. G. (2013). The importance of amylose and amylopectin fine structures for starch digestibility in cooked rice grains. *Food Chemistry*, *136*(2), 742–749. [CrossRef]

Umoh, E. O., & Iwe, M. O. (2014). Effect of processing on the nutrient composition of False Yam (*Icacina trichantha*) flour. *Nigerian Food Journal*, *32*(2), 1–7. [CrossRef]

Zhong, Y., Zhu, H., Liang, W., Li, X., Liu, L., Zhang, X., Yue, H., Xue, J., Liu, X., & Guo, D. (2018). High-amylose starch is a new ingredient to balance the nutrition and texture of food. *Journal of Cereal Science*, *81*, 8–14. [CrossRef]

Zulaiha, Z. (2018). Wasawasa is an African food widely eaten by the Dagombas in the Northern [sic] region of Ghana it is.... *Medium*.https://medium.com/@zulaihaziblim6/wasawasa-is-an-african-food-widely-eaten-by-the-dagombas-in-the-northen-region-of-ghana-it-is-39aac4baaa95. Accessed 19th July 2023 at 2.30pm.