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Improving willingness-to-pay studies for traditional food products in developing countries: Evidence using repeated experiments

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Abstract

Willingness-to-pay (WTP) studies for traditional food products are plausibly affected by unobserved decisions and strategic collusion between the experimenter and respondents. Similarly, WTP estimates in developing countries using a one-time survey might be inconsistent, as the acceptance of new products likely varies with exposure to product attributes. We use repeated experimentation, where subjects are randomised twice on treatments, to reduce hypothetical bias and account for dynamic convergences of consumers' preferences. We rely on longitudinal variation in treatments, which allows subjects' characteristics and setting to have little influence on WTP estimates. These experimental designs evaluated consumers' preferences for cakes from high-quality cassava flour (HQCF) and wheat flour mixtures in Nigeria. When analysed separately and combined in panels, we find a time-consistent, insignificant difference in consumers' preferences and WTP for all cake categories. Nonetheless, we find evidence of texture and moistness as favourable attributes of HQCF cakes. Intensifying agronomic research and processing techniques that enhance favourable attributes such as the texture and moistness of HQCF could improve acceptance.

Key words: preference for randomisation, WTP, revealed preferences, preference stability, HQCF

1. Introduction

Cassava (*Manihot esculenta Crantz*) is a traditional crop in Sub-Saharan Africa (SSA). Suggestions of using the root as an alternative to wheat flour have received significant attention (e.g. Owusu *et al*.

2017; Akintayo *et al*. 2020; Sampson 2020). Compared to wheat, cassava cultivation raises less severe ethical and environmental concerns (Gerbens-Leenes *et al*. 2009; Feyisa 2021). Furthermore, high-quality cassava flour (HQCF) is gluten-free and suitable for baked food products (Oluwole & Karim 2015). Therefore, in addition to promoting wheat import substitution, cassava inclusion is a sustainable solution to food security that could transform the rural economy (Abass *et al*. 2018).

To secure 'daily bread', wheat is important for food and nutrition security in Africa. However, many African countries confront worsening terms of trade due to their dependence on imported wheat grain and flour. Driven by population growth, urbanisation and a growing middle class, with a strong penchant for easy-to-make wheat products like bread, the demand for wheat in the region is increasing. The available data shows that, between 2000 and 2009, annual wheat consumption in the region grew by nearly 650 000 metric tons (MT) (Mason *et al*. 2015). In 2013, it reached 25 MT, with imports accounting for 17.5 MT at $6 billion. It is projected to reach 76.5 MT by 2025, of which 48.3 MT will be imported (FAOSTAT 2020).

Supporting traditional food products (TFP) could alleviate rising food bills and cushion wheat supply shocks in Sub-Saharan Africa (SSA). Traditional food products are classified as "products […] made accurately in a specific way according to the gastronomic heritage, […] and known because of [their] sensory proprieties and associated with a certain local area, region or country" (Balogh *et al*. 2016, p. 348; see also Guerrero *et al*. 2009). The food science literature identifies several locally grown alternatives to wheat in Africa, such as rice, sweet potato and cassava (Rakotoarisoa *et al*. 2011). Although policies mandating TFP inclusion are rising, enforcement would be challenging without understanding their acceptability by consumers. Therefore, the broad acceptability of locally grown foods as alternatives to wheat depends on whether consumers are willing to pay a premium for them compared to 100% wheat flour.

There have been efforts to understand consumers' preferences for cassava-wheat composite flours in baked food products in Africa (Owusu *et al*. 2017; Sampson 2020). Although the literature supports the inclusion of high-quality cassava flour (HQCF) in wheat flours at about 10% to 20% (Owusu *et al*. 2017; Sampson 2020), evidence is mixed at inclusion levels above 20% (Onyekuru *et al*. 2019). The limited informativeness of WTP estimates for HQCF largely reflects the general issues with hypothetical bias of studies done under quasi-experimental settings (Loomis 2014). Hypothetical bias arises under stated preference surveys due to the participants' uncertainty about the value of the goods under assessment (Loomis 2014; Bobinac 2019). Recent additions in the empirical literature suggest that, when evaluating the acceptance of traditional food products, studies need to be designed to rely less on subjective feedback and more on experimental designs to minimise strategic bias (Liljas & Blumenschein 2000; Schmidt & Bijmolt 2020; Meginnis *et al*. 2021).

On the other hand, incentivised trials studying acceptability by consumers in developing countries could aggravate strategic misrepresentation and limit the informativeness of WTP estimates. In studies where subjects are incentivised to participate in experiments, participants might strategically align their choices to reflect the experimenter's expectations (Mentzakis & Zhang 2012; Mørkbak *et al*. 2014). For instance, Morawetz *et al*. (2011) observe that experimenters implementing incentivised WTP valuations in Africa face ethical concerns if incentives pressure poor participants to align choices with experimenter expectations. Equally, although the complete randomisation of subjects into treatments keeps study groups as similar as possible and allows for robust identification of treatment on WTP, it probably does not protect against other types of bias. Flaws in experimental design threaten internal validity and selection bias, which introduce other unobservable confounding factors (e.g. experimenter's efforts) that can affect treatment effects (Chassang *et al*. 2012; Krauss 2018). Therefore, unobserved bias due to limited exposure and strategic collusion are sources of heterogeneity in treatment effects and significant challenges to the external validity of WTP experimental trials in developing countries.

A significant outcome of the review conducted on WTP methodologies supports repeated experiments to reduce hypothetical bias. Consumer preference might evolve dynamically as individual behaviour converges on neoclassical prediction due to greater exposure to the product (List 2003). Repeated elicitation, often across intertemporal periods, has also been used to enhance choice consistency in WTP valuation (Jorgensen *et al*. 2004; Czajkowski *et al*. 2014; Rigby *et al*. 2016). The central idea originates from the social psychology of cognitive dissonance. When told that a follow-up survey would be held, people prefer not to take inconsistent stands and adjust their stated WTP to avoid cognitive dissonance (Alfnes *et al*. 2010).

Mentzakis and Zhang (2012) provide evidence of intertemporal preference stability in a laboratory experiment where the experiment was conducted with the same subjects one week after the first test, using a between-subject in two different situations (hypothetical and real). It asks for subjects' preferences without any financial incentive in the hypothetical setting, and participants were incentivised in the revealed setting. The work done by Mentzakis and Zhang (2012) is very useful and perhaps belongs to a relatively unusual approach that examines the temporal stability of preferences under a different setting. The findings offer partial evidence in support of the stability of preferences. They find a higher instability in the preferences in the hypothetical treatments than in any of the WTP values (incentivised or hypothetical).

The contribution of this study is that we build on the above studies and incorporate simple extensions to randomised controlled trials (RCTs), namely repeated trials, where blind treatments corresponding to an undisclosed allotment are repeated randomly on the same subject on separate occasions to improve the dynamic consistency and external validity of the trial results. These experimental designs are used in this study to evaluate consumers' revealed preference for cake from high-quality cassava flour and wheat flour mixtures. We also used it to investigate the sensory attributes consumers would see as being improved at varying levels of HQCF inclusion in the composite flour.

We incorporate two key features. First, a single-blind technique to reduce strategic bias arising from subjects aligning preference with the experimenter's expectation because participants are unaware of the treatment category to which they belong. To this end, we recruited 130 subjects – cake consumers (age: 23 ± 3 years; sex: 85 female, 45 male; marital status: 7 married, 123 single) who indicated not having allergies to cassava and wheat flour. Participants were randomly assigned to five groups, with 0% HQCF (control group), and 25%, 50%, 75% and 100% HQCF treatment groups. Randomising subjects into treatments helps keep study groups as similar as possible and allows for robust treatment identification of WTP. A questionnaire (see Appendix 1) that extracted information on the subjects' socioeconomic and demographic distribution was administered, and they were asked how much they were willing to pay for the cake sample and the most preferred attributes. The experimental design allowed us to investigate the revealed preference in a way plausibly more robust than using only observational data.

Second, we repeated the experiment on the same subjects by inviting them for another experiment five days after the first. Why is this important? According to Alfnes *et al*. (2010), people who want to see themselves as rational and thoughtful, as well as honest and trustworthy, have a motivational drive to try to give consistent responses to a series of questions. This differs from cheap talk, and we refer to it as real talk by telling the respondents of a follow-up survey/experiment. The follow-up survey exploited within-subject design variation, while other parts that may be confounded due to the valid fears raised by the reviewer are sorted out in the model with fixed-effects (FE) estimation.

Combining the first and second experimental rounds produces a panel-level observation that isolates the treatment effect while controlling for other non-time-varying confounding biases. We estimated pooled OLS, and random and fixed-effect estimators that isolated the treatment effect and gave a more robust treatment effect. We found evidence of preference stability and WTP consistency for the first and second experiments.

When the two experiments were estimated separately, we found that consumers' WTP for cake made from 100% wheat flour was not significantly different from the cakes in the 25%, 50%, 75% and 100% HQCF treatment group. Similarly, when analysed at a panel level, the result supports a time-consistent insignificant difference in WTP and consumers' preferences for the five cake group categories. These findings allude to consumers' acceptance of confectioneries and pastries made from cassava-wheat composite flours (Owusu *et al*. 2017; Onyekuru *et al*. 2019; Sampson 2020).

Next, we investigated WTP for preferred sensory attributes associated with the cake groups. A recurrent concern expressed by commercial bakers concerns sensory attributes related to the acceptance of the end product from HQCF-treated composite flour. For example, the use of HQCF can face resistance due to taste, colour and texture-based discrimination of the end products among consumers (Bechoff *et al*. 2018). Although existing cassava-breeding programmes based on farmer-led trait identification can have some successes, combining the breeding work with market desires will lead to greater success. Research that merges an alliance between the demand- and supply-side ends of cassava value chains could help promote more market-driven client-oriented research (Bechoff *et al*. 2018). In support of this, we found the preferred attributes associated with HQCF to be texture, with HQCF inclusion at 25% ($p < 0.1$), moistness, with HQCF at 50% ($p < 0.1$), and HQCF at 75% ($p < 0.05$) as the preferred attributes associated with HQCF. We find evidence of an insignificant effect on other attributes.

The remainder of the paper is as follows. The next section describes the experimental design and the data collection technique. We provide the analytical framework in Section 3, while the various results are discussed in Sections 4 and 5. Section 6 investigates various mechanisms to explain the results. The paper ends with some concluding remarks in Section 6.

2. Experimental design

2.1 Subjects and participants

All subjects for the study were recruited randomly through advertisements posted on the WhatsApp social media channel to user groups comprising students and religious and social organisations in the local community. Written informed consent was obtained from every participant. Confidentiality of personal information was consistently preserved by anonymising the data obtained using a code corresponding to the personal identification information. The broadcast requested participants' interest in participating in research on consumer preferences for cassava and wheat-based flour pastry (cake). They were told to complete a Google form to participate in the study. The inclusion criteria were as follows:

1. Non-allergies to cassava flour and gluten from wheat.
2. Having eaten cake or any wheat-derived pastry at least once within two weeks before enrolment in the study
3. Must be able to read and understand English

4. If randomised to the HQCF treatment group, willingness to eat cake and complete the questionnaire, as appropriate
5. Willingness to complete two assessment sessions (baseline and end of study)
6. Be able to provide informed consent and be willing to sign an approved consent form that conforms to institutional guidelines

The initial broadcast was sent to a total of 150 prospective participants. There was a response rate of 92%, indicating that 138 said they would be available. Also, 142 (94.6%) prospective participants said they were not allergic to cassava. In comparison, the remaining eight (5.3%) said they were allergic to cassava, which made a total of 20 respondents who were not qualified to participate in the experiment because they were either not available for the research, or were allergic to cassava, which was the major research object of the experiment. A total of 130 respondents were eligible and participated in the first and second rounds of the experiment. They were sent a text to inform them of their selection for the research experiment. The message sent to them included the time and scheduled venue where the experiment would be held. A follow-up message was sent before the experiment, reminding them of the date, time and venue.

2.2 Data collection and timeline of experiment

HQCF and cake were produced under hygienic conditions in a food laboratory. Data used for the analysis in this paper come from a well-designed questionnaire administered at the end of the intervention on the two days of the experiment. Informed consent was received from all participants before the start of the experiments. Ethical approval was obtained from the Faculty of Agriculture, University of Ilorin Ethics Committee (UERC).

The food sensory evaluation laboratory was used for the analysis. Specifically, upon arrival, participants sat down and were randomly assigned cakes containing varying levels of HQCF. Shortly after, they filled out the questionnaire and provided answers on socio-economics and demographics, preference for cake attributes, and WTP measures. The randomisation was a single-blind experiment in that the subjects were unaware of the level of HQCF included in their cake. This was done to reduce strategic bias from conscious and unconscious bias, which could lead to the misrepresentation of preferences. However, the monitoring experimenter knew the treatment category.

The first balance checks were done regarding the distribution of socio-economics and WTP by treatment categories. Table 1 and Figure 1 show that the distribution of the variable of interest was equal across the treatment categories, indicating that randomisation was successful. In the main result, additional checks were carried out on randomisation by comparing the estimate of the treatment effect in the regression models with and without the addition of control variables.

Table 1: Average statistics across treatment groups

	WTP	Age	Sex	Laptop cost (NGN)	Phone cost (NGN)	House rent (NGN)	Monthly allowance (NGN)	Total number of observations (%)
Aggregate	162.34	23.4	0.65	73 983.85	104 666.20	118 019.20	25 430	
Treatment groups								
Group 0 (Control)	177.15	23.3	0.64	73 770.45	91 215.91	79 875	23 138.89	44 (17)
Group 1	168.23	24.3	0.63	80 254.90	139 139.20	107 568.60	29 261.90	51 (19.6)
Group 2	158.38	23.1	0.67	57 830.51	112 001.70	94 525.42	23 000	59 (22.69)
Group 3	151.76	23.2	0.66	79 901.96	90 676.47	165 377.60	30 270.27	51 (19.62)
Group 4	159.09	23.3	0.65	80 180	88 563.64	128 963	27 515.15	55 (21.15)
Difference in the mean score in the control group and the average of the other three treatment means	-17.83	0.19	0.02	256.8	16 190	42 803	4 013	
Two-sample t-test (@ p = 0.05)	-1.31	0.39	0.26	0.019	0.86	1.64	0.49	

Notes: NGN denotes Nigerian naira. Groups 1 to 4 represent the 25%, 50%, 75% and 100% HQCF treatment groups. Group 0 is zero % HQCF and is the control group (see in text for detailed discussion).

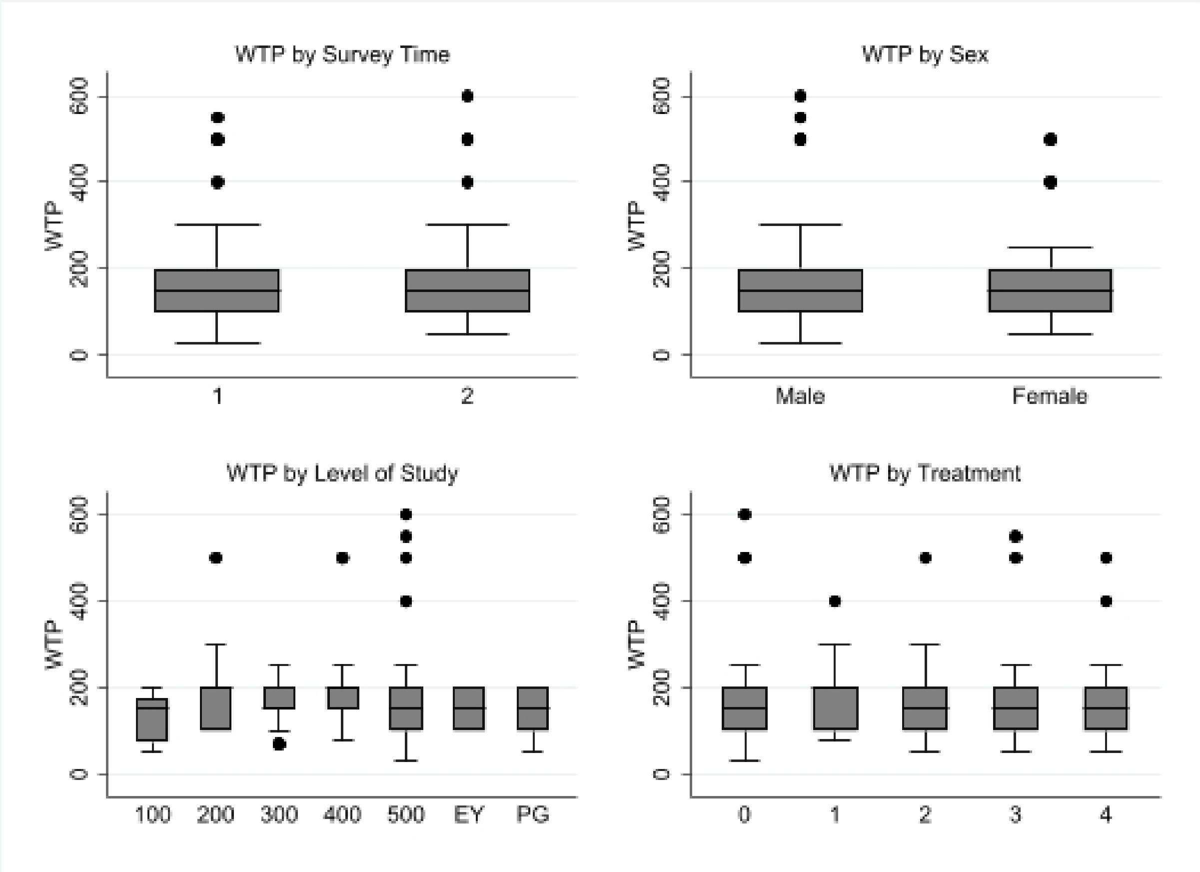

Figure 1: Distribution of WTP by various measures. EY represents extra-year students, while PG is for postgraduates. Survey times 1 and 2 denote first and second experiments, respectively

3. Analytical framework

This section presents our identification strategy and provides an intuitive justification for the underlying assumptions.

Our first approach to estimating the treatment effects of HQCF on preference and WTP is to posit a regression model separately for the two rounds in Equation (1). Then, in Equation (2), we pool the observations from the two rounds and estimate a random- and fixed-effects regression that accounts for strategic bias, bias with experimental design, and other unobservable heterogeneities.

$$WTP_i = \beta_0 + \beta_1 Xi'(T\,reat = 1) + \beta_2 Zi' + u_i \quad (1)$$

$$WTP_{it} = \beta_0 + \beta_1 X1'\,,it(T\,reat = 1) + \beta_2 Zi't + \beta_3 T_t(Time) + \beta_4 X2'\,,it(Time\times Treat) + \alpha_i + u_{it}, \quad (2)$$

where i indexes the individual participant and t the round of the experiment. The dependent variable, willingness to pay (WTP), measures the amount participant i is willing to pay for the cake they are randomly assigned based on the cake they usually buy outside of the experiment. We used this to indicate a preference for the cake sample presented in the group. X'_i is a vector of the treatment level representing the percentage of HQCF inclusion in the cakes. The treatment in each case is a dummy variable, observed as to be 1 if it takes any of the five categories, and 0 if otherwise: treatment 1 (0% HQCF), treatment 2 (25% HQCF), treatment 3 (50% HQCF), treatment 4 (75% HQCF), and treatment 5 (100% HQCF).

Z'_i is a vector of other socioeconomic and demographic characteristics that serves as a battery of controls to verify that randomisation was not partial. The error term (u_i) is a vector of idiosyncratic shocks. T_t is the time effect, while α_i are individual fixed effects, capturing any time and individual unobservable heterogeneity. The interaction of *Time* and the vector of treatments ($X2', it$) is to test for the time consistency of the treatment effect on WTP.

In both (1) and (2), we are mainly concerned with revealing causal relationships between the treatment category and the outcome (WTP). Random assignment of the treatments allows us to investigate and compare the relationships. However, the estimates of the treatment effect in equations (1) and (2) are valid under the following assumptions:

Assumption 1: *Strict exogeneity.* For Equation (1), strict exogeneity implies $E(u_i|X_{i1}, Zi') = 0$, i.e., u and X are independently distributed, and the correlation between the two is independent of the unobserved individual and observed characteristics. Because RCTs allow the treatment and control groups to look alike, other unobserved characteristics are less likely to violate the strict exogeneity criteria. In support of this assumption, if X'_i is randomly assigned, then the OLS estimators with and without the Z'_i in Equation (1) should be similar. If this is not the case, it is plausible that the experiment was not designed randomly.

Even though an RCT is the benchmark impact-evaluation strategy, there is still the possibility that the assignment was imperfectly randomised and that the treatment was not entirely blinded. This could likely occur due to experimenter bias and the strategic behaviour of participants. When trial samples were not representative of the general population, i.e. if participants were recruited on a social platform with strong links to the experimenter, participants receiving the treatments might be strategic in expressing their WTP. In this case, the error terms include all other unobservables that are difficult to measure, but plausibly correlated with the treatment effect.

In this regard, it might be helpful to carry out a follow-up experiment to allow for a panel-level observation to enable us to control these unobservable factors in Equation (2) with a fixed-effect estimator. Any omitted variable, hypothetical bias, or strategic behaviour that is constant (or relatively stable) over time at the individual level will bias (1) but will not bias (2), because the fixed effect will capture any effect they have. However, a follow-up experiment on the same participants implies an additional assumption of sequential exogeneity.

Assumption 2: *Sequential exogeneity*. This implies $E(\mu_{it}|X1', it, Zi't, \alpha_i, T_t) = 0$, i.e., after controlling for treatment, observable and unobservable factors, previous treatments do not influence contemporaneous WTP, and the error term is serially uncorrelated. This is a strong assumption, but it is not implausible under single-blind full randomisation. On the other hand, empirical evidence suggests that individual behaviour converges as market experience intensifies (List 2003). Through repetition and learning the experiment format, participants could make more precise and consistent decisions (List 2003; Brouwer *et al*. 2017). Practised consumers with earlier experience of a treatment effect may have a different disposition towards the experiment the second time, which may be aggravated if the selection effect affects the recruitment of participants. Empirically, we can test for this concern by interacting with *Time* and treatment in Equation (2). A significant difference in either direction violates the assumption of sequential exogeneity.

4. Results

This section is divided into four parts. Table 2 reports the results using the ordinary least square estimator separately for the two rounds of experiments. In the first two columns (I and II), the results from the analyses are reported without controlling for additional variables. Although these results suggest a statistically insignificant difference across preferences for the cake categories, they may be an artifact of the sampling procedure, leading to false inference. To amend this situation, we include additional controls for the respondents' socioeconomic and location-specific characteristics in the last two columns (III and IV). Overall, we find a statistically insignificant difference across preferences for the cake categories with and without the inclusion of controls.

Table 2: Estimates of cross-sectional regressions

	Effect on WTP			
	No control variables		**With control variables**	
	Round 1	**Round 2**	**Round 1**	**Round 2**
	(I)	(II)	(III)	(IV)
Treatment 1	-15.92	55.31	-64.72	15.79
	(25.25)	(32.03)	(112.29)	(102.61)
Treatment 2	-12.31	28.89	-19.89	103.96
	(20.14)	(17.84)	(103.27)	(127.28)
Treatment 3	-14.33	11.74	3.20	-34.53
	(21.40)	(17.21)	(106.81)	(60.71)
Treatment 4	-32.30	16.09	-58.59	-33.72
	(29.56)	(14.06)	(98.86)	(170.59)
Observations	130	130	100	100

Note: The treatment dummies are in five categories: treatment 1 (0% HQCF), treatment 2 (25% HQCF), treatment 3 (50% HQCF), treatment 4 (75% HQCF), and treatment 5 (100% HQCF). The response function is standardised, with the treatment 5 category set to zero, so each β_1 represents the estimated effect of HQCF inclusion on WTP relative to WTP associated with the treatment 5 category. Control variables include age, sex, address location, level of study, whether respondent eats out, parents' marital status and occupation, cooking skills, faculty, monthly allowance, laptop costs, mobile phone, and house rent, with robust standard errors (in parentheses). See in text for further discussions.

Even though the result of the analyses, when done separately, reveal similar insights, the scope of the study may be interpreted narrowly due to other confounding influences. Table 3 shows the results from analysing the treatment effect after combining the two rounds of experiments into panel-level observations. Columns V, VI and VII report the result for the pooled OLS, fixed and random effects, respectively. In addition, Table 3 includes the interaction of the treatment with time (experimental round) to control for the additional effect of time (stability) and the convergence effect as individual experience increases. The results in column VI also control for individual and experimental-level fixed unobservable heterogeneities with the fixed effect estimator.

Table 3: Estimates of panel data regressions

	Effect on WTP		
	Pooled OLS (V)	**FE (VI)**	**RE (VII)**
Treatment 1	12.69	32.30	29.72
	(34.73)	(28.58)	(36.54)
Treatment 2	13.60	-21.39	-13.81
	(31.07)	(17.05)	(22.34)
Treatment 3	-28.02	-18.21	-18.91
	(23.52)	(14.39)	(18.43)
Treatment 4	-27.59	-19.03	-19.20
	(23.77)	(16.72)	(21.47)
Survey time (first experiment = 1)	19.6	-19.15	-9.35
	(41.34)	(15.25)	(19.92)
Treatment 1*Survey time (D = 1)	-48.02	-15.78	-23.71
	(58.8)	(35.98)	(46.7)
Treatment 2*Survey time (D = 1)	-42.8	46.15	27.64
	(46.4)	(27.37)	(34.03)
Treatment 3*Survey time (D = 1)	-9.006	-5.01	-10.007
	(51.38)	(25.04)	(31.54)
Treatment 4*Survey time (D = 1)	-34.23	23.15	6.6
	(45.9)	(22.13)	(27.64)
Observations	200	200	200

Note: The treatment dummies are in five categories: treatment 1 (0% HQCF), treatment 2 (25% HQCF), treatment 3 (50% HQCF), treatment 4 (75% HQCF), and treatment 5 (100% HQCF). The response function is standardised, with the treatment 5 category set to zero, so each β_1 represents the estimated effect of HQCF inclusion on WTP relative to WTP associated with the treatment 5 category. All specifications include location and time effects, as well as controls, which have age, sex, address location, level of study, whether respondent eats out, parent's marital status and occupation, cooking skills, faculty, monthly allowance, laptop costs, mobile phone and house rent, with robust standard errors (in parentheses). Estimates of treatments + interaction terms were not significant at p = 0.001, 0.05 and 0.1 respectively across all models with and without the interaction terms. See in text for further discussion.

Table 4 shows the results for re-specifying equations (1) and (2) to account for just two categories: when the HQCF level is zero (control) and any treatment that includes at least 25% HQCF. Columns VIII to XII report analyses separately for the two rounds (VIII and IX), pooled OLS (X), and fixed and random effects (XI and XII). The results are similar to the findings in Table 3.

Table 4: Results from alternative specifications

	Effect on WTP				
	Round 1 (VIII)	**Round 2 (IX)**	**Pooled OLS (X)**	**FE (XI)**	**RE (XII)**
Treatment 0	-42.24	7.22	27.65	36.41	33.76
	(52.92)	(90.49)	(30.02)	(25.65)	(32.48)
Observations	100	100	200	200	200

Note: The treatment dummies are in two categories: treatment 0 (0% HQCF) and treatment 1 (≥ 25% HQCF). The response function is standardised, with the treatment 2 category set to zero, so each β_1 represents the estimated effect of HQCF inclusion on WTP relative to WTP associated with the treatment 2 category. All specifications include controls, which have age, sex, address location, level of study, whether respondent eats out, parent's marital status and occupation, cooking skills, faculty, monthly allowance, laptop costs, mobile phone, and house rent. Models X to XII account for location and time effects, with robust standard errors (in parentheses). See in text for further discussion.

5. Discussion

The potential of locally available wheat alternatives to flour garners much attention in many wheat-importing countries, especially given the current war between the two largest producers and exporters of wheat in the world – Russia and Ukraine. Given the economic importance of flour-based products to food security and the corresponding relevance of agricultural expansion of the cassava crop for rural economic transformation, it is important to understand consumer acceptance of products made with HQCF-treated flours. In addition, consumer acceptance of HQCF-treated products is important for marketability and is relevant for the widespread adoption of the policy in SSA. This paper conducted a revealed preference single-blind experiment to enhance this understanding. Overall, the study confirms prior findings about acceptability to consumers. However, unlike previous studies, we implemented an experiment that enabled the isolation of the HQCF treatment effect on consumers' preferences.

A number of key, important findings are highlighted in this article. First, the various estimators' results show that preference and WTP across the treatment categories do not vary, irrespective of the treatment level. This means HQCF-treated flours are relatively strong substitutes for 100% wheat flour. In addition, we show that, if facing a binary choice between a 100% wheat-based flour and an HQCF-treated alternative, consumers are indiscriminate, as they find their preference for the two choices to be similar. Importantly, these results suggest that consumers will be more responsive to adjusting consumption to HQCF-based pastries from wheat-based products.

To the authors' knowledge, this single-blind, randomised, repeated trial is the first well-controlled trial of the acceptance of traditional food that has been performed in a developing country context. However, despite the plausibility of less cognitive and strategic bias when compared with earlier studies, this study has important limitations. For example, despite detecting no significant differences in preference based on the level of HQCF inclusion, it cannot be ruled out that a distinction may be possible in a larger sample, an extended duration of experimentation, or a shorter assessment period. Also, these findings using cake cannot be generalised to other baked or fried confectionaries.

On the other hand, several steps were taken in the trial protocol to reduce sources of variability that may affect the study's WTP and preference-measurement methods. For instance, we provided relevant information to the subjects before the experiments started and ensured adequate demarcation to minimise strategic interaction among subjects and other participants.

6. Mechanisms: WTP for sensory attributes

The available evidence shows that the texture, colour and moisture of cassava-wheat composite bread and pastries differ significantly from pure wheat bread (Shittu *et al*. 2009; Owusu *et al*. 2017). For breeding efforts to be successful, improving the agronomic traits of the cassava plant would require end-users' preferences to enhance the crop palatability (Bechoff *et al*. 2018).

A recent attempt at qualitatively determining these attributes for bread in Ghana was carried out by Owusu *et al*. (2017). However, their qualitative findings are still subject to hypothetical bias, since the data was observational. This section analyses and discusses plausible mechanisms behind our core findings. Specifically, we investigate consumers' preferred attributes of texture, moisture, creaminess, taste, smell, and colour associated with HQCF-treated cakes. The approach follows the same experimental procedure under the same single-blind context to reveal preferences.

We estimated equations of the form

$$AWTP_{it} = \beta_0 + \beta_1 X1'_{,it}(Treat = 1) + \beta_2 Z_{i}'t + \beta_3 T_t(Time) + \beta_4 X2'_{,it}(Time \times Treat) + \alpha_i + u_{it} \quad (3)$$

$AWTP_{it}$ measures the amount participant i is willing to pay for the cake attributes of texture, moisture, creaminess, taste, smell, and colour of the pastry they were randomly assigned. We use this to indicate a preference for the cake attributes presented in the group. Other variables and parameters are defined in Equation (2).

Table 5 presents the estimated results from a fixed- and random-effects estimation of Equation (3). In all specifications, we find texture at an HQCF inclusion rate of 25% ($p < 0.1$), moistness at an HQCF of 50% ($p < 0.1$), and HQCF at 75% ($p < 0.05$) as the preferred attributes associated with HQCF. We find evidence of an insignificant effect on other attributes (Table 6).

Overall, the results suggest that these intermediating effects might improve the acceptability of HQCF among consumers. Breeding techniques should focus on improving the agronomic traits of the cassava plant associated with these attributes. For instance, lowering the fibre content and increasing the protein content of cassava hybrids might enhance crop nutritional value.

Similarly, cassava-processing technologies that improve end-user preference in relation to these sensory characteristics should be investigated. Starch is related to the textural properties of food components formed during processing, such as organic acids, cyanides and tannins, and gives fermented cassava products an acidic taste that might adversely affect smell and lower acceptability. Processing techniques that lower anti-nutritional compounds would also reduce the bitter taste.

7. Conclusion

The main aim of the study was to reveal, as close as possibly, Nigerian respondents' preferences for and attitudes towards the acceptability of wheat-derived food products with HQCF included at various levels. Nigeria is the world's largest cassava producer (FAOSTAT 2020). The proportion produced is a third more than Brazil's production and almost double that of Indonesia and Thailand (FAOSTAT 2020).

Understanding consumers' acceptance of traditional food products with environmental attributes and ethical issues is central to the design of agricultural and food policy (Animashaun *et al*. 2013; Balogh *et al*. 2016; Vapa-Tankosić *et al*. 2020). The experimental design adopted in this paper mitigates strategic and spurious misrepresentation of preferences and allows the investigation of the preferences better than using only observational data. Repeating the experimental procedure on the same subject builds on approaches to mitigating such biases.

The problem with many WTP studies is that stated preferences do not reveal true preferences. There is no standard way to reduce the hypothetical bias, as researchers have proposed many methods (e.g. cheap talk and certainty scale calibration) to reduce hypothetical bias (HB) in stated preference studies. We extend this line of improvements in WTP in the following ways: First, by using blinded treatments; with this we reduce the extent to which the research design endogenously influences respondents' decisions on preferences. Second, we tell them beforehand that a follow-up experiment will be conducted so that they can take the evaluation seriously, as they might not want to be seen taking an inconsistent stand. Why is this important? Alfnes (2020) points out that people who want to see themselves as rational and thoughtful, as well as honest and trustworthy, have a motivational drive to try to give consistent responses to a series of questions. In this fixed-effects (FE) design, the variation in exposure to treatments allows our analysis to isolate the treatment effect in ways that other unobservable factors that affect WTP are fixed and do not have a considerable effect on the outcomes of interest.

Table 5: Effect of treatments on WTP attributes

	Texture		Moistness		Creaminess		Taste		Smell		Colour	
	FE (XIII)	**RE (XIV)**	**FE (XV)**	**RE (XVI)**	**FE (XVII)**	**RE (XVIII)**	**FE (XIX)**	**RE (XX)**	**FE (XXI)**	**RE (XXII)**	**FE (XXIII)**	**RE (XXIV)**
Treatment 1 (control) HQCF = 0	-120.21	-80.59	-136.40	-97.05	-123.40*	-92.12	-125.33*	-104.13	-56.78	-46.41	-36.23	-28.22
	(90.05)	(100.29)	(85.29)	(97.63)	(73.94)	(85.91)	(74.82)	(88.4)	(48.30)	(50.75)	(43.91)	(48.2)
Treatment 2	50.61*	45.05	21.81	17.49	26.42	29.24	19.21	21.37	24.12	27.48	28.07	29.33
	(27.74)	(29.52)	(26.16)	(29.06)	(26.05)	(29.85)	(24.14)	(30.1)	(23.42)	(23.76)	(18.62)	(21.93)
Treatment 3	5.06	2.91	-7.64	0.49	-13.46	-12.55	-6.50	-9.1	-8.37	-15.71	-10.24	-8.65
	(28.59)	(29.13)	(30.37)	(32.11)	(25.14)	(29.69)	(26.90)	(32.9)	(24.19)	(28.15)	(17.63)	(19.57)
Treatment 4	7.85	11.94	-33.98	-25.9	-2.39	53.24	0.77	1.48	-4.96	-3.64	-15.26	-4.06
	(28.94)	(30.37)	(27.66)	(30.12)	(23.93)	(47.26)	(25.23)	(30.32)	(23.18)	(26.85)	(16.69)	(17.76)
Survey time (first experiment D = 1)	-63.32	-35.16	-107.65	-55.76	-73.11	-53.24	-42.03	-26.8	-24.01	-22.93	-55.05*	-45.35
	(66.45)	(45.59)	(65.3)	(46.87)	(55.82)	(47.26)	(57.83)	(53.6)	(43.23)	(38.77)	(29.97)	(25.17)
Treatment 1*Survey time (D = 1)	202.4	128.09	215.7*	132.09	192.84*	136.31	160.76	116.5	86.93	65.72	96.5	81.09
	(131.7)	(118.82)	(124.2)	(117.13)	(107.8)	(109.23)	(109.83)	(116.2)	(71.43)	(66.1)	(60.87)	(57.6)
Treatment 2*Survey time (D = 1)	-5.9	-6.05	35.75	21.44	19.3	19.37	8.69	2.41	-1.67	-2.76	4.32	1.65
	(60.66)	(54.6)	(62.34)	(55.65)	(52.67)	(53.29)	(52.82)	(56.78)	(46.12)	(47.22)	(35.02)	(36.8)
Treatment 3*Survey time (D = 1)	99.01	71.66	144.01*	83.12	108.59	89.02	67.36	55.01	33.11	43.54	59.26	56.91
	(86.39)	(66.79)	(85.52)	(71.27)	(73.02)	(68.44)	(77.07)	(77.89)	(55.39)	(54.28)	(40.42)	(36.8)
Treatment 4*Survey time (D = 1)	33.8	25.04	116.23**	74.03	43.79	35.36	19.44	9.25	39.05	40.66	48.99	34.62
	(54.58)	(40.66)	(50.9)	(37.13)	(43.68)	(38.16)	(48.01)	(43.58)	(39.05)	(36.98)	(31.36)	(26.4)
Observations	199	199	199	199	199	199	199	199	199	199	199	199

Notes: The treatment dummies are in five categories: treatment 1 (0% HQCF), treatment 2 (25% HQCF), treatment 3 (50% HQCF), treatment 4 (75% HQCF), and treatment 5 (100% HQCF). The response function is standardised, with the treatment 5 category set to zero, so each β_1 represents the estimated impact of HQCF inclusion on WTP relative to WTP associated with the treatment 5 category. All specifications include location and time effects, as well as controls, which have age, sex, address location, level of study, whether respondent eats out, parent's marital status and occupation, cooking skills, faculty, monthly allowance, laptop costs, mobile phone and house rent, with robust standard errors (in parentheses). See in text for further discussion.
FE = fixed effect; RE = random effect; ** p < .05, * p < .1

Table 6: Summary of effect of treatments on WTP attributes

	Texture		Moistness		Creaminess		Taste		Smell		Colour	
Net effect	**FE**	**RE**	**FE**	**RE**	**FE**	**RE**	**FE**	**RE**	**FE**	**RE**	**FE**	**RE**
Treatment 1 + Interaction			Positive @ p = 0.1		Negative @ p = 0.1							
Treatment 2 + Interaction	Positive @ p = 0.1											
Treatment 3 + Interaction			Positive @ p = 0.1									
Treatment 4 + Interaction			Positive @ p = 0.05									

Notes: FE = fixed effect; RE = random effect

Our study shows that mixing wheat flour with HQCF is acceptable, as what subjects are willing to pay for cakes assigned to them at random with different quantities of HQCF is statistically insignificant. We exploit the longitudinal variation in treatments, and control for the individual and time-specific unobservable heterogeneities that might confound results. In this regard, we find that WTP could increase if HQCF-treated cakes improve in texture and moisture.

Climate change, regional conflicts, and disease outbreaks worldwide, particularly in major wheat-producing countries, exacerbate supply shocks and global food security challenges (Emediegwu 2022; Emediegwu *et al*. 2022; Emediegwu & Ubabukoh 2023), For many wheat-importing countries, incorporating locally available alternatives could reduce import dependence and the threat of food insecurity. This paper presents the results of consumers' preference for HQCF after randomly assigning subjects to different categories of treated cakes twice.

The findings provided in this paper can support the links between cassava traits and end-user preferences for sensory characteristics to drive research on cassava breeding and processing.

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Appendix 1: Survey instrument

UNIVERSITY OF ILORIN
FACULTY OF AGRICULTURE
DEPARTMENT OF AGRICULTURAL ECONOMICS AND FARM MANAGEMENT
TOPIC: EXPERIMENTAL ANALYSIS OF THE ECONOMIC PREFERENCE FOR PASTRIES MADE FROM CASSAVA-BASED WHEAT FLOUR

Dear Respondent

This questionnaire is aimed at gathering information on the above topic and is designed for the purpose of research only. Any information supplied will be treated with **utmost confidentiality**. Your consent to use the information gathered is required. Kindly note that you are expected to sign this form as a form of agreement to filling this form.

………………………………………………..

Thank you.

1. Sex Male [ ] Female [ ]
2. Age ………………………
3. Marital Status Single [ ] Married [ ] Divorced [ ]
4. Level 100 [ ] 200[ ] 300 [ ] 400[ ] 500[ ] Extra year[ ] Postgraduate [ ]
5. Faculty Arts [ ] Agriculture [ ] Basic Medical Sciences [ ] Clinical Sciences[ ] Communication and Information Sciences [ ] Education[ ] Engineering and Technology [ ] Environmental Sciences [ ] Law [ ] Life Sciences [ ] Management Sciences [ ] Pharmaceutical Sciences [ ] Physical Sciences [ ] Social Sciences [ ]
6. How would you rate your culinary skills?
   Excellent [ ] Very good [ ] Good [ ] Poor [ ]
7. Do you eat outside? ……………………
8. In the last 2-3 days, did you eat outside………........................
9. How much did you spend eating outside …………………….
10. Extra occupation …………………………………..
11. Parent’s occupation …………………………………
12. Parent’s marital status Single [ ] Married [ ] Divorced [ ] Widowed [ ]
13. Where do you stay? …………………..
14. Rent per annum ………………………………………..
15. Laptop cost as at time of purchase ………………………………………………
16. Phone cost as at time of purchase …………………………………
17. Do you eat cake? Yes [ ] No [ ] Maybe [ ]
18. Are you allergic to cassava? Yes [ ] No [ ] Maybe [ ]
19. What is your major source of income?
    Relatives [ ] Personal Funds [ ] Skill [ ] Money lenders [ ]
20. What is your monthly stipend? ……………..

SECTION A: STATED PREFERENCE BETWEEN WHEAT FLOUR AND HIGH-QUALITY CASSAVA FLOUR

What attributes do you like most about this cake in comparison to the cake sold in markets

Attributes	Highly preferred	Neutral	Less preferred
Creaminess			
Taste			
Moistness			
Smell/aroma			
Texture			
Colour			

Others (specify) …………………………………………………………..

SECTION B: CONSUMERS WILLINGNESS TO PAY

Which of the following attributes would make you pay a higher premium for this piece of cake?

Attributes	Highly unlikely	Unlikely	Likely	Highly likely
Creaminess/richness in taste				
Taste				
Moistness				
Smell/aroma				
Texture				
Colour				

Others (specify) ………………………….

How much lower or higher are you willing to pay for each attribute in comparison to the amount paid for cake sold in the market?

Attributes	Less	Same	More	How much?
Creaminess/richness in taste				
Taste				
Moistness				
Smell/aroma				
Texture				
Colour				

How much will you pay more/less than the standard rate of 100 for the cake…………………….