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Predicting Acceptance of Biobased Products Based on Subjective Knowledge, Environmental Attitude, Perceived Usefulness, and Socio-demographic Characteristics

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Abstract: This study examines the influence of consumers' subjective knowledge, environmental attitude perceived usefulness and socio-demographics on their intentions to accept biobased products as an alternative to fossil based products. The study employs a five-point Likert scale questionnaire-based survey *(N = 465)* conducted in Lagos, Nigeria in the year 2022. Both descriptive statistics and Structural Equation Modeling (SEM) are employed in fulfilling the study objectives. Acceptance of biobased products is influenced by individual-level socio-demographic and psychological factors. Male respondents exhibited a greater perceived usefulness from biobased products and higher intention to accept biobased products compared to their female counterparts. Additionally, the Silent generation, similar to residents in peri-urban areas, showed a more favorable perceived usefulness and a stronger intention to accept biobased products than other generational cohorts. The strong positive relationship between perceived usefulness and intention to accept biobased products is in agreement with technological innovation acceptance studies. The findings are interpreted relative to industry and societal implications including the need to make individual oriented strategies the centerpiece of bioeconomy policies and promotional campaigns in order to enhance acceptance of biobased products.

Keywords: bioeconomy, biobased products, climate change, consumer acceptance, Nigeria

1. Introduction

Negative implications of unsustainable use of fossil resources have led to the emergence of bioeconomy (also known as biobased economy or knowledge-based bioeconomy) as an approach to combat climate change and other major societal challenges [1–3]. The bioeconomy is the production, utilization, conservation, and regeneration of biological resources, including related knowledge, science, technology, and innovation, to provide sustainable solutions (information, products, processes, and services) within and across all economic sectors and enable a transformation to a sustainable economy [4]. Adoption and diffusion of biobased products in the society are crucial for sustainable bioeconomy [5–7]. Operationally, bioeconomy employs renewable biological resources in innovative bio-technological processes to sustainably provide marketable biobased goods (and services) across all economic sectors, including food, healthcare, and energy sectors, to reduce our dependence on fossil resources to combat climate change, develop economies, create new jobs, and bring great opportunities to meeting the Sustainable Development Goals (SDGs) and the Paris Agreement [8–12].

Success of an innovation depends crucially on how quickly and to what degree a social system accepts such innovation. The underlying complex and multidimensional mechanisms shaping users' acceptance of new innovation like biobased products include individual-level factors such as knowledge [13–15], environmental attitude (EA) [16–18], and perceived usefulness (PU) [19–21] and individual socio-demographic factors [22–24]. Furthermore, meeting the SDGs and achieving long-term decarbonization target under the current carbon neutrality vision rely on a large-scale production and adoption of biobased products [9, 12, 25, 26], and any large-scale investment in bioeconomy by the industry requires knowing that consumers are willing to purchase biobased products and learning how best to market them.

From the foregoing and sparse information on the influence of individual-level factors on consumers' acceptance of bioeconomy [27, 28], it is important to understand effects of individual-level factors on consumers' acceptance of biobased products to increase the share of biobased products in the consumer market toward achieving the desired level of acceptance in the society. This is much more important in Africa where adoption of biobased products is quite scant [29–31] and knowledge base for the bioeconomy remains limited [32–34]. In order to expand the literature on acceptance of bioeconomy, this study is focused on

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exploring the effects of three individual-level factors, namely subjective knowledge (SK), EA, and PU, and five socio-demographic factors (gender, age, marital status, education level, and place of residence) on consumers' acceptance of biobased products. The study also make policy suggestions on how to create a more consumer-oriented market environment for biobased products toward designing effective strategies and initiatives in order to enjoy multiple benefits of adoption and diffusion of biobased products in the society.

2. Literature Review

Consumer knowledge is an important variable affecting consumer behavior [35, 36], including acceptance of bioeconomy and biobased products [13, 14, 37]. Knowledge is recognized as a positive predictor of public support and acceptance of biobased products [14, 15, 38], but limited knowledge of biobased products has been established among consumers [39–41]. SK (i.e., what individuals think they know) is a stronger driver of behavior than objective knowledge [35, 42–44]. SK, which has more influence on actual pro-ecological behavior than objective knowledge [45, 46], plays important role in influencing consumer's willingness to accept and adopt new products [36, 47–49]. Knowledge is recognized as a positive predictor of acceptance of biobased technological innovations [14, 15, 50], and consumers purchase bio-products based on their knowledge of the products [38, 51, 52]. It is more difficult to measure objective knowledge than SK [19], leading us to develop the following hypothesis:

H1. Consumers' SK of biobased products has a positive effect on their intention to accept biobased products.

Attitude is a predictor of behavior and findings suggest that EA predicts environmental behavior [53–55]. Behavioral intentions to accept biobased products stem directly from attitude [56]. Studies have established relationship between EAs and choice-based behavior, including intention to accept biobased products [16, 17, 57, 58]. Furthermore, studies found a link between EA and purchase intention with regard to biobased products [59–61]. The New Ecological Paradigm (NEP) scale is a popular uni-dimension measure of EA [62, 63]. Higher NEP scores depict higher levels of pro-environmental attitudes, which may lead to more positive attitude toward environmentally friendly products like biobased products [19, 64, 65]. Thus, we assume the following hypothesis:

H2. Consumers' EA measured by NEP has a positive effect on their intention to accept biobased products.

Acceptance of innovation increases with PU from such innovation [66–68]. Studies showed that acceptance of biobased products is influenced by PU from the products [69–71]. Thus, the following hypothesis is submitted:

H3. Consumers' PU from biobased products has a positive effect on their intention to accept biobased products.

In addition to playing significant role in acceptance of bioeconomy [16, 72], socio-demographic factors have been validated as significant factors in the construction of discourses and perceptions of bioeconomy [27, 73]. Age, gender, marital status, level of education, place of residence, employment status, and family income have all been validated as significant factors in the public acceptance of biobased products [11, 27, 40, 72, 74, 75]. Klein et al. [16] reported weak influence of socio-demographic factors on purchase intention of bioeconomy products. Negative relationships between socio-demographic factors and acceptance of biobased products also exist in literature [17, 76]. In this study, we suggest the following related hypothesis:

H4. Consumers' socio-demographic characteristics have positive effect on their intention to accept biobased products.

3. Research Methodology

3.1. Research design

This study employed descriptive cross-sectional design of survey research. Survey research is a widely recognized approach with clear benefits for describing and exploring variables and constructs in a short time for a fairly low cost [77, 78].

3.2. Characteristics of respondents

The survey was conducted in Lagos, Nigeria between February 2022 and July 2022. Lagos is the commercial and industrial capital of Nigeria. Based on Lagos' population estimates of over 21 million people, the sampled population was calculated using the simplified Yamane formulae [79]. The calculated sample size of approximately 400 was divided by the expected response of 80% to overcome risks of nonresponses or poorly answered questionnaires.

Proportional stratified random sampling was employed in selecting the study respondents and conformed to ethical standards. We adopted the criteria specified by Sijtsema et al. [41] to ensure the respondents are not expert in bioeconomy or have unique knowledge of biobased products.

The process of sorting the collected data revealed 35 uncompleted responses among the 500 questionnaires administered. The valid 465 questionnaires, at 93% response rate, were analyzed for interpretation. There was fairly even distribution among the survey respondents. Respondents comprised 235 (50.54%) men and 230 (49.46%) women. A total of 115 (24.73%) were generation Z (25 year and below), 110 (23.65%) were millennial (26–41 years), 104 (22.37%) were generation X (42–57 years), 77 (16.56%) were boomers (58–76 years), and 59 (12.69%) were silent generation (77 years and above). Altogether, 179 (38.50%) were single, 166 (35.70%) were married, 36 (7.74%) were divorced, 48 (10.32%) were separated, and 36 (7.74%) were widowed. Most respondents were university graduates (40.00%), while 21.94% were senior secondary school certificate holders, 23.01% were national diploma and equivalent holders, and 15.05% have postgraduate degrees. With regard to place of residence, 182 (39.14%) reside in urban area, 183(39.35%) in peri-urban area, and 100 (21.51%) in rural area. Table 1 presents the respondents' characteristics.

3.3. Instruments

Composite construct of three items adapted from past studies [80, 81] was used to measure SK, using a five-point Likert scale. They are "I do not feel very knowledgeable about biobased products, SK1"; "Compared to most other people, I know less about biobased products, SK2", and "When it comes to biobased products, I really do not know a lot, SK3". The responses were reverse coded. The respondents' score in EA was the mean of the

Table 1
Characteristics of respondents

	Demographic profile	Frequency	Percentage
Gender	Male	235	50.54
	Female	230	49.46
		465	**100.00**
Age	25 and below	115	24.73
	26–41	110	23.65
	42–57	104	22.37
	58–76	77	16.56
	77 and above	59	12.69
		465	**100.00**
Marital status	Single	179	38.50
	Married	166	35.70
	Divorced	36	7.74
	Separated	48	10.32
	Widowed	36	7.74
		465	**100.00**
Education level	SSCE	102	21.94
	NCE/ND	107	23.01
	Degree	186	40.00
	Postgraduate	70	15.05
		465	**100.00**
Place of residence	Urban	182	39.14
	Peri-urban	183	39.35
	Rural	100	21.51
		465	**100.00**

scores of five statements adapted from Liu et al. [19]: Humans are severely abusing the environment (EA1); Plants and animals have as much right as humans to exist (EA2); The earth is like a spaceship with very limited room and resources (EA3); The balance of nature is very delicate and easily upset (EA4); and If things continue on their present course, we will soon experience a major ecological catastrophe (EA5). Possible responses were "strongly disagree" (one point), "disagree" (two points), "unsure" (three points), "agree" (four points), and "strongly agree (five points). The score of PU from biobased products was also the mean score calculated by measuring the respondents' agreement with four statements ("using biobased products would be useful for me, PU1"; "using biobased products would be convenient for me, PU2"; "using biofuels would be advantageous for me, PU3"; and "I support the use of bio-based fertilizers as a way combat climate change, PU4"), using a five-point Likert scale. The PU items were adapted from Tran and Cheng [71]. Intention (INT) to accept biobased products was measured based on the answers to three questions, using a five-point Likert scale; the higher the mean score, the higher the intention: "I intend to use biofuels if it is available (INT1)"; "I would go out of my way to find biobased products to purchase (INT2)"; and "I would like to recommend biobased products to my family and friends (INT3)". The INT items were adapted from similar studies [19, 46, 71].

3.4. Analysis

The process of sorting the collected data revealed 35 uncompleted responses among the 500 questionnaires administered. The valid 465 questionnaires, at 93% response rate, were analyzed for interpretation. The result analysis was performed using Microsoft Excel, the Statistical Package for the Social Sciences, and the Analysis of Moment Structures to present, analyze, and infer the relationship between the variables.

4. Results

4.1. Descriptive statistics of the survey study constructs

Table 2 shows the distribution of respondents' response to the constructs. SK and EA showed relatively smaller mean score in comparison to PU and intention.

Respondents' responses to each of the measures were further classified into three groups – positive (agree + strongly agree), neutral (not sure), and negative (strongly disagree + disagree) – as

Table 3
Classification of survey results

		Strongly agree + agree	Not sure	Disagree + strongly disagree
Subjective knowledge	SK1	167	82	216
	SK2	96	176	193
	SK3	202	52	211
	Percentage	33.3	22.2	44.5
Environmental attitude	EA1	80	39	346
	EA2	75	53	337
	EA3	71	136	258
	EA4	70	109	286
	EA5	85	96	284
	Percentage	16.3	18.7	65.0
Perceived usefulness	PU1	207	78	180
	PU2	207	100	158
	PU3	216	78	171
	PU4	202	53	210
	Percentage	44.7	16.6	38.7
Intention	INT1	216	68	181
	INT2	226	107	132
	INT3	206	94	165
	Percentage	46.5	19.2	34.3

Table 2
Descriptive statistics of constructs

Constructs	Number of items	Possible minimum value	Possible maximum value	Mean	Standard deviation
Subjective knowledge	3	3	15	8.43	0.97
Environmental attitude	5	5	25	11.71	0.68
Perceived usefulness	4	4	20	12.61	0.78
Intention to accept	3	3	15	9.56	0.92

Table 4
Decomposition of survey measure items

		SK Mean	NEP Mean	PU Mean	BI Mean
Sex	Male	8.67	11.85	13.06	9.88
	Female	8.20	11.57	12.16	9.23
Age	25 and below	6.70	11.13	11.91	9.23
	26–41	9.48	10.68	12.77	9.55
	42–57	9.36	12.45	12.25	9.10
	58–76	8.86	12.61	13.18	9.86
	77 and above	7.69	12.29	13.58	10.63
Marital status	Single	7.37	11.11	12.57	9.70
	Married	8.74	11.36	11.75	8.78
	Divorced	10.72	12.25	12.08	8.92
	Separated	9.27	13.75	14.29	10.60
	Widowed	8.92	13.06	15.11	11.69
Education level	SSCE	4.39	10.94	10.34	8.30
	NCE/OND	6.06	11.20	11.07	8.71
	Degree	10.49	11.77	14.03	10.37
	Postgraduate	12.50	13.46	14.50	10.53
Place of residence	Urban	8.26	11.75	12.41	9.47
	Peri-urban	8.57	12.02	12.85	9.69
	Rural	8.51	11.09	12.56	9.48

shown in Table 3 to get a deep understanding of their responses. There were 216 respondents who do feel knowledgeable about bioeconomy (SK1), 193 respondents believed they know less about biobased products when compared to most other people (SK2), and 211 respondents submitted that they do not really know a lot about biobased products (SK3), resulting in 44.5% of the respondents expressing poor SK of biobased products. 65.0% of the respondents also having negative EA with 53.0%. There were 44.52% of respondents who believe biobased products would be useful for them (PU1) and would be convenient for them (PU2). There were 46.5% of residents who expressed positive attitudes to use biofuels if it is available (INT1). Those who will go out of their way to find biobased products (INT2) and recommend their family and friends to buy biobased products (INT3) accounted for 48.6% and 44.3%, respectively. These results indicated that a large proportion of respondents had moderate self-assessed SK of bioeconomy and low EA. The highest proportions of positive attitudes are attributable to PU of biobased products and intention (INT) to accept biobased products.

Decomposition of the measure items based on socio-demographic profiles of the respondents is shown in Table 4 for more clarity and better interpretation. Male respondents have better SK, higher EA, better PU from biobased products, and higher intention to accept biobased products than the female respondents. The results in relation to age were diverse, with the millennial having highest score in SK, the boomers in EA, and the silent in PU and INT. Divorced respondents came top in SK, separated in EA, and widowed in PU and INT. Respondents with postgraduate degrees and those residents in peri-urban area had the highest scores in all the four constructs.

4.2. Validity and reliability of the measures

The validity and reliability of the measures were verified by confirmatory factor analysis and item-to-total correlations at the 0.1% significance level as shown in Table 5. All the standardized factor loadings in this study were greater than 0.50 cut-off for acceptable loading [82], thereby underlying the validity of the constructs as the right indicators to measure their relevant variables. The composite construct reliabilities of the constructs in this study are 0.86, 0.73, 0.91, and 0.83 for SK, EA, PU, and INT, respectively. These values were all above the acceptable threshold of 0.70 [83], suggesting all the items constantly measure the same latent factor. The squared multiple correlations (R-squared) were well-defined by the measure items with most of the R-squared above the threshold criteria of 0.50 [84]. The value of the average variance extracted for the construct variables was above the accepted requirement of 0.50 [85], implying that the instrument variables are valid and there is no convergent validity problem in the model tested. Results of the reliability test based on Cronbach's alpha were all equal to or greater than the traditionally accepted lower limit of 0.70 [86], which showed internal consistency of the measures.

Table 5
Validity and reliability estimates for measures

Constructs	Items	Standardized loadings	Squared multiple correlations	Composite construct reliabilities	Average variances extracted	Cronbach's alpha
Subjective knowledge	SK1	0.839	0.89	0.86	0.67	0.87
	SK2	0.835	0.53			
	SK3	0.779	0.66			
Environmental attitude	EA1	0.629	0.55	0.73	0.53	0.77
	EA2	0.655	0.50			
	EA3	0.634	0.46			
	EA4	0.645	0.45			
	EA5	0.548	0.51			
Perceived usefulness	PU1	0.903	0.67	0.91	0.71	0.71
	PU2	0.818	0.84			
	PU3	0.807	0.50			
	PU4	0.832	0.52			
Intention	BI1	0.838	0.54	0.83	0.61	0.70
	BI2	0.775	0.56			
	BI3	0.734	0.51			

4.3. Relationship between individual-level factors and intention to accept biobased products

Standard path coefficients analysis was done to examine the possible relationship between the individual-level factors and intention to accept biobased products. The results are presented in Table 6.

Table 6
Relationship between individual-level factors

Relationship path	Standard coefficient β		p-value	
SK to INT	0.09	Weak relationship	0.01	Significant relationship
EA to INT	0.07	Weak relationship	0.04	Significant relationship
PU to INT	0.76	Strong relationship	<0.01	Significant relationship

Both SK ($\beta = 0.09$, $p = 0.01$) and EA ($\beta = 0.07$, $p = 0.04$) had positive influence on intention to accept biobased products. The results show that hypotheses H1 and H2 are supported. The relationship between PU and intention to accept biobased products was strong, thereby supporting the hypothesis (H3) that consumers' PU from biobased products has a positive effect on their intention to accept biobased products.

4.4. Relationship between socio-demographic factors and intention to accept biobased products

Table 7 shows the relationships between socio-demographic factors and intention to accept biobased products of the respondents, using Pearson's correlation coefficient (Pearson r) analysis. All the relationships were positive, supporting hypothesis (H4) that consumers' socio-demographic characteristics have positive effects on their intention to accept biobased products.

5. Discussion and Conclusion

This study examined consumers' intention to accept biobased products regarding their SK of biobased products, EA, PU from biobased products, and socio-demographic characteristics.

Consumers' level of SK is moderate. This is in alignment with prior studies [11, 39–41, 87–89]. This is not unexpected since bioeconomy products are not readily available in Nigerian market and they have not been adopted or diffused in Nigerian societies. However, the respondents are ready to accept biobased products as evident in the high PU and intention to accept found in this study. The high rate of PU and INT aligned with an earlier study in the country [90]. These findings together with the positive relationship found between all the three individual-level factors (SK, EA and PU) and intention to accept biobased products highlight the need for a consumer-oriented approach to achieve social desirability of biobased products and their large-scale diffusion and adoption by consumers. These results are similar to the results of past studies in acceptance of biobased products [59, 61, 91, 92] and other similar low-carbon technological innovations [93–95].

The relationship between PU and intention was positive, strong, and significant, in alignment with prior studies [69–71, 96]. Since acceptance of bio-technological innovations rises as we learn about their values and usefulness [15], we suggest that consumers' intention to accept biobased products depends more on users' appreciation, and promotional campaigns should be launched to convey the right information on the usefulness of biobased products to consumers.

Weak relationships found between all the socio-demographic factors and intention to accept biobased products were all significant except for place of residence. These weak relationships showed that socio-demographic factors are poor predictor of acceptance of biobased products among Lagos' consumers. These results aligned with prior mixed results in literature [16, 17, 76]. Respondents with high educational level also have higher intention to accept biobased products. Moving forward, education – both formal and informal – should be treated as a transformative game changer in bioeconomy policies and strategies. Furthermore, based on the significant relationships found, it is desirable for policymakers to identify and match policy interventions to population segments.

Nigeria, like most African countries, does not have dedicated bioeconomy policy, which is required to promote acceptance of biobased products in the country. Hence, the starting point is the collaboration of all relevant stakeholders to formulate a formal national bioeconomy policy. A pre-condition for acceptance of biobased products deduced from this study is the need for formal and informal education and investment in communication campaigns to reinforce the importance and PU from biobased products. People seem to be willing to acquire products in their local stores. Biobased products should be made readily available in local stores and clear information on the products provided by labeling and in-store promotional materials based on the factors influencing acceptance biobased products as identified in this study to increase the consumers' knowledge and PU from biobased products. University–industry collaboration is imperative to investigate in detail the individual-level dynamics of consumer markets for manufacturers to take biobased products to market segments.

Table 7
Relationship between socio-demographic factors and individual-level factors

Relationship path	Pearson r		***p*-value**	
Gender to INT	0.10	Weak correlation	0.04	Relationship is significant
Age to INT	0.11	Weak correlation	0.02	Relationship is significant
Marital status to INT	0.15	Weak correlation	0.01	Relationship is significant
Level of education to INT	0.27	Weak correlation	0.01	Relationship is significant
Place of residence to INT	0.01	Weak correlation	0.86	Relationship not significant

In conclusion, this study showed that SK of biobased products, EA, and PU from biobased products influences and predicts intention to accept biobased products, albeit the relationships were weak for SK and EA. PU from biobased products is an enabler of acceptance of biobased products in alignment with technological innovation acceptance studies.

Ethical Statement

This study does not contain any studies with human or animal subjects performed by any of the authors.

Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

Data Availability Statement

Data available on request from the corresponding author upon reasonable request.

Author Contribution Statement

Oluwaseun James Oguntuase: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Project administration. **Oluwatosin Benedict Adu:** Conceptualization, Methodology, Validation, Resources, Writing – review & editing, Supervision, Project administration. **Oluwafemi Sunday Obayori:** Conceptualization, Methodology, Validation, Resources, Writing – review & editing, Supervision, Project administration.

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