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Where is the market? Assessing the role of dryer performance and marketability of solar-dried products in acceptance of solar dryers amongst smallholder farmers

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ABSTRACT

Agricultural technological development is a crucial strategy for agricultural commercialization and socio-economic transformation in Africa. However, a key challenge to technology use in agriculture remains the limited farmer acceptance of unfamiliar technologies. This paper uses a sample of 245 okra farmers drawn from northern Uganda to assess the drivers of the farmer acceptance of solar drying technology. On the basis of drying performance, farmers perceive the solar dryer to perform better than the open sun-drying method. Structural equation modelling results show that the drying rate and perceived product quality are the main determinants of farmer perceptions on product marketability. Further, product marketability drives acceptance of solar dryers among farmers. We conclude that acceptance of solar dryers is dependent on: i) the drying rate, ii) favorable perceptions towards product quality, and iii) perceived marketability of the solar-dried product. We call for policy action on intensification of efforts that promote solar drying technology, including supporting local artisans to fabricate dryers, to enable increased value addition and consumption of nutritious foods.

1. Introduction

Agricultural technological development, including solar dryers, is considered a crucial strategy in improving food security and overall socio-economic transformation [1–4]. Central to technological development, such as solar drying of farm produce, are concerns relating to farmer acceptance and use [5]. Other common concerns include dryer performance [6], and perceptions on marketability of solar-dried products for downstream consumption [7]. Reportedly, solar drying technology enhances crop productivity because the output comes with added value to farm produce [8]. For environmentalists, solar dryers are considered part of the green technologies because they are dependent on clean sun radiation that does not pollute the environment.

Across research and development spheres, there is a growing belief that solar dryers can easily contribute to transformation of agriculture from subsistence to market-oriented production [9,10]. This is because solar drying technology prolongs the shelf-life of

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fresh produce, allowing consumption of vegetables and fruits to occur even during lean seasons that tend to be associated with higher market prices [11–13]. From a sustainability standpoint, solar drying technology is cost-effective, depends on cheap solar radiation for energy supply, and can be fabricated using affordable local materials [10,14]. Consequently, farmers are likely to experience better market competitiveness, if solar dryers are integrated in postharvest management of farm produce [15].

At consumer level, the limited awareness and knowledge on product quality and value have rendered solar-dried products less consumed, especially amongst the rural population [16]. Yet, perceptions of farmers on marketability of solar-dried products might be important for farm-level decisions to accept the solar dryers. It makes no economic sense for the farmers, to invest time and effort in solar drying of farm produce, if the likelihood of finding consumers of the solar-dried products is low. That aside, various scholars [16,17] have pointed out that solar drying technology is a superior approach for preserving farm produce. For example, solar-dried products are always more hygienic than those preserved using open sun-drying method. Unlike outputs from open sun-drying methods, solar-dried products tend to be free of contamination from rain water and dust. Further, solar-dried products are more attractive for consumption for two reasons namely: i) preservation of natural color, and ii) retention of nutrients [17].

Despite the well-known value of solar dryers, their acceptance and overall uptake in the smallholder farming context remains very low [17–19]. This therefore raises questions over what might be driving farmer acceptance of this sustainable technology. While research on solar dryers is growing, especially in terms of consumption of solar-dried products [4,18,19], empirical work on marketability of solar-dried products is lacking. Yet again, what drives farmer perceptions on marketability of solar-dried products is not well understood. That aside, previous research has not analyzed the role of product marketability in fostering acceptance of solar dryers at farm level. Therefore, the purpose of this study was two-fold i.e., i) compare farmer perceptions on performance of solar drying and open sun-drying methods; ii) assess the drivers of perceived product marketability as a precursor for acceptance of solar dryers in smallholder farming context.

1.1. Theoretical perspectives and hypothesis development

This study adopts the technology acceptance model [TAM] to analyze the drivers of perceived marketability of solar-dried products and farmer acceptance of solar dryers [19,20]. While several behavioral models [e.g., the theory of planned behavior, theory of reasoned action, and technology acceptance model] have been advanced to explain decisions for behavioral change [21,22], most of these theories barely bring out the concept of perceived usefulness or effectiveness, a key precondition for acceptance of technologies such as solar dryers.

Advanced by [21], TAM argues that the use of technologies (such as solar dryers) is dependent on its acceptance by users [21,23]. At individual level, acceptance of a technology is based on perceived future usefulness of technology [21,24]. Therefore, the rationale for studying acceptance of a technology is understanding factors that shape one's decisions on uptake of the technology in question. This allows technology developers and promoters to manipulate such factors for increased acceptance and hence, increased utilization of the technology within the population [22,25].

TAM identifies two main antecedents of technology acceptance i.e., perceived usefulness [PU] and perceived ease of use [PEOU] [26,27]. Perceived Usefulness relates to the degree to which a person believes that using a particular technology would enhance his or her output performance. In the case of the solar dryer, this relates to the belief that solar drying would deliver good quality products [28,29]. On the other hand, perceived ease of use is the degree to which a person believes that using a particular technology is free from effort [23]. For instance, a faster drying rate of the produce is associated with reduced time and effort to dry produce. If a technology is easy to use, then the acceptance barriers are conquered.

Several scholars have argued that perceived usefulness [PU] (e.g., perceived output quality) and PEOU (e.g., drying rate of solar dryer) affects technology acceptance differently depending on the context and stage of technology development [30,31]. This has given room for empirical modification of the TAM. For instance [32], examined PU, as a performance factor in terms of technology effectiveness. This study therefore extends the TAM to analyzing acceptance of solar dryers, adding concepts of drying rate and

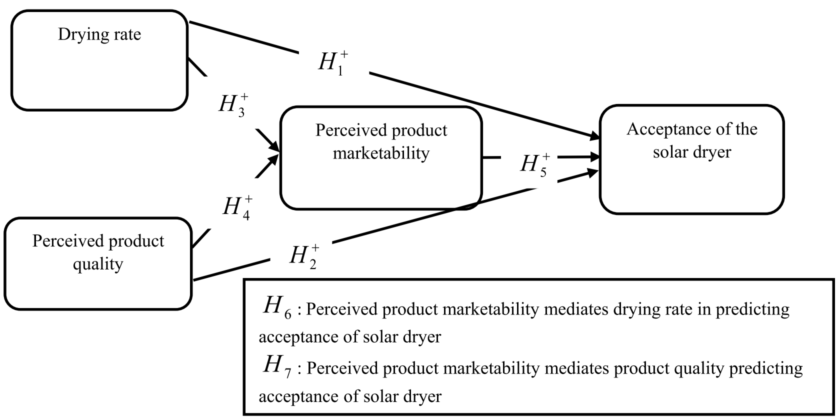

Fig. 1. Conceptual framework.

perceived product quality (Fig. 1).

The drying rate is operationalized as farmer perception that the solar dryer quickly drives moisture from fresh product. Key elements in this construct included: i) preference of the solar dryer to other drying methods; ii) perception that the solar dryer is fast; and iii) the belief that the performance of the solar drier encourages farmers to use it. For the perceived quality of the solar-dried product, the focus was on whether the solar drying method gives a good quality product compared to other drying methods. Accordingly, this construct was operationalized as; i) farmer evaluative attitude towards quality of the solar-dried product; and ii) farmer affection towards the solar-dried product.

Based on the assumption that both drying rate and perceived quality of solar-dried product might be important factors for the farmer to accept to use solar dryers, it was hypothesized that:

H1. *Drying rate positively influences acceptance of the solar dryer;*

H2. *Perceived product quality positively influences acceptance of the solar dryer.*

The study further presupposed that the marketability of the solar-dried product is the immediate precursor of farmer acceptance of the solar dryer. This implied that a farmer is likely to evaluate whether a solar-dried product is attractive to buyers prior to acceptance of using the solar dryer. Marketability of solar-dried products in this study is operationalized as the evaluative attitude of ease of marketing and the attractiveness of the solar-dried products to the farmer and buyer [2,3,8]. Thus, it is hypothesized as follows:

H3. *Drying rate positively influences perceived product marketability;*

H4. *Perceived product quality positively influences perceived product marketability;*

H5. *Perceived product marketability positively influences acceptance of the solar dryer.*

Further, the study tested for the mediating role of product marketability in acceptance of solar dryers as follows:

H6. *Perceived product marketability mediates drying rate in predicting acceptance of the solar dryer*

H7. *Perceived product marketability mediates product quality in predicting farmer acceptance of solar dryer*

2. Material and methods

2.1. Study context

Contextually, this study focused on acceptance of solar dryer technology amongst smallholder farmers. Empirical data were collected from okra farmers of Gulu and Omoro districts, northern Uganda. The two districts were purposively selected because they are the leading producers of okra in Northern Uganda. Due to its high local demands, okra has been recognized as one of the vegetable enterprises with high commercial potential in northern Uganda. Owing to the short shelf life of okra, preservation is commonly done through cutting and open sun-drying. While fast and cheap, reportedly, open sun-drying reduces the quality of the final product since such a product gets contaminated with soil and other foreign materials [33]. This open sun-drying also lowers the nutritive quality of the product. Therefore, the introduction of the solar drying technology is viewed as a better alternative for achieving an improved product quality and preserved nutritive value.

3. Research design

3.1. Designing the proto-type solar dryer

This study applied a quasi-experimental design in data collection and analysis. The study used the cabinet-type solar dryer for field testing and comparison with open sun-drying method. Prior to data collection, a prototype cabinet-type solar dryer, was designed, fabricated, and tested for its performance parameters at the Department of Biosystems Engineering, in the Faculty of Agriculture and Environment, Gulu University. The dryer's dimensions were as follows: 1.5 m (length), 1 m (width) and 0.78 m (height). It also had an outer covering of transparent ultraviolet (UV) polythene sheet purposely for good sunlight interception. This solar dryer also had a collector inclined at an angle of 3° for maximum solar energy capture. The solar dryer was equipped with both air inlet and outlet at the front and the back respectively, to allow natural air circulation (to improve the solar drying rate and efficiency). Lastly, it had two doors and four trays made of plastic mesh and wood, and the inner part made of plain iron sheet.

3.2. On-station testing of the solar dryer

The prototype solar dryer was subjected to on-station drying tests using okra samples to assess its performance parameters before field installation at farmsteads. During the trials, fresh okra samples were washed, chopped into small pieces of about 1.5 cm (H) to facilitate faster drying. The chopped okra was weighed using a digital weighing scale before separation into two study specimens as follows: i) a treatment specimen for drying using the solar dryer; and ii) the control specimen for open sun-drying through spreading on tarpaulins. One thermometer was inserted inside the solar dryer chamber while the second one was placed on the okra under open sun-drying. Subsequently, temperature variations were recorded at an hourly interval. Overall, drying performance for both the solar dryer and open sun-drying methods were measured in terms of moisture content, drying time and drying rate.

3.3. Field-based data collection

Seven tested solar dryers were installed at different demonstration sites for the selected okra producer groups. These producer groups included 4 drawn from Gulu district and 3 from Omoro district. The producer groups were previously using open sun-drying to preserve okra. All the 7 participating producer groups were given a practical training on the use of solar dryer before being provided with one prototype solar dryer. One and half months after the training, a farmer survey was conducted amongst members of participating producer groups to assess their perceptions on the performance of the solar dryer as compared to their conventional open sun-drying method. Participating producer groups were purposively selected due to their previous experience in okra production and preservation. A list of members from each of the seven producer groups constituted the sampling frame. From this sampling frame, simple random sampling was used to select study respondents. On the basis of more less equal number of members, 35 okra farmers were selected per group which gave a total sample size of 245 respondents for the study.

Data was collected using a researcher-administered, semi-structured questionnaire. The first part of the questionnaire captured data on socio-economic characteristics of okra farmers, while the second part covered data concerning farmers perceptions on solar dryer performance parameters i.e., drying rate, quality and marketability. Each of the parameters on performance of the solar dryer was measured on a 5-point Likert scale (1 = strongly disagree; 5 strongly agree).

Assessment of the sample profile in terms of mean (M) and standard deviation (SD) indicated that okra farmers were mainly females (70%) with generally good access to agricultural extension service (83%), and agricultural credit (83%). Farmers also had small landholding/acreage (M = 5.05; SD = 5.94), and produced okra on small pieces of land (M = 0.59; SD = 0.52) [Table 1].

3.4. Data analysis

All analyses were conducted using the statistical package for social scientists (SPSS) version 25. The study used two approaches for achieving the results i.e., descriptive statistics and hierarchical structural equations modelling. Descriptive statistics, including means and standard deviations were computed for the following variables: drying rate, product cleanliness, product aroma, perceived product quality and perceived product marketability. In addition, t-tests were carried out in order to assess whether there are significant differences in performance parameters between the solar dryer and open-sun drying method.

The hierarchical structural equations modelling (SEM) was performed in the AMOS software to assess the casual relationships hypothesized in the study. Hierarchical SEM was chosen ahead of partial least squares (PLS) as it is robust and efficient at dealing with large samples, exceeding 200 observations. It is also a proven technique for not only analyzing data taking on a form of Likert-scale or rated responses, but also simultaneous estimation of several causal relationships [34]. Data analysis involved both exploratory factors analysis (EFA) and confirmatory factors analysis (CFA). First, EFA was used for data reduction and assessing sampling adequacy. The results of Kaiser-Meyer-Olkin (KMO = 0.902) and Bartlett's sphericity test ($\chi 2 = 2703.472$, df = 153 and $P < 0.000$) met the baseline conditions of sampling adequacy and suitability of the dataset for SEM as explained by [35] [Table 2].

Preceding SEM analysis, diagnostic tests were conducted on the data to establish whether the data met the assumptions for SEM i.e., no multicollinearity; measurement validity; convergent validity; and discriminant validity [36,37]. For discriminant validity, the square root values for AVE ranged from 0.638 to 0.942, and were greater than the correlates that ranged from 0.407 to 0.888 [Table 3]; thus, supporting the assumption of the existence of adequate discriminant validity. For multicollinearity, the correlates were less than the maximum threshold value of 0.6 and hence, a confirmation that there was no risk of multicollinearity in data. Since the values of AVEs [Table 3] and factor loadings [Table 2] were all above the minimum threshold of 0.5, the pre-conditions of adequate convergent validity were supported. Lastly, composite reliability was assessed using Cronbach alpha, which ranged from 0.681 to 0.960 hence, a confirmation of composite reliability.

Table 1
Sample characteristics.

Variable	Mean (M)	Standard deviation (SD)
Farm size (acres)	5.05	5.94
Okra plotland (acres)	0.59	0.52
Quantity of okra harvested (kg)	2.29	0.71
Quantity of okra dried (kg)	1.15	0.89
Quantity of okra sold (kg)	1.59	0.585
Education (years of schooling)	6.37	3.68
Distance to the market (km)	0.18	0.31
Other statistics (Percentages)		
Female farmers	70.3%	
Access to extension services	82.9%	
Access to credit	83.3%	

Overall, okra producers dealt in small quantities of okra i.e., fresh okra (M = 2.29; SD = 0.71); dried okra (M = 1.15; SD = 0.89) and quantity sold (M = 1.59; SD = 0.585). The socio-demographics were as follows: education level in years of schooling (M = 6.37; SD = 3.68); distance to market (M = 0.18; SD = 0.31).

Table 2
Exploratory Factor analysis results.

	Standardized Factor loadings			
Items	DR	PM	PQ	FA
I like the time it takes for the solar dryer to dry okra	0.605			
The solar dryer is fast at drying of okra	0.756			
The drying rate of the solar dryer encourages me to use it	0.579			
Cronbach Alpha = 0.681				
I like the attraction of okra dried using a solar dryer		0.949		
The solar dryer is good for ease of marketability of my okra product		0.930		
Okra dried using the solar dryer is attractive to buyers		0.948		
Cronbach Alpha = 0.960				
I like the color appearance of solar-dried okra product			0.608	
The solar dryer gives a good color appearance of dried okra product			0.674	
The color appearance of solar-dried okra encourages me to use the solar dryer			0.631	
Cronbach Alpha = 0.660				
I find the solar dryer design encouraging for drying okra				0.627
Overall, the quality of dried okra from solar dryer is acceptable				0.747
I intend to continue using the solar dryer because of its rate of drying okra				0.807
I will continue using the solar dryer based on local materials used to construct it				0.614
Cronbach Alpha = 0.791				

Note: DR = Drying rate; PM= Perceived marketability of solar-dried product; PQ = Perceived quality of the solar-dried product; FA= Framer acceptance of solar dryer.

Table 3
Assessment of construct validity.

			Correlations			
Variables	AVE	CR	1	2	3	4
Perceived quality of solar-dried Product	0.407	0.998	0.638[a]			
Drying rate	0.424	0.998	0.152	0.651[a]		
Perceived marketability of solar-dried product	0.888	0.999	0.348	0.48	0.942[a]	
Farmer acceptance of solar dryer	0.505	0.996	0.236	0.276	0.708	0.710[a]

Note: Values on diagonal with superscripts ′a′ = $\sqrt{AVE}$.

Subsequently, a CFA was performed to assess the fit of the derived constructs from EFA. The CFA further enabled determination of significant path relationships and bootstrapping for explaining effect sizes of significant relationships [38]. The CFA results reveal that baseline values (specification) for all the fit indices were within the acceptable range [39] and thus, confirming model fit. These include the ratio of χ^2/DF = 2.334 (spec≤3); GFI = 0.920 (spec. ≥ 90); AGFI = 0.90 (spec.≥ 90); IFI = 0.956 (spec. ≥0.95); TLI = 0.941 (spec. ≥ 0.95); and CFI = 0.955 (spec. ≥ 0.95); and RMSEA 0.074 (spec.<0.08).

4. Results

4.1. Performance of the solar dryer and open sun-drying techniques

Assessment of the moisture content (Fig. 2) variations shows that solar-dried okra generally attained a lower moisture content

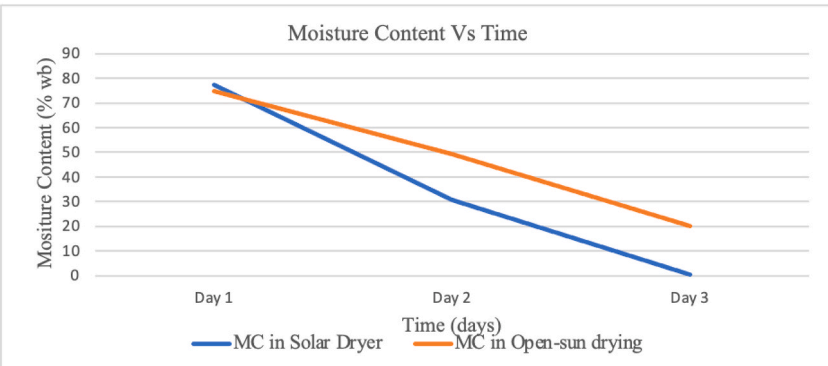

Fig. 2. Moisture content reduction in sun drying and solar drying.

compared to sun dried products over the entire drying period. The results indicate that faster moisture reduction is achieved under solar drying compared to open sun-drying as seen by lower moisture levels after three days of drying is achieved.

With regards to temperature, the solar dryer prototype generally had higher temperatures throughout the day compared to the open sun-drying (Fig. 3). Further, towards the peak (midday), a rapid increase in temperature was realized for the solar dryer relative to open sun-drying.

4.2. Farmer perceptions of open sun-drying and solar dryer methods

Results reveal that farmers generally perceived the solar dryer technology to be superior compared to the open sun-drying method. Significant differences in perception were observed between solar drying and open-sun drying methods on all performance parameters i.e., drying rate, cleanliness, product aroma, product quality and marketability [Table 4]. The most rated performance parameter of the solar dryer was product cleanliness (M = 4.80; SD = 0.34) followed by product aroma (M = 4.73; SD = 0.38). For open sun-drying method, the most rated parameter was the drying rate (M = 2.14; SD = 0.76), while the least rated parameter was product quality (M = 1.66; SD = 0.68).

4.3. Drivers of solar dryer acceptance

Path analysis results [Table 5] indicate that the drying rate ($\beta = 0.272$, $P < 0.05$); perceived quality of the solar-dried products ($\beta = 0.346$, $P < 0.01$); and perceived product marketability ($\beta = 0.335$, $P < 0.01$) positively and significantly influence farmer acceptance of solar dryers, lending support to H_1, H_2 and H_5 [Table 5]. Further, both the drying rate ($\beta = 0.558$, $P < 0.01$) and perceived product quality ($\beta = 0.214$, $P < 0.05$) are positive and significant influencers of farmer perceptions on product marketability of the solar-dried product, supporting hypotheses H_3 and H_4 respectively.

4.4. The mediating role of product marketability on solar dryer acceptance

Bootstrapping results that test for the mediating role of perceived marketability of solar-dried products are presented in Table 6. The results show that the indirect effects of perceived marketability of solar-dried product (β = 0.198; 95%CI = 0.057∼0.709) in mediating the relationship between drying rate and farmer acceptance of solar dryers is significant. Likewise, indirect effects of perceived marketability of solar-dried product (β = 0.076; 95%CI = −0.036∼0.664) are significant and so mediating the relationship between perceived quality of solar-dried product and farmer acceptance of solar dryers. Thus, the mediation role of perceived marketability of solar-dried products in farmer acceptance of solar dryers (hypotheses H_6 and H_7) is confirmed in this study.

4.5. Effect sizes of direct relationships

Table 6 results further show that direct relationships met the criterion of practical relevance of effect sizes [β ≥ 0.2] as affirmed in [38,39]. Specifically, results show that the biggest effect size is found in the relationship between drying rate and perceived marketability of solar-dried product ($\beta = 0.558$; 95%CI = 0.191∼0.891; hypothesis H_3). The finding suggests that dying rate accounts for 56% of the total variation in perceived marketability of the solar-dried product. The second biggest effect size is in the relationship between drying rate and farmer acceptance (β = 0.470; 95%CI = 0.159∼0.817; hypothesis H_1), suggesting that drying rate predicts 47% of the variation in farmer acceptance of solar dryers. For the relationship between perceived quality of solar-dried product and farmer acceptance of solar dryer (β = 0.422; 95%CI = 0.053∼0.740; hypothesis H_2), results reveal that perceived product quality predicts 42% of the variation in farmer acceptance of solar dryers. The association between perceived marketability of the solar-dried product and farmer acceptance of solar dryers (β = 0.355; 95%CI = 0.063∼0.575; hypothesis H_5) also posted high effect size depicting

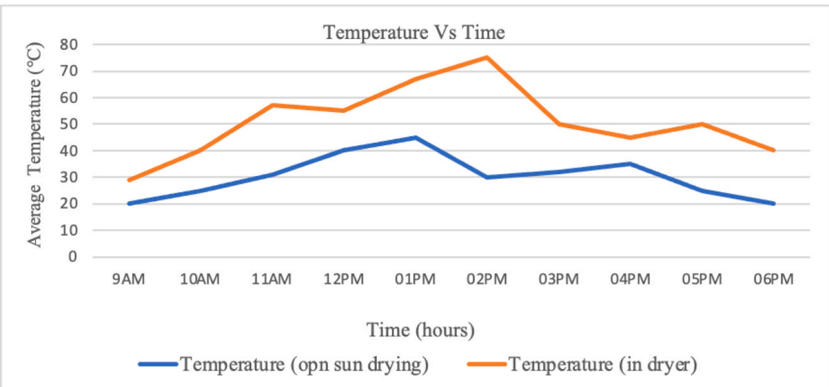

Fig. 3. Temperature changes in open sun-drying and solar dryer methods.

Table 4
Perception of open sun-drying and solar dryer methods.

Product attributes	Solar drying technology		Open sun-drying		Mean diff.	t-value
	Mean	SD	Mean	SD		
Drying rate	4.604	0.492	2.142	0.766	2.462	37.596***
Product cleanliness	4.802	0.340	1.916	0.631	2.886	56.543***
Product aroma	4.725	0.383	1.748	0.728	2.977	50.543***
Perceived product quality	4.637	0.464	1.664	0.680	2.973	48.250***
Perceived marketability	4.087	1.315	1.962	0.637	2.125	22.517***

***Note:** Means computed using Likert scale data, *** indicate the significant level at 1%.

Table 5
Effect of performance parameters on solar dryer acceptance.

Regression path	Path coefficient β (S.E)	T-value
H_1: Drying rate → Acceptance of solar dryers	0.272 (0.170)	2.208*
H_2: Perceived product quality → Acceptance of solar dryers	0.346 (0.174)	3.142**
H_3: Drying rate → perceived product marketability	0.558 (0.283)	5.077**
H_4: Perceived product quality → perceived product marketability	0.214 (0.308)	2.044*
H_5: Perceived product marketability → Acceptance of solar dryers	0.335 (0.048)	3.960**

***Significant at 1% and ** Significant 5%.

Table 6
The mediating role of perceived product marketability.

	Standardize effect			Bias-corrected (95% CI)	
Regression Path	Direct effect	Ind. effect	Total effect	Lower limit	Upper limit
H_1: Drying rate →Acceptance of solar dryers	0.272	0.198	0.470	0.159	0.817
H_2: Perceived quality →Farmer accept. of solar dryer	0.346	0.076	0.422	0.053	0.740
H_3: Drying rate → Perceived product marketability	0.558	–	0.558	0.191	0.891
H_4: Perceived quality → Perceived product marketability	0.214	–	0.214	−0.166	0.524
H_5: Perceived product marketability →Acceptance of solar dryers	0.355	–	0.355	0.063	0.575
H_6: Drying rate → Perceived product marketability → Acceptance of solar dryers	–	0.198	0.198	0.057	0.709
H_7: Perceived quality → Perceived product marketability →Acceptance of solar dryers	–	0.076	0.076	−0.036	0.664

practical relevance. Accordingly, the finding implied that perceived marketability of the solar-dried product predicts about 36% of the variation in farmer acceptance. Lastly, for perceived quality of solar-dried product and perceived marketability of solar-dried product ($\beta = 0.214$; 95%CI = −0.166~0.524, hypothesis H_4), results reveal that perceived product quality explains 21% of the variation in perceived product marketability.

5. Discussions

Solar drying technology, as an alternative to open-sun drying method, is not widely used to preserve farm produce in smallholder farming contexts of Sub-Saharan Africa [23]. Despite its demerits such as produce contamination, less attractive appearance of dried output and less nutritious products; open-sun drying remains a common method for preserving farm produce [5]. For the solar drying technology, existing literature highlights that output products retain their natural colour, are always clean and nutritionally better than the open-sun dried products [40]. Nevertheless, the success of technology development for solar drying of farm produce as well as farmer acceptance of the solar dryers remains a challenge to researchers and development practitioners [4,41]. This in part is blamed on farmer lack of awareness and knowledge on nutritional value of solar-dried products as well as unfavourable perceptions and attitudes towards solar-dried products [2,38]. Generally, an evaluation of existing empirical work shows that analyses illustrating the linkage of dryer performance factors with perceived marketability of solar-dried products in influencing acceptance of solar dryers are lacking.

Results show that the protype solar dryer, experimented in this study, performs much better than the open sun-drying method on all product drying parameters. Notably, farmers rated the solar drying technology better than the sun drying method on the product drying parameters i.e., drying rate, product cleanliness, product aroma, perceived product quality, and perceived product marketability. These findings are consistent with earlier studies that report that solar dryers are fast-drying methods because of their ability to generate higher temperatures that quickly drive moisture out of the fresh product, and thus, assuring product quality [42]. Also, solar dryers have been reported to yield much superior products in terms color appearance, tasting texture and nutritional content [7,8,43]. The findings in the current study give an impression that farmer perceptions and attitudes towards solar dryers can be improved if such technologies are not only demonstrated within the farming contexts of smallholder farmers but also consistently yield good products.

It is interesting to note that farmers perceive the solar dryers to be better technologies at producing products with better quality, i.e., cleanliness, superior product aroma and attractive product color. These favorable perceptions, as also affirmed in earlier studies [44,45], might be the reason why farmers believe that solar-dried okra product is more marketable compared to open sun-dried product. In this study, it is argued that increasing the production and consumption of solar-dried products is partly dependent on farmers beliefs that such products are marketable to consumers. Yet, perceived product marketability is related to product quality in terms of cleanliness as well as attractiveness in terms of product aroma and color.

This study also reveals that both the drying rate and perceived quality of the solar-dried product have positve effects on farmer acceptance of solar dryers. On the drying rate, the finding corroborates results in earlier studies illustrating that technology effectiveness, such as drying rate, influences user acceptance of the technology [5,14]. However, the current study finding overcomes an earlier contradiction that solar dryers in Uganda are characterized by prolonged drying time [18]. The variation in findings might be related to either differences in technology design or crop produce in question. For instance, some dryers may not permit fast outflow of moisture from the cabinet. On the other hand, some crop produce may have higher moisture content and low dry matter content, which factors affect the drying rate of the produce.

Concerning the positive effect of product quality perceptions on farmer acceptance of dryers, the finding varies from the study of [8] who stress that negative perceptions among rural households are responsible for low rating of solar-dried product. However, the study agrees with [7] whose arguments show that among nutritional-sensitive and knowledgeable communities, solar-dried products are well treasured. Overall, this study argues that perceived usefulness of the solar drying technology, for example fast drying rate and good quality product output, is essential for gaining farmer acceptance of dryers. It means that the acceptance and diffusion of solar drying technology is dependent on two critical parameters i.e., i) how quickly the technology dries fresh produce; and ii) the perceived quality of product output. Indeed, literature contends that product colour, cleaniness, taste and nutritional content are important parameters in promoting uptake of solar dryers and consumption of solar-dried, and thus, outght to be harnessed for uptake of solar dryers [44].

The current study also shows that perceived product marketability mediates the influence of dryer performance factors i.e., drying rate and product quality in predicting acceptance of the solar dryers. This implies that perceived product marketability enhances farmer acceptance of solar dryers. Because the solar drying technology maintains the natural green-color appearance of okra, the product becomes attractive to consumers, and hence more marketable [15]. In support of this line of argument [15], stressed that solar dryers produce high quality and healthier dried products that can favorably out compete open sun-dried products on the market. Since farmers are also consumers of the solar-dried products, they might be motivated by the retention of natural color and hence quality in the solar-dried products. The preserved natural color is further linked to preservation of nutrients sought after by most consumers, and thus, favorable perceptions towards marketability of solar-dried product. It can thus be argued that farmer beliefs about dryer effectiveness and positive perceptions about the quality of solar-dried products combine with perceived product marketability to influence farmer acceptance of solar dryers.

6. Conclusions and recommendations

This study reveals that farmers perceive solar drying technology to be superior to open sun-drying method with respect to drying rate, product cleanliness, product aroma, product quality and product marketability. It has further been established that farmer acceptance of solar drying technology is dependent on the drying rate of the solar dryer and perceived quality of the solar-dried product. It has also been shown that perceived product marketability mediates the drying rate and perceived product quality in predicting farmer acceptance of the solar drying technology. Therefore, this study concludes that farmer acceptance of solar dryers can be improved through demonstration of fast-drying rates, superior quality of solar-dried products, as well as perceived marketability of the solar-dried product. We call for policy action on intensification of efforts on promoting solar drying technology for value addition and increased consumption of nutritious foods. This may entail supporting artisans to fabricate locally adaptable and affordable solar dryer for widespread uptake. For further research, the study recommends that future studies examine the role of solar dryers in agricultural commercialization.

Theoretically, this study extends the technology acceptance model (TAM) with concepts drawn from solar drying technology. Basing on data from experimentation of solar dryers among smallholder okra farmers, this study deepens the literature on technology acceptance with concepts on the drying rate of solar dryers and perceived marketability of solar-dried products. It demonstrates that the farmer acceptance of solar dryers is dependent on the combination of drying rate, perceived product quality as well as perceived marketability of solar-dried products.

A key limitation is that this study relied heavily on self-reported data for modelling the drivers of farmer acceptance of solar dryers. This potential source of bias was minimized by the use of a large sample size that enhances precision of findings.

Author contribution statement

Peter G. Korsuk Kumi: Conceived and designed experiment; Performed experiments; Analyzed and interpreted data; Wrote the Paper.

Stephen W. Kalule: Conceived and designed experiment; Analyzed and interpreted data; Contributed analysis tools; Wrote the Paper.

Samuel Elolu: Contributed analysis tools; Wrote the paper.

Walter Odongo: Contributed analysis tools; Wrote the Paper.

Collins Okello: Conceived and designed experiment; Wrote the Paper.

Data availability statement

Data will be made available on request.

Declaration of competing interest

All authors declares that they have no conflict of interest to disclose in this manuscript.

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