Measuring effect of improved melon shelling technology adoption on well-being of rural women in Niger state, Nigeria using Propensity Score Matching (PSM) approach

[1]Oyediran, W. O., [2]Ayinde, I. A., [1]Fakoya, E. O. [1]Sodiya, C. I. and [3]Omoare, A. M.
[1]Department of Agricultural Extension and Rural Development, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria
[2]Department of Agricultural Economics and Farm Management, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria
[3]Department of Agricultural Education, Federal College of Education, Abeokuta, Ogun State, Nigeria
Correspondence contact details: oyediran_wasiu@yahoo.com

Abstract: Melon is an edible crop used for diverse delicious delicacies in West African countries. However, its processing remains tedious which might have adverse effects on the well-being of melon processors. Improved technology was introduced with the aim of reducing the burden of processing melon in Nigeria. This study therefore investigated the effects of improved melon shelling technology on the well-being of rural women in Niger State, Nigeria. Data were collected from survey of one hundred and ninety adopters and seventy-five non-adopters of improved melon shelling technology in Niger State, Nigeria. Propensity Score Matching (PSM) method was used to evaluate the effect of improved melon shelling technology on the well-being of rural women in the study area. Results show that literacy was very low for both adopters (4.2%) and the non-adopters (0%) but non-adopters have higher experience (19.2 years) in melon processing than the adopters (11.3 years). Personal Well-being Index-Adult (PWI-A) reveals that income and savings ($\overline{X}$=8.28), household food security ($\overline{X}$=8.62) and civic engagement in the community ($\overline{X}$=9.15) of adopters were worthwhile. Also, 67.4 percent of the adopters had a good well-being ($\overline{X}\geq 51$) while 81.3 percent of non-adopters had a poor/not worthwhile well-being ($\overline{X}<50$). The results of PSM showed a positive impact of improved melon shelling technology on the well-being of adopters ($t = 0.41$, $p < 0.05$). This study recommends that the non-adopters in Niger State should respond positively to technical changes by adopting and optimally utilising improved melon shelling technology rather than manual method in order to improve their well-being.
Keywords: rural women, melon shelling technology, well-being, Propensity Score Matching

INTRODUCTION

Processing of melon seeds into diverse products is extremely an important activity in its value chain because melon offers postharvest opportunities and value. The process of making snacks, sweetener, oil, and other melon products is well established in the rural areas of Nigeria. Today, there is considerable interest in processing to reduce postharvest losses in fruits and vegetables and as well to add value. In the past and up to the present, Nigeria has suffered tremendous loss of food products due to lack of proper and adaptable processing and packaging technologies (Udoh, 2009). A bulk of melon seeds are lost due to poor method of de-ppoding, fermentation, washing, drying, shelling, de-stoning, de-hulling, winnowing, grinding, oil extracting, roasting, and packaging. Over the years, melon had always been shelled manually with hands. Shelling is an important step in the processing of melon to its finished products. Shelling melon with hands often resulted in serious pains on the fingertips, ankle, waist and vertebra of the women. Breaking melon against stones often causes bruise in the hands of the processors. Traditionally, women working in tandem take several hours harvesting the melon, separating the seeds from the pod, drying, grinding, and allowing the seeds to steeping in salt to extract the oil, which is another important food product. However, it is difficult to make more than one gallon (4.55litres) of oil at a time because of the dearth of technology (Michael, 2010). The manual shelling of the seeds therefore remains a limiting factor to the mass production and industrialization of melon in Nigeria (Shittu and Ndrika, 2012). Accelerating reductions in drudgery and low productivity require some drastic efforts in expanding the economic activities of the rural women who are involved in melon processing and marketing activities. As part of the Federal Government of Nigeria's effort to revamp agriculture, staple crop processing zones were established while improved small scale processing technologies, including melon processing technology, were promoted as a precondition for the overall growth in quantity and quality of agricultural commodities and supply in Nigeria (This day live, 2013). This growth is necessary to increase the nation's food production, Public Private Partnership (PPP), youth and women empowerment, among others (Akinwumi, 2012). This is to facilitate food security, diversify the economy and enhance foreign exchange earnings.

The food industry and agricultural sectors are strongly interrelated in most Sub-Saharan African (SSA) countries, and it can be a strong driving force towards the expansion in economic scale and activity of rural communities. In this regard, there has been increased development on improved melon processing technology (motorized melon shellers,) which is introduced to rural dwellers by the extension arm of National Centre for

Agricultural Mechanization (NCAM) in collaboration with the Niger State Agricultural Development Projects (NSADP) through exhibition and seminars to educate the melon farmers, processors and marketers on the advantages of its adoption (Mohammed *et al*., 2014; The Tide, 2013).

Empirical studies have shown that gains from adoption of new agricultural technology influenced the poor directly, by raising productivity and income of farm households, and indirectly, by raising employment (Evenson and Gollin, 2003; Diagne *et al.*, 2009). The adoption of innovation is however the last step in a decision-making process to make full use of an innovation having considered that such will impact positively on the well-being of the adopter. To this end, the introduction of improved melon shelling technology is to reduce wastages, drudgery and contamination (sand, debris, dust) associated with traditional methods. The technology is designed to ease melon processing operations and increase productivity which will in turn affect economic returns and well-being of the rural women. The importance of technology in women empowerment cannot be over-emphasized, as it influences well-being of rural women and their households. In Nigeria, rural women are increasingly involved in melon processing for their livelihood sustainability. This technology could facilitate a better melon processing in terms of timeliness, cleanliness, reduced damage and large turnout. The broad objective of this study was to assess effect of melon shelling technology adoption on the well-being of rural women in Niger State.

METHODOLOGY

Data for this study were collected from survey of rural women in Niger State in the Northern part of Nigeria. The respondents for this study were selected based on the *a priori* information that they processed melon for commercial purpose. Snowball method was used to select seventy-five non-adopters of improved melon shelling technology while one hundred and ninety adopters were randomly selected from the list of 4,639 registered melon processors in Niger State, making two hundred and sixty-five melon processors selected for this study.

Data were collected on socio-economic characteristics and rural women well-being. Well-being of the rural women in melon processing was operationalized by using Core Welfare Indicator Questionnaire (NBS, 2006) and scale of Personal Well-being Index Adult (PWI-A) developed by International Well-being Group (IWbG, 2013) which focused on 7 domains. Scores were obtained and aggregated based on the number of items answered correctly with the maximum score of 100 and minimum score of 0. Mean score obtained from NBS and PWI-A was used to categorize the well-being as not worthwhile/poor for mean value below 50, and worthwhile/good for scores above mean value of 50.

Assuming technology was randomly assigned to households – as it would be in an experiment for example – one could evaluate the causal effect of new technology adoption on households' well-being as the difference in average well-being between adopters of improved technology and non-adopters of the new technology. However, samples drawn from a non-experimental design have the problem of self-selection since the selection is not random. This makes it difficult to separate the effect of technology from other factors that can affect the decision of adoption. Scholars have reported that in the presence of selection bias, the comparison of means can provide misleading results (Crost *et al.,* 2007; Ali and Abdulai, 2010). The Propensity Score Matching (PSM) method was used to address the self-selection and evaluation bias. This method takes into account the counterfactual situation: "how much did the adopters benefit from improved melon shelling technology compared to the situation if they had not adopted. In this study, a Logit model was applied to estimate the propensity score. Logit model was used because of its mathematical convenience and simplicity as reported by Greene (2008). The propensity score represents the estimated propensity of being an adopter of improved melon shelling technology. The dependent variable takes the value of 1 if the rural woman is an adopter and 0 otherwise: the larger the score, the more likely the individual would be to adopt improved melon shelling technology. The choice of explanatory variables (i.e. conditioning variables) in predicting propensity score is crucial in propensity score matching analysis. The selection of covariates is in line with the assumption of un-confoundedness. Selection of variables that influence both treatment and outcomes, but are not affected by the treatment is recommended (Caliendo and Hujer, 2005). With a view to the conditional independence assumption, explanatory variables that are significant determinants of well-being and also correlated with technology adoption were selected. Socio-economic characteristics of the rural women such as, age, household size, educational status, marital status, household size, years of experience, man day, non-farm income, a dummy variable representing whether or not improved technology was adopted, and ownership of melon processing assets were selected. The variables used in this study were based on previous researches that have examined the impact of technology adoption on farmers' well-being in developing countries taking self-selection into account (Mendola, 2007; Wu *et al.,* 2010; Becerril and Abdulai, 2010). The basic

idea behind PSM was to match each adopter with an identical non-adopter and then measure the average difference in the outcome variable between the adopters and the non-adopters. It typically does this by comparing outcomes between beneficiaries and a control group (African Impact Evaluation Initiative (AIEI), 2010). Since the data for this study were obtained from survey, non-experimental impact evaluation design was preferred and analysed using Propensity Scores Matching (PSM).

The welfare effect of a technology (causal effect) for an individual processor is the difference between the outcomes:

$T_i = Y_i(1) – Y_i(0)$ .....(1)

T_i = treatment indicator (improved melon shelling technology)

$Y_i(1)$ = level of outcome variable for an individual processor who uses improved melon shelling technology

$Y_i(0)$ = potential level of outcome variable if this individual processor does not use improved melon shelling technology.

The difference between the actual and counterfactual situation known as 'Average Treatment Effect (ATT) on the treated' defined by Rosembaum and Rubin (1983) as:

$T_{ATT} = E(Y|T = 1) = E[Y(1)|T = 1] – E[Y(0)|T = 1]$ .....(2)

Technological effect is written as:

$E(Y(1)|T = 1)] – E[Y(0)|T = 0] = T_{ATT} + E[Y(0)|T = 1] – E[Y(0)|T = 0]$.....(3)

The difference between the left-hand side of equation (3) and T_{ATT} is the so-called self-selection bias. The true parameter T_{ATT} is only identified, if:

$E[Y(0)|T = 1] – E[Y(0)|T = 0] = 0$ .....(4)

The PSM estimator for ATT is written in general as:

$_{T}PSM/ATT = {}_{Ep(x)T=1}\{E[Y(1)|T = 1, P(X)] - E[Y(0)|T = 0, P(X)]\}$ .....(5)

RESULTS AND DISCUSSION

Socioeconomic characteristics

The study reveals that 31.1% of adopters were between 31 – 40 years of age, while 41.3% of non-adopters were above 51 years of age. The mean age of adopters was 35.8 years, while that of non-adopters was 43.3 years which indicate that non-adopters are older than the adopters. Proportion of adopters that were married was higher (84.7%) than that of non-adopters (50.7%). But, non-adopters had higher proportion for separated (22.6%) and widowed (20%) compared to 5.3% separated and 3.7% widowed among adopters. More than forty percent of adopters (41.6%) and non-adopters (49.3%) did not have formal education. Respondents that had primary education were higher (43.2%) for adopters than non-adopters (29.3%). Meanwhile, the proportion of respondents that had secondary education was almost the same for adopters (21.6%) and non-adopters (21.3%) but non-adopters did not attain tertiary education (0%), while few adopters attained tertiary education (4.2%). This implies that literacy was higher among adopters than the non-adopters. On the other hand 21.3% of non-adopters had more (11 people) in their households as against 11.6% adopters that had same number of household members. The mean of household size for adopters and non-adopters were 8 and 9 people respectively. This shows that the household size of non-adopters is relatively higher than that of adopters. Also, 53.3% of non-adopters had more than 21 years of experience in melon processing, while 11% adopters had similar years of experience. The mean year of experience for adopters was 11.3 years while that of non-adopters was 19.2 years. This indicates that non-adopters have higher experience in melon processing than the adopters. Also, the results on man-day of the respondents shows that 65.3% of non-adopters spent more than 9 hours in melon processing compared to 35.8% adopters that spent the same number of years in melon processing. The respondents were involved in various non-agricultural income activities with 26.3% adopters and 30.7% non-adopters engaged in petty trading, and 4.7% adopters and 6.7% non-adopters were into food stuff selling, while only few (2.6%) adopters were employed into civil service to generate additional incomes.

Table 1: Distribution of respondents by their socio-economic characteristics (n = 265)

Socioeconomic characteristics	Adopters (n=190)	Non-Adopters (n=75)
Age (years)		
Less than 30	50(26.3)	11(14.7)
31 – 40	59(31.1)	14(18.7)
41 – 50	57(30.0)	19(25.3)
51 and above	24(12.6)	31(41.3)
Mean	35.8	43.4
Marital status		
Single	12(6.3)	5(6.7)
Married	161(84.7)	38(50.7)
Separated	10(5.3)	17(22.6)
Widowed	07(3.7)	15(20.0)
Years of Education		

Socioeconomic characteristics	Adopters (n=190)	Non-Adopters (n=75)
No formal education	79(41.6)	37(49.3)
Primary education	82(43.2)	22(29.3)
Secondary education	41(21.6)	16(21.3)
Tertiary education	08(4.2)	0(0.0)
Household size		
Less than 5	16(8.4)	7(9.3)
6 – 10	152(80.0)	52(69.3)
11 and above	22(11.6)	16(21.3)
Mean	8	9
Years of experience		
Less than 10	101(53.2)	12(16.0)
11 – 20	68(35.8)	23(30.7)
21 and above	21(11.0)	40(53.3)
Mean	11.3	19.2
Manday (hours)		
6 – 8	122(64.2)	26(34.7)
9 and above	68(35.8)	49(65.3)
Mean	8.1	9.0
Non-Farm income activities		
Petty trading	50(26.3)	23(30.7)
Civil service	05(2.6)	0(0.0)
Food stuff selling	09(4.7)	05(6.7)
None (Full-time melon processors)	126(66.3)	47(62.6)

Source: Field Survey, 2018. Values in parenthesis are percentages

Well-being of rural women in the melon processing activities

From the results of PWI-A in Table 2a, the mean score of health shows that the general state of health of adopters ($\bar{X}$ = 5.59) and non-adopters ($\bar{X}$ = 5.01) in relation to melon processing activities was moderate. Since there is a common saying that "health is wealth" hence, good health is an important indicator of quality life and overall well-being (Dolan *et al*., 2008). The result also shows that the income and savings for adopters were better ($\bar{X}$ = 8.28) while that of non-adopters were poor ($\bar{X}$ = 2.86). This indicates that return on investment for melon is economically viable for the adopters of improved melon shelling technology and thereby considered it worthwhile. Contributions of adopters to household food security was relatively high ($\bar{X}$ = 8.62) than that of non-adopters ($\bar{X}$ = 8.62), hence adopters felt satisfied with food and nutrition domain of well-being. The support given to children's education by adopters was worthwhile ($\bar{X}$ = 8.23) compared to low support from the non-adopters ($\bar{X}$ = 3.41). This is an indication that income, household food security and children's education of adopters of improved melon shelling technology are better than that of non-adopters. The result coincides with the findings of Sodiya and Oyediran, (2014) that melon production contributed to rural farmers' household food security, served as income to farmers, gift to relatives, seeds for next cropping season and as local medicine in treating some ailments in Oyo State, Nigeria. These findings also support the assertion of Klasen, (2002) and United Nations, (2009b) that rural women access to technology and better income could enhance their children's nutrition, education and well-being. Globally, women have been recognized for their unique contributions to livelihood sustainability and well-being of their families through food production, processing and marketing of agricultural produce (IFPRI, 2012; World Bank, FAO and IFAD, 2009). The respondents also reported that their civic engagement in the community was worthwhile for adopters ($\bar{X}$ = 9.15) and non-adopters ($\bar{X}$ = 5.35) though that of adopters shows a relatively high satisfaction. However, the adopters ($\bar{X}$ = 4.70) and non-adopters ($\bar{X}$ = 2.65) considered their accommodation as not worthwhile and it was rated low. This may be due to lack of some basic facilities like furnished kitchen and toilet that are not up to standard if compared to modern houses in the urban centres in Nigeria. Consequently, the respondents described the housing condition as not worthwhile. This dissatisfaction may not be unconnected with the rural women cosmopoliteness that exposes them to modern houses in cities, and the limitation to jointly fund a house project that belongs to their husbands especially in a polygamous family set up. A poor and unsafe housing constitute a large burden to individuals (Fabrice and Culver, 2010). According to Maslow (1954) cited in Huitt, (2007) housing is one of the physiological needs of an individual and it is essential for well-being. But, the adopters ($\bar{X}$ = 8.64) and non-adopters ($\bar{X}$ = 6.90) indicated that they were satisfied with their relationship to other people in the melon processing and marketing

activities and enjoyed recognition within the community. Social contact is fundamental to the sense of well-being, as it has bearing both on life evaluations (Boarini *et al*., 2012). Similarly, security domain showed that adopters ($\bar{X}$ = 8.84) and no-adopters ($\bar{X}$ = 7.54) felt satisfied with safety as there was no reported case of thefts, attacks, and work place hazards in the study area. Boarini *et al*. (2012) reported relationship between experience of victimization and well-being. Also, the adopters were satisfied with their leisure ($\bar{X}$ = 6.72) and life ($\bar{X}$ = 6.38) while non-adopter were dissatisfied with their leisure ($\bar{X}$ = 2.16) and life ($\bar{X}$ = 4.27). Thus, adopters of improved melon shelling felt satisfied with achievements in the melon processing and considered their well-being as worthwhile compared to the poor case of non-adopters. In line with findings from this study, Nwanesi (2006) reported that the level of well-being and the economic position of most rural women depend on several factors; these include whether they are landless or landowning, whether they have access to productive resources and technology or whether they are recognized in the community. It was further stated that the size of the rural women's production is equally important, if they have their own income and satisfied with it, if they have taken any micro-credit loans, or if their income is reserved for a "head of the family" or children, and if they sell their products to make profit or give out some as charity. These are some of the dynamic features which shape the feelings of rural women on their economic position and well-being status in Nigeria.

The result of categorization of well-being in Table 2b indicates that 67.4 percent of the adopters had a good well-being ($\bar{X} \geq 51$). In contrast, most (81.3%) of non-adopters had a poor/not worthwhile well-being ($\bar{X} < 50$). The implication from the results of foregoing is that adoption of improved sheller technology for processing melon has a multiplier effect on the growth and development of melon processing in terms of output, income generation and savings as well as further investment. Technology adoption has the potential of improving the livelihood needs of rural women through increased income levels leading to women being food secured, having access to better housing, women's ability to pay their wards education, payment of medical bills and reduction in vulnerability of the women (Fadilah *et al*., 2013). Doss *et al*. (2003) cited in Idrisa *et al*. (2010) also opined that adoption of improved technologies is an important means to increase the productivity of smallholder agriculture in Africa, thereby fostering economic growth and improved well-being for millions of the poor households.

Table 2a: Well-being of Rural Women in the Melon Processing

s/n	Well-being domains	Classification	Adopters (n = 190)	Non-adopters (n = 75)
			$\bar{X}$	$\bar{X}$
	Objective well-being			
1.	Health	Psychological	5.59	5.01
2.	Food and Nutrition	Physical	8.62	5.42
3.	Income and savings	Economic	8.28	2.86
4.	Education	Physical	8.23	3.41
5.	Accommodation	Physical	4.70	2.65
	Subjective well-being			
6.	Social cohesion and relations	Social	8.64	6.90
7.	Civic engagement	Psychological	9.15	5.35
8.	Physical safety	Social	8.84	7.54
9.	Leisure	Psychological	6.72	2.16
10.	Life satisfaction	Cognitive	6.38	4.27

Source: Field Survey, 2018.

Table 2b: Categorization of Well-being of Melon Processors

Well-being	Scores	Adopters (n = 190)		Non-adopters (n =75)	
		Frequency	Percentage	Frequency	Percentage
Not worthwhile/Poor	< 50	62	32.60	61	81.30
Worthwhile/Good	≥ 51	128	67.40	14	18.70

Source: Field Survey, 2018

Estimate of Average treatment effect (ATT) of technology adoption on rural women well-being

The statistical significance of the ATT was tested using t-values calculated from 50 times bootstrapping standard errors as recommended by Becker and Ichino, (2002). The technological effect on rural women well-being is estimated through two different methods, that is, the Nearest Neighbour Matching (NNM) and the full matching methods. The common support condition is imposed and the balancing property is set and satisfied in all regressions at 1% significance level. The different matching algorithms produced different quantitative results, but the qualitative findings are similar. Overall, matching estimates show that improved technology adoption has a positive and robust effect on rural women well-being. The results of full matching presented in Table 3 show a positive impact of improved melon shelling technology on rural women's well-being, a significant value of t = 0.41, that is, experiencing a good well-being by 41.0%. Also, the nearest-neighbour causal effect of technology on rural women's well-being is highly significant and equal to about t = 1.83, which is the average difference between well-being of similar pairs of melon processors but belonging to different status in their melon processing operations (adopters and non-adopters). For this study it is inferred that the difference between the economic returns and well-being of both matched groups are the outcome of their decision to adopt the improved melon shelling technology. This is based on the fact that the two groups are matched on the equality of their propensity scores. In addition, the good well-being is attributed to the higher productivity with attendant higher economic returns from improved melon shelling technology. The result is in agreement with similar findings on poverty analysis measuring the differential impact of agricultural technology adoption on poverty reduction among the rural households using PSM. Becerril and Abdulai (2010) reported that adoption of improved maize reduces the probability of falling below poverty line roughly between 19 to 31 percent in the two study areas of Oaxaca and Chiapas, Mexico. Similarly, Mendola (2007) founds that adoption of high yielding varieties (HYVs) of rice has a positive and robust effect on households' income and the way out of poverty in rural Bangladesh. The result is also in consonance with general findings of Hazell (2008), Wu *et al*. (2010), Challa and Tilahun, (2014) regarding the impact of agricultural technologies on household poverty reduction and well-being.

Table 3: Technological effect on rural women well-being matching estimates

Dependent variable	**Effect**	
	NNM	Full matching
Well-being	0.02[b]	0.82[b]
	(1.83)***	(0.41)***
Balancing property satisfied	Yes	Yes
Common support imposed	Yes	Yes
Observations		
Treated	190	
Controls	75	

Source: Calculated from field data, 2018. t-statistics in parenthesis.
[b]Bootstrapped t-statistics, 50 replications. *** Significant at 1% level

CONCLUSION

The use of cross-sectional data at establishing the effect of technology adoption on well-being is a great task because it is not so easy to separate socio-economic factors from technology effects. The self-selection bias was addressed with PSM model and the findings show a positive impact of improved melon shelling technology adoption on rural women well-being. It is therefore recommended that non-adopters in Niger State should continue to respond positively to technical changes by adopting and optimally utilising improved melon shelling technology rather than a very tedious hand shelling method. The melon processors should as well form themselves into larger cooperative groups for easy access to modern technology, agricultural loans and other government largesse. In addition, agricultural extension services should be proactive in the service delivery and ensure adequate training support is given to the rural women, this will facilitate further adoption of the technology in the study area.

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