

**PRODUCTION AND UTILIZATION OF JACKFRUIT (*Artocarpus
Heterophyllus*) IN UGANDA**

Balamaze J¹, Muyonga JH¹ and YB Byaruhanga^{1*}



Joseph Balamaze

*Corresponding author email: ybbyaru@gmail.com; ybbyaruhanga@caes.mak.ac.ug

¹Food Technology, Business Incubation Centre, School of Food Technology, Nutrition and Bio Engineering Makerere University, P. O. Box 7062 Kampala Uganda



ABSTRACT

Jackfruit originated from East Asia, known to be the largest tree born fruit weighs up to 30kg and yields 50-80 tons per hectare annually. The fruit has large potential in Uganda and has been used in value added products on a small and rudimentary scale. This work assessed the production and utilization patterns of jackfruit with a view of determining its capacity to sustain industrial scale processing. A cross-sectional survey was conducted in jackfruit producing regions from April to June 2016. The study variables were household farm size, number of jackfruit trees, types, utilization methods and constraints associated with jackfruit production. A purposive sampling design was used to select districts, sub-counties, parishes and villages to participate in the survey. A total of 400 household heads from the study area were interviewed using a semi structured questionnaire. Responses and observations were recorded; secondary data was also reviewed for information on the total number of households in a district. The results showed that 32% of the respondents worked on 1-2 acres of farmland on which they have at least 2-7 jackfruit trees. About 57% of jackfruit trees were planted while the remaining 43% were inherited. The study area was estimated to have about 1.7 million fruiting jackfruit trees with the number of fruits per tree varying between 20-120 fruits and weighing 11 kg, on average. Jackfruit harvest season in Uganda has two peaks in March to April and November to December, with the latter season yielding more fruit. Jackfruit is categorized into white, orange and yellow types based on the pulp color, hard or soft according to pulp texture. About 78% of households produced jack fruit mainly for home consumption, 16% of the households sold the fruit, and 6% fed it to animals while 1% of the household processed them into dried chips or jackfruit wine. The estimated jackfruit production per district in the study area was 0.3 million metric tons/annum. Although the study area has a potential of producing jackfruit for industrial processing, there is need to grow more jackfruit in an organized manner to meet the increasing and competing demands for both home consumption and industrial processing.

Key words: Jackfruit *Artocarpus heterophyllus*, production, categorization, utilization, household, consumption, flakes



INTRODUCTION

Worldwide, jackfruit (*Artocarpus heterophyllus*) is mainly produced in Asia with India and Bangladesh being the world's leading producers with an average of 1.25 million metric tons of fruit annually [1]. The lifespan of the jackfruit tree is 60 to 70 years and a mature plant produces up to 700 fruits per year [2]. Jackfruit is known to be the heaviest fruit with an average fruit weight 10-30 kg [3] and annual average yield of 50-80 tons of fruits per hectare of land [1].

Jackfruit production and consumption in many other countries is on the rise and it is becoming of great economic value because of its traditional value and rich mouth feel. In India, the total area under jackfruit cultivation is approximately 30,000 acres, of which, an estimated one million trees are grown in back yards of Karnataka region alone producing fruits valued at 19 million dollars per year [1]. Jackfruit is also widely grown and consumed in East Africa (Burundi, Kenya, Uganda and Tanzania). In Tanzania, it is locally produced in several regions of the country including: Zanzibar, Mwanza, Bukoba, Tanga and Morogoro where it is mainly available in the fresh form [4]. In Uganda, jackfruit is mainly grown in the central, western and eastern regions of the country despite the fact that many households in other parts of the country have jackfruit trees in their gardens [5]. Like many sub-Saharan African countries, the economy of Uganda largely depends on agriculture from which the majority of the rural populations derive their livelihoods and incomes [6]. Due to the importance of the agricultural sector, the Government of Uganda has put renewed emphasis on this sector. This is supported by many proposed policies including: Plans for Modernization of Agriculture, Uganda's National Agriculture Policy 2011, Farmer Education and Training Program and the Development Strategy and Investment Plan [6]. The latter policy emphasizes that, to realize improved raw material production from agriculture, there should be a simultaneous development in value addition and industrial production for agricultural products [7].

Jackfruit comprising 28-33% pulp and 67% waste from which a lot of value-added products can be processed. However, currently little information exists on the production capacity, utilization and processing of jackfruit in Uganda. Information on jackfruit production and utilization is crucial for the improvement of the economic value of this fruit in the country. The main aim of this study was to establish the current jackfruit production levels and utilization in order to explore its potential to support both household consumption and industrial processing.

METHODOLOGY

Study area

The study was conducted in five purposively selected districts of Central and Eastern regions of Uganda namely: Mityana, Kayunga, Kamuli, Luuka and Jinja which cover a total land area of 6,046 Km² in 49 Sub-counties with 426,136 households and a population of 1.5 million [8]. These districts were selected mainly because the jackfruit vendors in Kampala city markets identified them as the major sources of the fruit sold in Uganda.



The sample size “n” was calculated according to [9]

$$n = \frac{Z^2 pq}{d^2} = \frac{(1.96 \times 1.96) \times 0.5 \times 0.5}{0.05 \times 0.05} = 386$$

Where;

n = sample size

P= proportion of respondents growing jackfruit nationwide (not known, so it was assumed at 50%)

q = (1-p)

d = Acceptable degree of error (5%)

z = Normal deviation (confidence limit as 1.96 at 95% CI)

The annual jackfruit production was estimated by multiplying the average number of trees per house hold (T), the yield per tree (Y), the number of seasons (S), the average weight of a jackfruit (W) Kg and the number of households in study area (H). The product was converted into tons by dividing by 1000.

$$\text{Annual production (Million MT)} = [T \times Y \times S \times W \times H] 0.001$$

In each of the study districts, one county and sub-county were purposively selected. One parish was purposively selected from a county and four villages were purposively selected from each parish. In summary, the sampling plan for respondents was 5 districts x 1 county x 1 sub-county x 1 parishes x 4 villages x 20 households summing up to = 400 respondents. An average of 20 respondents was selected from each village and interviewed using a comprehensive, semi-structured questionnaire. It included information on farmer's land size, jackfruit production levels (number of trees on the farm and yield per tree), types of harvesting methods, post-harvest losses, consumption, utilization, marketing and associated problems. The respective Village Council chairpersons guided the enumerators through the village when selecting and interviewing respondents. Eligibility for inclusion in the study was the presence of jackfruit tree (s) in the household garden. The questionnaire was pre-tested using 40 farmers in Naluwembe village, Kammengo sub-county Mpigi district. During the pre-testing, respondents were probed to determine the precision and flow of the questions. The questionnaire was then revised and edited before the final interview.

Data entry and analysis was performed using SPSS version 20 software. Descriptive statistics were used to discuss results.

RESULTS AND DISCUSSION

Jackfruit production

The household farmland size in the study area varied from 1 to 16 acres with 81% owning 1 to 4 acres, 8% owned more than 5 acres while 10% of the households did not know their farmland size (Table 1). The number of trees owned varied from 1 to 16



trees (Table 2); the majority of households (69%) owned 2 to 7 trees with about 41% of the respondents reported that their trees were planted, 23% were inherited while others (19%) did not know (Figure 1). Households reported jackfruit yield ranging between 20 and 120 fruits per tree per season, about a third of the households reported 50 – 60 fruits per tree per season, while the rest reported varying yields. Annual jackfruit yield for the districts ranged from 0.17 to 0.40 MT with an average of 0.3 MT (Table 3).

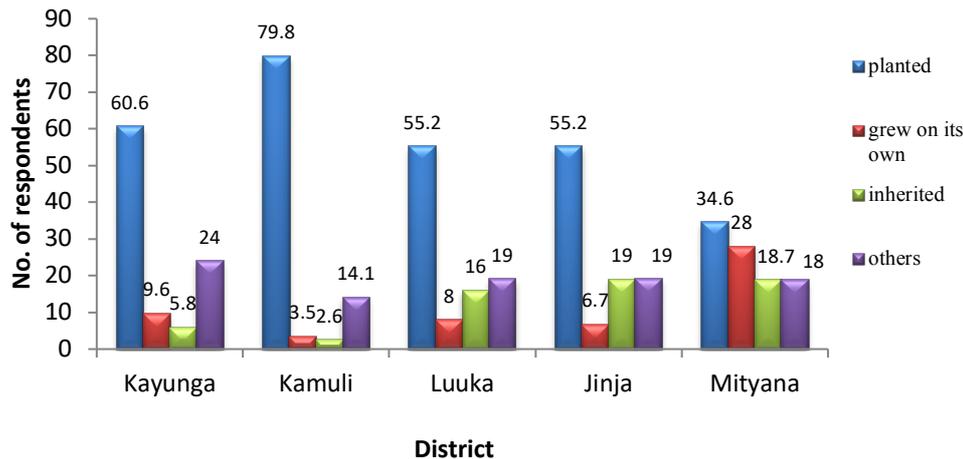


Figure 1: Showing how jackfruit trees are acquired by households in selected districts of Uganda

The jackfruit production reported in the study area was mainly characterized by small holder farm sizes (1-4 acres) on which 2-7 jackfruit trees are grown either intercropped or planted along the edges of the farming area. There was no single jackfruit orchard reported in the study area. Despite the non-existence of orchards, most of the jackfruit trees found in the study area were deliberately planted (41%) which is an indication that farmers are interested in the crop and they may be ready to scale up production if the opportunity arises. This is consistent with what was observed in Hawaii, one or two jackfruit tree(s) are commonly found near rural farm homes often intercropped with coffee, pepper, vanilla, and betel palm [10]. This type of farming system may not be adequate for industrial processing of jackfruit, where volumes of a particular variety may be required. In some parts of Kenya and South Africa, however, commercial production for other fruits has been initiated [11]. In India on the other hand, jackfruit orchard production exists where trees are planted at 30 x 40 ft and the country has roughly 30,000 acres under jackfruit production. The increasing importance of jackfruit has caused the Indian government horticulturists to promote the planting of jackfruit trees along highways, waterways and railways to add to the country's food supply chain [10]. This probably explains why India is among the world's leading producers of jackfruit [10]. The production patterns reported in the present study area need to be improved possibly by planting known jackfruit varieties in orchards with proper agronomical management practices. This will probably increase the average jackfruit production, beyond the current estimated annual production of 0.3 million metric tonnes. The improvement in the jackfruit production may result in increased production

levels enough to support both household consumption and industrial processing. Besides, under large scale jackfruit production the tree parts contribute to both firewood and timber supply [11] which in the long run can reduce pressure on environmental degradation caused by deforestation.

Fruiting time and harvesting periods

A 3-4 year period was reported by the majority (46%) of the respondents as the starting time for jackfruit to bear fruits (Table 4). Also, two peak harvest seasons were reported: March to April and November to December, the latter generally regarded as the major jackfruit harvest season. The fruit harvest season overlaps (March-June) were reported mainly in Mityana district (Table 5). The average yield per tree per season was approximately 55 fruits with an average weight of 11 ± 5 kg. In relation to the large fruit size, high yield, two peak season harvest and season overlaps, jackfruit has a big potential for reliably supplying fruits for industrial processing. On the other hand, early fruit bearing period (3-4 years) after planting, would ensure a quick raw material supply and may encourage farmers to venture into commercial planting of the crop. The yield of 250 fruits and 4-14 years reported in India as fruiting time after planting were different from what was observed in the study area [1, 12]. This probably could be due to differences in environmental conditions and management practices existing in the two production areas and possibly explains why India is one of the leading jackfruit producers. Generally, in Uganda, jackfruit is mainly concentrated in the central and eastern regions of the country; this could possibly be due to heavy rains received by the two regions [13]. In relation to size, jackfruits in the study area were relatively heavier (11 ± 5 kg) than 4.6 kg reported in Malaysia [14]. In this context, large fruits yield more pulp and waste compared to small ones. Therefore, jackfruit varieties grown in the study area could be more profitable for industrial processing due to their larger than those grown in other parts of the world. On the other hand, the harvesting season reported in the study area is not as widely spread as that reported in India, which principally occurs from March to June, April to September, or June to August, depending on the climatic conditions of the region. In view of this, India enjoys a more spread annual jackfruit production than the study area which has only two distinct season periods with a few overlaps. In general, jackfruit is a perennial crop and it takes over 70 years continuously producing fruits, making it a reliable source of raw material for industrial processing [1].

Characterization of jackfruit by the farmers

Respondents characterized jackfruit pulp based on the color, texture and ease of splitting open when the fruit is ripe (Table 6). Three pulp colors reported were; yellow (41%), orange (31%) and white (28%), in terms of texture 71% reported white while 63% reported orange to have hard texture flakes. About 64% of the respondents indicated that yellow flakes had a softer texture, there was also a jackfruit type locally called *Lebbe* in Mityana district which could be split open when ripe using bare hands, and this was reported by only 2% of the respondents. Categorizing jackfruit based on pulp color as reported in the study area may not be conclusive particularly when the fruits are for making minimally processed jackfruit flakes packed in transparent packets. In such products flake size and texture plays a major role in determining product acceptability. Usually consumers prefer big size and hard textured flakes and



therefore jackfruit varieties which produce such types of flakes are more suitable for minimal processing. Compared to soft flakes, the hard texture ones would withstand textural defects caused by minimal processing operations such as blanching and vacuum packaging [15]. Furthermore the Lebbe type of jackfruit (Table 6) seemed to be related to Barka type reported in India, which has soft, sweet flakes and the fruit easily breaks open using bare hands [12]. This type of jackfruit could be more suitable for making pulp-based products like jams, marmalades or juices. In terms of energy conservation, pulping soft flakes takes a reasonably short time and therefore less costly than pulping hard flakes. Other types of flakes reported in India are; Koozha chakka, the fruits have small, fibrous, soft, mushy, but very sweet flakes. Whereas, Koozha pazham, a more commercially important type with hard and crisp flakes [12]. The way jackfruit is identified in India is in some way different from that reported in the study area where it is mainly based on pulp color differences. Therefore, if jackfruit is to be produced for industrial processing scale, the fruits should be adequately characterized in terms of physical and chemical properties to enable accurate identification of varieties. In Bangladesh for example sweetness and texture of jackfruit pulp are quality characteristics considered seriously by producers or marketers of agricultural products [16].

Utilization of jackfruit in the household

Over 80% of respondents reported that jackfruit produced is used for home consumption with about half of the respondents consuming it any time of the day by every family member. Teenagers and children under 10 years were identified to be consuming more jackfruit than younger or older family members (Table 7). Sixteen percent of the respondents reported to sell some of the harvested fruit whereas 6% fed some of the harvested fruits to animal (cows and pigs). Very few respondents (1%) reported processing the flakes into other products like dried jackfruit chips or wine (Fig. 2).

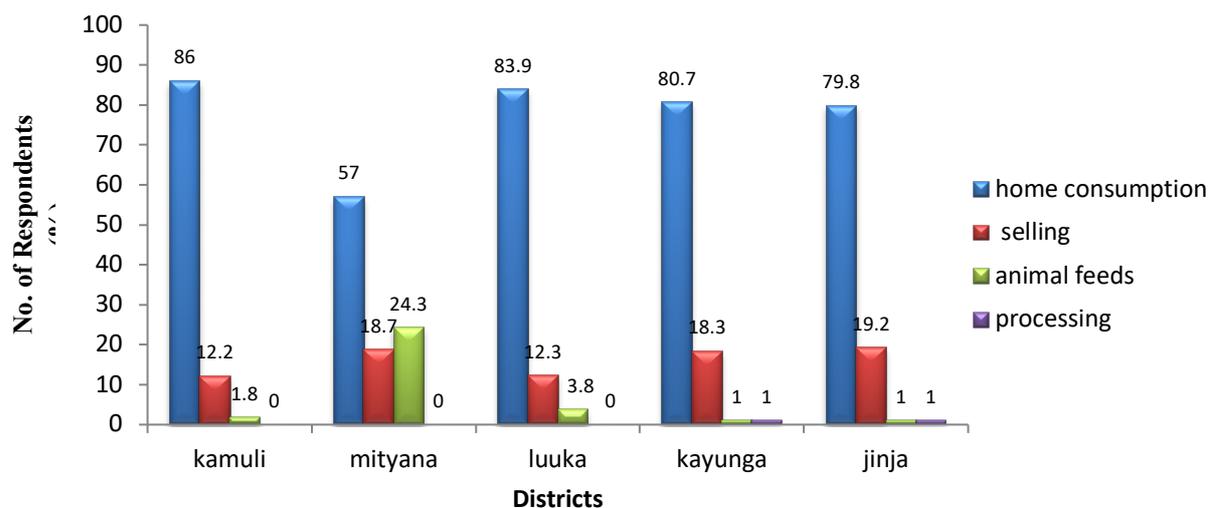


Figure 2: Showing how Jackfruit is utilized by households in selected districts in Uganda

The biggest portion (over 80%) of the harvest is consumed, jackfruit being the largest known fruit, a single fruit could serve several family members. Nutritionally, jackfruit is known to be a good source of vitamin B₆ which is not common in other fruits [1]. Vitamin B₆ is required for the formation of red blood cells and various neurotransmitters; it helps to maintain nerve function, a healthy immune system and healthy antibodies [1]. Therefore, consumption of jackfruit may contribute to good nutrition and health status of household members. In many Asian countries' jackfruit is considered a miracle crop that can be used to save millions of people from hunger due to its nutritional composition, size and the many ways in which it can be prepared [12, 17]. During peak season periods due to lack of alternative use, the fruits which cannot be consumed are fed to animals and therefore nutrient drain. In the study area, processing of jackfruit flakes to value added product is still limited and was only reported in Kayunga district where the flakes have been dried into jackfruit fine chips and sold to local market. The proportion of the harvested fruits processed is very small (1%) compared to that which is consumed (80%) or fed to animals (6%). Therefore, encouraging farmers to focus on processing of jackfruit will be a solution to solving fruit wastage particularly during season periods. It should also be noted that jackfruit quality characteristics are critical considerations for value addition and having a lot of produce does not guarantee marketability if consumers do not like the produce [16, 18, 19].

Jackfruit marketing and losses

In the study area, 11-23% of the respondents reported selling their harvested jackfruit through middle men who pay an average price of USD 0.57 per fruit. Whereas only 2-6% of the respondents reported selling their fruits by the road side either whole fruit or cut pieces for passers-by to buy, 76% reported they do not sell jackfruit at all. With regards to jackfruit losses, 60% of the respondents reported losing an average of 15 fruits per season, 23% reported losing 50 fruits per season whereas 13% of the respondents reported not to lose any jackfruit in a season (Fig. 3).

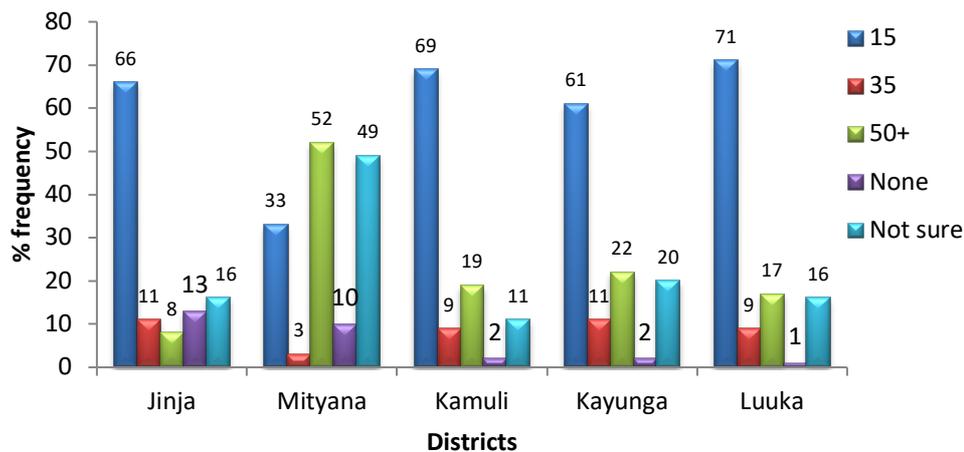


Figure3: Showing jackfruit loss estimates experienced by households in selected districts in Uganda



Results showed that very little income is obtained from jackfruit sells (about USD 0.57) per 10 kg jackfruit. Similarly, a report from Malaysia indicated that the money generated from selling jackfruit is very low and can only be used to meet daily household requirements [20]. Obtaining little income from jackfruit sales results in the underutilization of the fruits and therefore causing the post-harvest losses reported in the study area. High post-harvest losses of jackfruit could also be caused by the fact that jackfruit spoils easily if not consumed or preserved within a few days [21]. Similar to many Asian countries, 75% of jackfruit produced is lost due to poor harvest handling and lack of a ready market [22]. Lack of alternative ways of utilizing the crop, prompts farmers to feed it to animals, allows it to waste or cut down trees for wood fuel. To curb such losses, alternative ways of utilizing jackfruit (value addition) other than household consumption need to be developed. Saving losses in the harvested jackfruit may reduce strain on food supplies particularly when the harvests from other food sources are low due to unfavorable environmental conditions.

CONCLUSION

The present study showed that jackfruit production in Uganda is still largely subsistence in nature despite farmers growing a variety of jackfruit types. The unorganized jackfruit production coupled with small scale production may not suit industrial processing of jackfruit. The production of jackfruit needs to be improved for it to contribute significantly to household livelihoods of farmers. Quality parameters need to be given prime consideration when growing jackfruit. Jackfruit farmers and traders need to be educated about quality requirements in order to develop capacity for market orientated production and industrial scale jackfruit processing. Further studies should focus on detailed characterization of the different jackfruit varieties in Uganda and establishing their potential for industrial and commercial uses.

Acknowledgement

The authors acknowledge MAK-AFDB-HEST GOU project and Food Technology Incubation Center School of Food Technology Nutrition and Bio-Engineering, Makerere University, for the funds and facilities that made this work possible.



Table1: Showing the distribution of total farmland sizes for households in selected districts of Uganda

Farmland size (acres)	Percentage frequency of households by district					
	Jinja	Kamuli	Kayunga	Luuka	Mityana	Average
1	13	34	11	39	42	28
1-2	28	43	27	30	32	32
3-4	33	14	31	20	10	21
5-9	4	3	5	6	6	6
10-15	3	0	3	1	3	2
16	2	0	2	1	0	1
Not sure	17	6	21	3	7	10

Table 2: Showing the number of jackfruit trees owned by households in selected districts of Uganda

Number of tress owned	Percentage frequency of households by district					
	Jinja	Kamuli	Kayunga	Luuka	Mityana	Average
1	6	3	7	9	6	6
2-3	39	26	38	33	33	34
4-7	35	32	35	34	38	35
8-11	14	17	14	11	13	14
12-15	2	3	2	6	9	4
>16	4	19	4	7	1	7

Table 3: Showing estimated jackfruit yields reported by households in selected districts of Uganda

Yield (Fruits tree ⁻¹ season ⁻¹)	Percentage frequencies of households by district					Average
	Jinja	Kamuli	Kayunga	Luuka	Mityana	
< 20	18	12	19	5	1	11
30-40	9	7	9	10	23	12
50-60	30	31	30	46	26	33
70-90	15	9	13	13	20	14
100-120	9	17	9	13	13	12
> 120	17	22	16	11	5	14
Not sure	2	2	4	2	12	4
<i>Annual production (MT)</i>	<i>0.403</i>	<i>0.345</i>	<i>0.297</i>	<i>0.172</i>	<i>0.309</i>	<i>0.305</i>

Table 4: Showing estimated jackfruit fruiting time as reported by households in selected districts of Uganda

Fruiting time (Years)	Percentage frequencies of households by district					Average
	Jinja	Kamuli	Kayunga	Luuka	Mityana	
3	30	32	31	25	9	25
4	20	25	20	20	20	21
5	6	27	3	28	16	16
6	17	4	18	9	5	11
Not sure	27	12	28	18	50	27

Table 5: Showing jackfruit harvesting seasons as reported by households in selected districts of Uganda

Season	Percent frequencies of households by district					
	Jinja	Kamuli	Kayunga	Luuka	Mityana	Average
January-February	20	5	22	11	6	13
March-April	17	8	15	2	41	17
May-June	8	0	8	6	19	8
July-August	0	4	0	1	1	1
September-October	1	8	2	7	6	5
November-December	50	72	49	73	28	54
Not sure	4	3	4	0	1	2

Table 6: Showing jackfruits flake texture as reported by households in selected districts of Uganda

Pulp type	Percentage frequency of households in selected districts growing different jackfruit types											
	Jinja		Kamuli		Kayunga		Mityana		Luuka		Average	
	Hard	Soft	Hard	Soft	Hard	Soft	Hard	Soft	Hard	Soft	Hard	Soft
Yellow	51	49	26	74	53	47	30	70	18	82	36	64
Orange	61	39	53	47	64	36	66	34	73	27	63	37
White	74	26	63	37	75	25	74	26	67	33	71	29
lebbe	-	-	-	-	-	-	-	2	-	-	-	-

Table 7: Showing jackfruit consumption as reported by households in selected districts of Uganda

Consumer category	Percent frequencies of households by district					Average Frequency
	Luuka	Jinja	Kamuli	Mityana	Kayunga	
<10 years	9	8	4	14	9	9
Teenagers	21	5	13	7	6	10
Adults	1	0	0	2	0	1
All members	47	57	54	45	58	52
Neighbors	1	4	0	0	4	2
Others	22	27	28	32	24	27

REFERENCES

1. **APAARI.** Asia-Pacific Association of Agricultural Research institutions. Jackfruit improvement in the pacific region. Maliwan Masion, 39, Phra Atit Road: Asia-Pacific Association of Agricultural Research institutions, 2012.
2. **SCUC.** Southampton Centre for Underutilized Crops; Jackfruit field *Artocarpus heterophyllus* manual for extensional works and farmers. Southampton, UK: Southampton Centre for Underutilized Crops, 2006.
3. **Leo S** Encyclopedia of Life. *Artocarpus heterophyllus* jackfruit, p. 1. 2012.
4. **Devotha Gabriel Mushumbusi.** Production and characterization of jackfruit jam Msc. dissertation Sokoine University of Agriculture. Morogoro, Tanzania. 2015.
5. **Ndyomugenyi EKW, Okot M and D Muteetika** Production and availability of Jackfruit in Eastern and Central Regions of Uganda. Kampala: Mak Press, 2014.
6. **NPA.** National Planning Authority. Vision 2040. Kampala, Uganda: National Planning Authority, 2014.
7. **MAAIF.** Agricultural sector development strategy and investment plan, 2010.
8. **UBOS.** Uganda Bureau of Statistics. The Uganda Population and Housing Census, 2014.
9. **Isreal GD** Determination of Sample Size. Gainesvilles: University of Florida press, 2013.
10. **Ken L and P Robert** Jackfruit Hawaii Tropical fruit growers, collage of tropical agriculture and Human resources (CTAHR) University of Hawaii Fruits and Nut, 2011.
11. **UIA.** Uganda Investment Authority Report, 2012.
12. **Morton J.** Jackfruit. *Artocarpus heterophyllus* p. 58–64. In: Fruits of warm climates Miami FL 1987.**UNMA.** Uganda National Metrological Authority; Review of the Rainfall Performance in December, 2015 and the Outlook for January 2016.
13. **Azad AK** Studies on floral biology, pattern of fruit set and quality of fruits borne in different section of jackfruit plants. An M.Sc. (Ag.) Thesis, Dept. of Hort., BAU, Mymensingh, 1989.
14. **Kim DM, Smith NL and CY Lee** Effect of heat treatment on firmness of apples and apple slices. *J. Food Process. Pres.* 1994; 18: 1–8.

15. **Norhashila I and K Bisant** Consumer preference for jackfruit varieties in Malaysia *J. Agribus. Markt.* 2013; 6: 37- 51.
16. **Goldenberg S** Jackfruit heralded as a ‘miracle’ food crop. *The Guardian*, 23/04/2014.
17. **Ritthiruangde JP, Srikamnoy W and T Amatayakul** Optimization of jackfruit sauce formulation using response surface methodology. *Kasetsart; J. Nat. Sci.*, 2011; 45: 325-334.
18. **Haq N** Jackfruit *Artocarpus heterophyllus*. Southampton Centre for Underutilized Crops, University of Southampton. Southampton, UK.
19. **Hassan M, Ahmed M and M Miah** Agro-Economic Performance of Jackfruit-Pineapple Tract Agroforestry System in Madhupur *J. Agric. Rural Dev.* 2008; 6: 147-156.
20. **Benjamin ES** January 18. *World atlas*. Retrieved, from World Leaders In Jackfruit Production: <http://www.worldatlas.com/articles/world-leaders-in-jackfruit-production.html>. Accessed, April 20. 2017.
21. **Horsburgh C and J Noller** Exotic tropical fruits and vegetables, category marketing opportunities. Rural Industries Research and Development Corporation: Australia. 2005.