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Factors influencing post-harvest losses of apples among growers in Paktia, Afghanistan

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Abstract

Postharvest losses have been highlighted as one of the determinants in fresh crop production in most developing countries. Losses in agricultural sector in the province of Paktia are largely due to the perishable quality of the produce and ineffective management of post-harvest. Many post-harvest losses are direct result of factors such as harvesting, sorting, grading, packaging, storage, transportation and marketing. Thus, it is important to identify factors related to postharvest losses of apples among the growers in Paktia, Afghanistan. Survey of three districts, namely Gardiz, Ahamdaba, and Saidkaram was conducted with 279 apple growers that were selected using systematic random sampling. Data were collected using structured questionnaires via face to face interview. Data collected were then analyzed using descriptive analysis, chi-square analysis and factor analysis. The finding of descriptive analysis showed that among all the post-harvest activities based on the percentage ranking, all apple growers (100%) were involved in the marketing of apples in search of both direct or indirect channels to sell their produce to reduce the losses. This means in order to reduce apples losses, it is important to find a market for their products. From the Chi-square analysis results, there was a significant association between education level (P=0.046), farm size (P=0.000), farm experience (P=0.019), yield (P=0.000) and post-harvest losses. Moreover, the factor analysis results revealed seven factors that influenced post-harvest losses of apples namely harvesting, sorting, grading, packaging, storage, transportation and marketing. Therefore, establishing proper storages and packaging facilities will reduce apple grower's losses, and enable easier marketing of their produce in different season throughout the year. Furthermore, sorting and grading will raise the value of apple products for a better marketing. Meanwhile, road transport and transportation system also have a significant impact on distribution of apple products in the study area. Therefore, it can be concluded that road transport and transportation system should be improved in order to reduce the losses of apple production.

1. Introduction

Apples are an important fruit and ranked third after grapes and almonds in Afghanistan (Fitrat and Verma, 2015). Apple trees are climatically well-suited and cultivated most widely in Afghanistan (Safi and Bunnel, 2013). Although Afghanistan's commercial apple production began with varieties imported only during the past 25 years, Afghan apples are among the crunchiest, sweetest, and largest in the region. Grown mainly in central Afghanistan, these apples are distinctive for their size, deep red color, high Brix content (very sweet) and flavor. Afghan apples maintain their flavor and freshness up to seven months in cold storage (Safi and Bunnel, 2013). Premium prices are based on size, color and grading of the fruit (United State Agency for International Development, 2017). Apple production in Afghanistan is expected to rise by 5 to 10% per year, or from 59,850 tons to 175,000 tons in the last 8 marketing years (2010-2017), due to favorable conditions, increased extension and minimal pest and disease problems (Food and Agricultural Organization Statistical Databases, 2018). Furthermore, apple production is at the top of fruit production annually in Paktia province. A minimum of 4,710 tons of apples is sold into the market

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every year (Department of Agriculture, Irrigation and Livestock, 2019).

However, losses in the agricultural sector in Paktia province are high due to high perishable nature of the produce and poor post-harvest handling. This calls for efficient post-harvest management on part of the farmers backed by strong infrastructure facilities for proper storage (National Horticulture and Livestock Project, 2019). In Paktia province, fruits are harvested manually. Efforts have been made to use and expand new and appropriate methods as well as equipment for the harvesting of apple products to avoid or mitigate mechanical injury (Agriculture Development for Afghanistan Pre-development Training, 2012). However, growers are not used to new and modern methods of harvesting. Growers are also not harvesting apples at the exact maturity time, so they lose more produces at harvest time. Physiologically, apples must be harvested at the appropriate maturity level, as the storage life and eating consistency are associated with the harvest maturity level.

Generally, harvesting may take place over a wide spectrum of maturities. Proper use of containers during harvesting and field management helps reduce crop losses due to injury or concentration of heat in the field (Rolle, 2006). Apples are neither sorted nor graded, especially those intended for sale in traditional markets. Therefore, apple growers usually sell their produce in the province of Paktia without either sorting or grading. Currently, wholesale and retail traders conduct manual sorting and grading to a certain extent, particularly for sale to supermarkets. There are no electronic grading and sorting equipment available (National Horticulture and Livestock Project, 2019). Due to mechanical failure and degradation of high material created by physically damaged and low-quality goods, physical and quality damages are sustained. Therefore, grades and specifications for apples must be developed that are appropriate to all stakeholders in the apple industry (Wasala *et al.,* 2014).

Apple's appropriate packaging plays a crucial role in preserving product quality as it helps protect against physical and chemical damages and promoting competitiveness in the market as well as making it accessible in a convenient format (Yildirim *et al.,* 2018). The high cost of packaging combined with inadequate information on packaging and unavailability of appropriate packaging, have all been major hindrances to the export trade of Paktia apples. The idea of packing house establishments in the province of Paktia is completely absent. Overall, fruits are packed on the farm without any pretreatment. Some can also be delivered without packaging. In fact, a significant amount of the apples are lost by apple growers due to the lack of adequate packaging systems in Paktia (National Horticulture and Livestock Project, 2019). Moreover, indigent fruit storage contributes to increased losses because of cross-contamination within the crates.

For fresh apples, the optimal storage temperature is the lowest temperature that does not cause chilling damage. Mechanical cooling is typically used to store fresh fruits (Mashau *et al.,* 2012). Adequate cool storage technologies are needed in the province of Paktia to reduce the post-harvest losses of apples (National Horticulture and Livestock Project, 2019). In addition, increased distances between production areas and markets, induced by urbanization, necessitate the transport of produce from rural to urban centers in Paktia province over long distances. Imperfect transportation, refining and distribution facilities in Paktia Province leads to a high proportion of post-harvest losses, which is between 10 and 40% on average (Department of Agriculture, Irrigation and Livestock, 2019). Due to the lack of sophisticated means of transportation, careless handling of the packed produce during loading and unloading, corrugated roads leading to maximum vibration of the vehicles, lack of storage facility, tightly squeezed packages into the vehicles and lack of air circulation facility within vehicles leading to heat buildup inside the vehicles cause deterioration and finally loss of the produce (Rattanawong and Ongkunaruk, 2018).

Marketing is a very critical factor in apple sales. Apples cannot be conserved until they are stored (Yahaya and Mardiyya, 2019). Unlike the marketing of industrial products, the marketing of agricultural products is not well organized. This fundamental difference necessitates the creation of special systems, institutions and infrastructure in the marketing of agricultural products (National Horticulture and Livestock Project, 2019). The infrastructural facilities of the current wholesale and retail markets in Paktia are inadequate to boost the distribution and health of apple products (Department of Agriculture, Irrigation and Livestock, 2019). In consideration of the above discussion, the aim of this study is to determine latent factors influencing postharvest losses among apple growers in Paktia, Afghanistan.

2. Materials and methods

The research was conducted in Paktia province, Afghanistan. The three districts, namely Gardiz, Saidkaram and Ahmad Aba, were purposively selected as they represent the top three apple-producing districts

of Paktia province. A registered list of apple growers and villages was obtained from the Department of Agriculture, Irrigation and Livestock of Paktia province. Out of 52 villages, 26 villages and then from a total of 923 apple growers, 279 apple growers were selected based on systematic random sampling technique. Primary data were collected using structured questionnaires via face to face interviews. The target group intentionally consisted of apple growers. Information and data obtained from questionnaires were coded and analyzed using SPSS software. Descriptive analysis was used to describe the characteristic of the socio-demographic profile and post-harvest activities based on percentage and ranking. Chi-square analysis was used to explore the significant association between the socio-demographic profile and post-harvest losses. Factor analysis was also applied to identify factors that influence post-harvest losses of apples. A Likert scale of 1 to 5 (1 represents strongly disagree and 5 represents strongly agree) was used to measure the factors that influence the post-harvest losses. Data accuracy tests were conducted to determine whether the data obtained were fit to undergo factor analysis or otherwise through the Kaiser-Meiyer-Olkin indicator (KMO), Bartlett's Test of Sphericity and Varimax rotation method.

3. Results and discussion

3.1 Socio-economic characteristics of respondents

Socio-economic characteristics of the respondents participated in this study were shown in Table 1. The results indicated that all 279 respondents were males, representing 100% while there was no female in the study area. It shows that males contribute a whole proportion to apple production, and this could be attributed to certain cultural beliefs, such as the inability of a female to participate in cultivation. 43.0% of the respondents aged between 41-50, followed by 26.16% in the age range of 31-40 years old, and 24.73% were in the age between 51-60 years old. Meanwhile, only 5.02% aged below 30 years and the remaining 1.08% aged above 61 years old. This is an indication of a strong labor force in the agricultural sector in the study area. Also, as high as 34.1% of the respondents had no formal education, 10.08% of the respondents, however, received primary education, 27.6% of the respondents had attained secondary education, 21.5% attained high education and 6.1% attained bachelor's degree. Majority of the apple growers (47.3%) among the 132 respondents reported 6-10 years farming experience, 72 respondents (25.8%) reported between 11-15 years of farming experience, 58 respondents (20.8%) reported between 1-5 years of farming experience, 16 respondents (5.7%) reported between 16-20 years of experience whereas, the remaining 1 respondent (0.4%) had more than 21 years of farming experience. Apple growers among 224 respondents (80.3%) had between 1-4 jerub small size farms, 17.2% of the 48 respondents had between 5-8 jerub medium-size farms and 7 respondents (2.5%) had more than 9 jerub large farms. The yield production from small size farms is 1000-5000kg with 145 respondents (52.0%), 36.9% of the 103 respondents have between 5001-10000 kg yield from medium-size farms and the minority of apple growers with 31 respondents (11.1%) produced more than 10000kg yield from large farms.

Table 1. Socio-economic characteristics of the apple growers (n = 279)

Profile	Category	Frequency (n)	Percentage (%)
Age	20-30	14	5.0
	21-40	73	26.2
	41-50	120	43.0
	51-60	69	24.7
	61-Above	3	1.1
Gender	Male	279	100.0
	Female	0	0.0
Education level	Uneducated	95	34.1
	Primary Education	30	10.8
	Secondary Education	77	27.6
	High Education	60	21.5
	Bachelor	17	6.1
Experience	1-5	58	20.8
	6-10	132	47.3
	11-15	72	25.8
	16-20	16	5.7
	21-Above	1	0.4
Farm Size	1-4	224	80.3
	5-8	48	17.2
	9-Above	7	2.5
Yield	1000-5000	145	52.0
	5001-10000	103	36.9
	10001-Above	31	11.1

3.2 Identifying of post-harvest activities

Postharvest handling integrates activities from harvesting, sorting, grading, packaging, storage, transportation to marketing (Mahmud, 2017). Figure 1 shows the amount of post-harvest activities undertaken by apple growers who participated in this study. Apple harvests in Paktia are normally performed by hand-harvesting by apple growers themselves with family members or hired labors. As the result shows, 89% of the apple growers in Paktia are harvesting their own apples on their own or through labors. 86% of the apple growers in Paktia sort apples by their family or by hired labors. 88% of the apple growers in Paktia province grade their apples based on size, color, and shape. 91% of the apple growers pack their apples for the market. In Paktia province, many apple growers use plastic bags for

packing of apples and some apple growers use paper cartons as well. 87% of apple growers keep their apples in storage. About 84.5% of apple growers transport their apples to the market and finally, 100% of apple growers are involved in the marketing of apples. Apple growers sell their apples to local, regional traders as well as retailers and directly to the consumers. This indicates that apple growers use different channels for marketing (Department of Agriculture, Irrigation and Livestock, 2019).

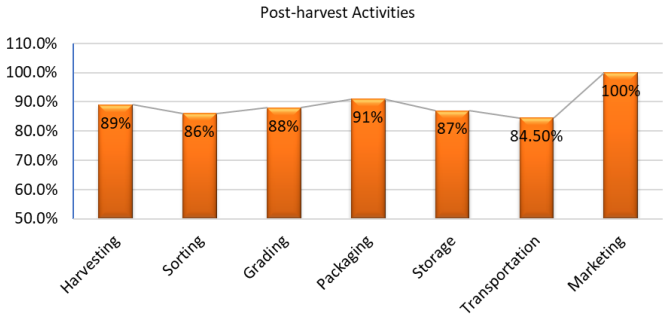

Figure 1. Post-harvest activities of apple growers in Paktia Province

3.3 Association between socio-economic characteristics and post-harvest losses of apples

The Chi-Square analysis was used to determine the significance of the selected variables in this research. As summarized in Table 2, four variables, namely, education level, farming experience, farm size, and yield were found to be significantly associated with the dependent variable. Age, on the other hand, showed a non-significant association with post-harvest losses of apples.

Table 2. Chi-square test between socio-demographic profiles and post-harvest losses of apples

Variable	X^2	d.f	Sig	Decision
Age	15.957[a]	12	0.193	Failed to reject H_0
Education level	21.280[a]	12	0.046*	Reject H_0
Farm size	112.868[a]	6	0.000**	Reject H_0
Farm Experience	24.211[a]	12	0.019*	Reject H_0
Yield	237.620[a]	6	0.000**	Reject H_0

**Significant at 1% level of significance, * Significant at 5% level of significance.

Education level (x^2=21.280, P=0.046) was significant to apple post-harvest losses at 0.05% level of significance. This implies that education level has had an effect on the adoption of appropriate agricultural technologies and skills to the farming population over the years. This result is consistent with the findings of Alemayehu *et al.* (2018) that education level has a significant relationship with post-harvest losses of fruits at (P=0.021) and concluded that formal education of the farmers may reduce post-harvest loss by 29%, compared to those farmers with informal education. Farm size (x^2=112.868, P=0.000) was significant to apple post-harvest losses at 0.01% level of significance. This implies that the larger the area put into cultivation, the higher the quantity harvested and chances of losses due to poor handling and lack of proper storage will be reduced. Adisa *et al.* (2015) also indicated in the study of Yam post-harvest losses in Nigeria that the larger the area put into cultivation the higher the quantity harvested and chances of losses due to poor handling and lack of proper storage are also higher.

Farm experience (x^2=24.211, P=0.019) was significant to apple post-harvest losses at 0.05% level of significance. This implies that farmers who have more experience have less post-harvest losses. This finding is in line with the study carried out by Alidu *et al.* (2016) that experience has a positive influence on the quantity of fruit loss. Moreover, according to chi-square results, yield also has a significant relationship with post-harvest losses (x^2=237.620, P=0.000*) at 0.01% significance level. Hence, an increase in harvested volumes increases damages because there are no adequate storage facilities available. This finding is also in line with Alidu *et al.* (2016) that quantity harvested was positively related to quantity loss (P=0.00). However, age status (x^2=15.957, P=0.193) was not significant to apple post-harvest losses. Busari *et al.* (2015) also indicated that there is no significant relationship between the age of the respondent and the quantity of fruit loss (P=0.898). This indicates that the age of apple growers does not influence on the apple post-harvest losses in the study areas. This may be presented to the fact of constraints and other production factors can affect post-harvest losses.

3.4 Factors influencing post-harvest losses

Factor analysis was used to determine factors that influence post-harvest losses of apples in this study. There were 31 items related to the factors affecting the post-harvest losses in the questionnaire and principal components analysis (PCA) was carried out to explore the validity of items. The Kaiser-Meyer-Olkin (KMO) measures the sampling adequacy and predicts if the data are likely to be well factored based on correlation and partial correlation ranging 0 to 1, which should be greater than 0.6 before factor analysis can be carried out (Hair *et al.,* 2009). Table 3 shows that the KMO value was 0.800, indicating inter-correlations between the factors, whereas Bartlett's test of Sphericity was significant (Chi-square = 4225.667, P<0.000). Therefore, the data are suitable for PCA (Tabachnick and Fidell, 2014).

As shown in Table 4, seven factors were identified from the 31 items as well as the factor loadings,

eigenvalue and variance. The factors loading of un-eliminated standardized items in this study were in the range of 0.504 to 0.851. An item is considered reliable if the standardized loading value is greater than 0.5 (Sawyer and Levine, 1966). Therefore, variables with small extraction (below 0.5) were eliminated. Factors with eigenvalues of more than 1 are considered significant whereas those with eigenvalues of less than 1 are considered insignificant and therefore, disregarded. The total variance explained in this study was 66.96%, which is mediocre. This factor solution goes with 33.31 % of information lost in the data reduction effort.

Table 3. Kaiser-Meyer-Olkin and Bartlett's Test of Sphericity

Kaiser-Meyer-Olkin Measure of Sampling Adequacy	0.800
Bartlett's Test of Sphericity	
Approx. Chi-Square	4225.667
Df	465.000
Sig.	0.000

Accordingly, harvesting was recognized as the first factor that influences the post-harvest losses of apple growers. This factor consisted of seven sub-variables and had a total variance of 17.598%. The Eigenvalue of this factor was 5.455. The result suggests that harvesting factor is the major considerations concerning post-harvest losses. Utilizing precise harvesting techniques and skilled workers during apple harvesting will reduce post-harvest losses. Fruit harvesting is a crucial stage where fruits are susceptible to bruise damage (Toivoen *et al.,* 2007). The spreading of the harvested fruits on the ground during harvesting may cause fruits to bear heavy spore load from the farm if harvested fruits lay on the field for more than four hours. Harvesting by handpicking can cause compression damage when gasp forces surrounding the fruits exceed a threshold for tissue failure (Li and Thomas, 2014). This highlights the need for adopting proper means of picking to minimize the bruise of fruits.

The second factor that influenced post-harvest losses was labeled as sorting, which had a total variance of 10.742% and eigenvalue (5.455) and comprised of four sub-variables. The result indicates that in order to reduce post-harvest losses, apple growers must practice fruit sorting in their field. Removing non-marketable and unsound (reject) fruits as well as material such as twigs, leaves and unattached stems and extraneous material like stones, rocks and rubbles, also offer the consumers the initial quality guarantee (Nissen *et al.,* 2016). Apple hand sorting involves visual inspection and elimination of undesirable items, and staff needs to be qualified to recognize fruit with incidences of deformities, blemishes or pests and diseases (Nissen *et al.,* 2016). Moreover, washing is a normal post-harvest procedure to avoid adhesions, soil, latex and pathogenic exterior structures from fruits and vegetables (Hassan, 2010).

The third factor was labeled as grading, which had a total variance of (9.091%) with (2.818) eigenvalue and included four sub-variables. Hence, apple grading by size, shape and color becomes very competitive and immediately sell out on the market and therefore avoid post-harvest losses. For successful and efficient marketing campaigns, grading is an essential aspect and should not be ignored and care should be taken when grading since untrained labor can damage the skin and allow for microbiological contamination (Saeed *et al.,* 2010). Grading systems provide farmers with many kinds of details, such as scale, color, shape, fault, and condition inside. Among these, size and color are the most important characteristics for the precise classification and/or sorting of citrus such as oranges, lemons and tangerines (Londhe *et al.,* 2013).

Packaging was labeled as the fourth factor, which has a total variance of (8.427%) with (2.612) eigenvalue and consisted of four sub-variables. Packaging is one of the essential factors to minimize post-harvest losses and making them desirable to consumers in the vegetables and fruit markets. Standard packaging offers protection against mechanical intervention, adverse physiological changes and pathological deterioration during transport, distribution and marketing (Yahaya and Mardiyya, 2019). Significant packaging components include an extensive variety of boxes such as wooden boxes, bamboo bins, jute sacks, earthen pots and corrugated fiberboard boxes. Kumar *et al.* (2016) reported similar findings with litchi fruit packaging where they assessed losses during long-distance transportation. Corrugated fiberboard box (CFB) packaging is more effective in reducing both mechanical and pathological losses for apples, as opposed to conventional wooden boxes (Lu *et al.,* 2010). Overall, the strategies to reducing losses of packed fruits could revolve around designing of new packaging systems.

The fifth factor was labeled as storage, which has a total variance of (7.723%) with (2.612) eigenvalue and involved four sub-variables. By storing products, time management can be improved, and marketing and consumption can be done leisurely. Storage increases the length of the production season and helps to ensure consistent seasonal fruit distribution. Meanwhile, storage is normally needed in the value chain to ensure uninterrupted supply of processor raw materials. (Znidarcic and Pozrl, 2006). The regulation of temperature is very critical in cold store. The lowest temperature is an optimal weather state for storage of fresh fruits and will not inflict chilling damage to the

Table 4. Factors influencing post-harvest losses of apple among growers in Paktia, Afghanistan

Factors/Items	Factor Loadings
Factor 1: Harvesting	
Rough handling at harvest can greatly affect the quality of apples	0.917
Use of skilled workers at harvesting can reduce post-harvest losses of apples	0.880
Poor harvest techniques increase post-harvest losses of apples	0.860
Harvesting of apples in non-proper time increase the post-harvest losses	0.842
Harvesting of apples by hand decrease post-harvest losses	0.809
Harvesting of apples by shaking trees increase post-harvest losses	0.763
Lack of harvesting equipment increase the post-harvest losses	0.840
Eigenvalue	5.455
Percentage of variance	17.598
Cumulative percentage of variance	17.598
Factor 2: Sorting	
Sorting practices decrease the post-harvest losses	0.895
Sorting to remove low quality will be useful for maintaining the quality of the apples and decrease the post-harvest losses	0.888
Non-availability of skilled labor in sorting increase apple post-harvest losses	0.871
Lack of sorting automatic machine increase the post-harvest losses	0.857
Eigenvalue	3.246
Percentage of variance	10.472
Cumulative percentage of variance	28.070
Factor 3: Grading	
Grading of apples based on size increase the market value and decrease the post-harvest losses	0.827
Grading of apples based on maturity index or color increase the market value and decrease the post-harvest losses	0.823
Grading of apples based on shape increase the market value and decrease the post-harvest losses	0.732
Non-available of grading machine increase the post-harvest losses of apples	0.719
Eigenvalue	2.818
Percentage of variance	9.091
Cumulative percentage of variance	37.161
Factor 4: Packaging	
Non-availability of packing materials increases the post-harvest losses of apples	0.834
Use of proper packaging prevents apples from physical damages	0.853
Use of wooden crates decrease the post-harvest losses during transportation	0.708
Non-available of packaging machine increase the apples post-harvest losses	0.703
Eigenvalue	2.612
Percentage of variance	8.427
Cumulative percentage of variance	45.588
Factor 5: Storage	
Non – availability of storage facility increases post-harvest losses of apples	0.783
Keeping harvested apples under the shaded area or away from direct sunlight decreases the post-harvest losses	0.822
Poor infrastructure of cold storage affects the quality of apples and increase the post-harvest losses	0.785
Limited space of warehouses increases the post-harvest losses	0.765
Eigenvalue	2.394
Percentage of variance	7.723
Cumulative percentage of variance	53.311
Factor 6: Transportation	
Using different kind vehicles for apples transferring increase the amount of losses of apples	0.813
Stored apples are transferring to market without quality damaged	0.825
Apples low-level packaging status during transportation affect the quality and increase the losses	0.728
Rough loading and unloading of apples can greatly increase physical damage to apples and increase the losses of apples	0.691
Without packaging, transferring of apples to market increase the losses	0.722
Eigenvalue	2.253
Percentage of variance	7.269
Cumulative percentage of variance	60.580
Factor 7: Marketing	
Unstable and low market price increase the losses of apples	0.830
Lack of product specification information increase the losses of apples	0.822
Lack of reliable market information increases the losses of apples	0.755
Eigenvalue	1.894
Percentage of variance	6.109
Cumulative percentage of variance	66.690

produce (Ramjan and Ansari, 2018). The sufficient storage capacity, cold storage availability, and facilities of warehousing are very important requirements to reduce wastage and maintain the quality of the food products (Negi and Anand, 2015).

Transportation was labeled as the sixth factor with an eigenvalue of 2.253. This factor explained a total variance of 7.269% and consisted of five sub-variables. Transportation and distribution of the fruits are the most important areas of postharvest loss (Ramjan and Ansari, 2018). Apple growers have to transfer their apples in different kind vehicles for decreasing losses. Time and distance are two factors that can be solved only with a modern and competent transportation system. Vehicle transport intends to carry fresh produce must be equipped by the refrigeration temperature system to sustain the quality of produce along the journeys (Kitinoja and Thompson, 2010). Normally, mechanical damage occurs due to rough handling or from vibration during transportation (Aba *et al.,* 2012). Therefore, quick and modern transportation of fruits is crucial for effective high-quality marketing and conservation.

The last factor that affects the losses was labeled as marketing, with a total variance of (6.109%), (1.894) eigenvalue, and included three sub-variables. It is critical that horticultural produce hit the market as early as possible and at a time when it is most desired by the consumer. A proper and effective marketing program is important to avoid fruit losses, as well as for a decent return from the same products (Ramjan and Ansari, 2018). A great and effective marketing strategy is important to prevent fruit and vegetable loses, and it is possible to get a decent return for the effort and resources invested at a time when the consumer wants the product the most (Yahaya and Mardiyya, 2019). Marketing cooperatives should be encouraged among producers of major commodities in important production areas. Such organizations are especially needed in developing countries because of the relatively small farm size (Kader, 2004).

Internal reliability tests were conducted to verify the internal accuracy of the measuring element and Cronbach's alpha of the seven-factor components. The alpha scored in this study ranged between 0.781 to 0.902, which exceeded the minimum requirement guideline by Nunnally (1978) of explanatory research which is above 0.5. Table 5 shows the internal reliability test of the latent factors. Harvesting (0.902) scores the highest reliability value which indicates good internal consistency among the items representing each factor. This was followed by sorting (0.871), transportation (0.817), packaging (0.795), storage (0.795), marketing (0.785) and grading (0.781).

Table 5. Internal Reliability Analysis

Factors	Numbers of items	Cronbach's alpha
Harvesting	7	0.902
Sorting	4	0.871
Grading	4	0.781
Packaging	4	0.795
Storage	4	0.795
Transportation	5	0.817
Marketing	3	0.785

4. Conclusion

The study has shown that post-harvest losses are very significant in apple production in Paktia province, Afghanistan. Findings of the study revealed that numerous apple growers were involved in all post-harvest activities based on various percentage ranking. All (100%) apple growers were engaged in marketing activity to sell their apples in direct or in indirect channels. Therefore, a great and effective marketing strategy is essential to prevent apple loses. Furthermore, there was a significant relationship between apple grower's education level, farm experience, farm size, yield and post-harvest losses. Hence, raising or improving the education level of apple growers, experience and storages will minimize the post-harvest losses. Seven factors were extracted to identify which factors influenced post-harvest losses of apples namely harvesting, sorting, grading, packaging, storage, transportation and marketing. Based on the findings, this study concludes that apple growers need storage facilities and suitable transport system to reduce the losses. Moreover, sorting, grading and packaging are the three other most significant and necessary factors that lead to higher market sales and standard packaging system avoids the apple losses encountered by apple growers. Findings of this study can assist the government with the right policy and agriculture development of apple production in Afghanistan that will benefit the stakeholders in the industry.

Conflict of interest

The authors declare no conflict of interest.

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