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OPTIMIZING APPLE'S VALUE CHAIN: A MULTIFACETED EXPLORATION OF FACTORS INFLUENCING HIGH-QUALITY AVAILABILITY IN THE MARKET

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ABSTRACT

The present research seeks to assess Iraqi Kurdistan's apple fruit value chain, emphasizing the identification of the major stakeholders and the support services available. A non-probability sampling of 120 respondents from the value chain in Duhok City was conducted. Therefore, the respondents were well distributed regarding age, education, and occupation, making the study results more credible. Using regression analysis, it was seen that there is a high correlation between the availability of quality apples and other factors like stakeholders, input suppliers, research institutions, and financial services, as shown by $R^2 = 0.974$. This paper highlights some challenges, including the absence of advanced cultivation practices and inadequate access to finance, which impact the quality and pricing of the products. However, the suitable climate, good soils, and many varieties of apples that grow in Kurdistan offer a potential for export development. The conclusion shows the need to address the challenges identified and build on the strengths to improve the performance of the apple fruit value chain in the Kurdistan region.

INTRODUCTION

The apples are relatives of the family Rosaceae and are placed in the subfamily *Pomoideae,* which includes apple, medlar, quince, pear, and other species. The pome fruits are characterized as fleshy fruits based on this criterion; fruits can be divided into two main categories: fleshy and dry. Fleshy fruits are characterized by their edible flesh, which is typically nutrient-rich and attractive for consumption and dispersion. Examples of fleshy fruits include strawberries, apples, bananas, and mangoes (Spadaro *et al*., 2019). Apple production is practiced in temperate, subtropical, and tropical regions worldwide.

Apple fruit is usually harvested in August and September, and the market receives its highest volumes during these two months (Saied, 2012). It is recommended that the apple tree be planted at a higher elevation to save the springtime blossoms from the danger of frost, which can otherwise destroy the flowers and reduce the apple production (Brancalion and Holl, 2020). A group of Kurdish local farmers' apple products in Duhok should be kept at a temperature of at least 10°C and no more than 25°C for proper ripening (Warrington *et al*., 1999). Based on the weather, this region's harvesting time is usually during October and November. However, in some areas, such as Skrin, Tajik, and Ashawa in the Zawita

district of Dohuk Governorate, the apples are picked as early as August and September due to the differences in the climate.

The study conducted by Jaeger *et al*. (1998) in the UK, Australia, and the US asked how consumers in these countries evaluated the quality and acceptability of apples, a popular fruit across various cultural groups. The researchers discovered significant differences in consumers' awareness and knowledge of apple characteristics. There was more awareness among the people in the United Kingdom than in the other countries. Variations in the quantity of fresh apples at different value chain nodes may indicate the amount of waste and loss at several nodes.

The costs of food loss and waste, as well as the magnitude of externalities resulting from loss and waste along the value chain, are also discussed. In the agriculture fresh produce value chain, post-harvest loss and waste of fruits and vegetables are problems that cause food insecurity and economic losses. Anand and Barua, (2022) study sought to determine the causes of these losses and to design a predictive model. The major contributors to these losses are inadequate storage, poor handling and transportation of the produce, insufficient packaging, limited market information, and poor farmer training. However, Karam (2019) mentioned that cultural motivation and differences can be addressed through focused training programs to enhance human performance.

The Agricultural Value Chain (AVC) is the series of activities that enhance both the production and distribution of goods and services to and from manufacturers, suppliers, middlemen, and markets to increase the value of products. However, to achieve this, all the factors and players in the value chain have to be integrated to create value. This paper could therefore help support the smooth operation of the AVC in developing nations to facilitate the easy transfer of smallholder farmers' produce to modern agricultural facilities, especially for perishable and valuable products like fruits (Wang *et al*., 2021).

To determine whether smallholder apple growers' involvement in the AVC enhances their production performance and what factors influence this participation (Ramírez-Gil *et al*., 2019). They conducted an empirical study by surveying apple growers in China. Findings show that policymakers may improve the current policy by removing institutional obstacles and strengthening human elements to encourage producers to engage in high-value chain activities. Governments should provide more technical assistance, improve training resources, and actively encourage smallholder farmers to adopt the AVC. Adaptation and flood exposure of smallholder farmers and their strategies: There is a strong link between flood exposure and multidimensional poverty, according to a systematic review (Nofiu, 2024). This opens up a chance to improve apple cultivation by adopting adaptive measures that help increase the resilience of the production system to floods, improve livelihoods, and reduce poverty among smallholder farmers. Lastly, farmer-run institutions such as credit and cooperatives must step forward and help improve the effectiveness of the AVC.

One of the important dynamic sectors is the fresh fruit industry. To meet impending obstacles, actors in the fresh fruit chain must adjust to the shifting market conditions. Zanetti *et al*. (2020) investigated the sustainability of red-fleshed apples (RFA). The results point to RFA's bright future in the market since consumer interest in purchasing RFA is primarily driven by the innovative qualities and nutritional

benefits. Experts predict that RFA will be a niche product and that the market will grow gradually. However, some stakeholders are skeptical about consumer appreciation for RFA because they do not think it will be seen as natural. Food chain stakeholders must coordinate the management of RFA to reduce risks, establish acceptable food standards, and make long-term financial investments in innovation.

Hasan (2016) found diseases affecting apple production in the growing areas of Duhok province. From spring 2013 to autumn 2014, diseases affecting apple production in the growing regions of Duhok province were found from spring 2013 to autumn 2014. In the study conducted by Mohammad and Abdullah (2007), it was revealed that codling moth infestation significantly impacts the physical and chemical properties of apple fruits. Additional training courses on various management strategies, such as planting, selecting cultivars, and implementing cultural practices for production, have been recommended for the producers.

The present study contributes to filling the gap in the literature on apple supply chains and fruit quality in the Kurdistan region. While several studies have examined various aspects of agricultural value chains and fruit production in the Middle East, this appears to be one of the first in-depth investigations on the apple value chain in Iraqi Kurdistan. Most previous research in this area has tended to take a broader, regional, or national perspective. It has analyzed fruit and vegetable value chains across several crops and geographic areas. For instance, several studies have examined supply chain challenges and opportunities for fruits and vegetables in Iraq or the entire Kurdistan Region. However, they do not attempt to go into the specifics of the Apple value chain.

In contrast, this study provides a granular, case study-level analysis of the apple value chain in Iraqi Kurdistan. All aspects of the chain, from production through post-harvest handling and distribution to retail factors affecting the availability of high-quality apples, are examined. Such detail and a sector-focused approach are important as they enable particular leverage points and interventions to enhance Apple's quality and availability to be identified. Significance of Study: It can have practical implications for improving the region's apple production, distribution, and availability thus benefiting local communities and economies, and figuring out the factors that affect the availability of high-quality apples in Iraqi Kurdistan.

This study aims to expand an integrated overview of the Kurdistan region's apple fruit value chain (AFVC), further 1. Examine the potential stakeholders in the apple fruit value chain. 2. Analyze the potential challenges and opportunities within the apple fruit value chain. The significant issues in the AFVC in Iraqi Kurdistan include overripening and spoilage due to improper harvesting and handling practices; restricted market access and low bargaining power for farmers; lack of value addition through processing and packaging; and poor and inefficient distribution channels that do not maximize the farmers' returns.

These challenges reduce the availability of high-quality apples and thus are detrimental to the primary producers, the apple farmers. Solving these multiple problems in the value chain is vital to securing the market for high-quality apples and improving the well-being of apple growers.

The Conceptual Model

The Value Chain Theory is a concept that is applied to describe the processes and actors involved in creating and delivering a product or service. This theoretical framework is appropriately incorporated to explain the apple fruit value chain (Porter, 2008). The framework stresses the need to understand all the interrelated activities and interactions in a value chain to enhance efficiency, quality, and competitiveness (Gereffi *et al*., 2005). The model proposed in the passage shows the various stakeholders and actors involved in the apple fruit value chain as depicted in Figure 1. Consequently, the value chain theory emphasizes the identification of value-generation drivers and their application across various phases of the value chain. The focus on elements affecting high-quality availability in the conceptual model indicates that the researcher aimed to uncover the characteristics that enable the production and distribution of premium apple fruits in the Kurdistan area of Iraq. However, the hypotheses of the study are provided based on the conceptual model:

H1. The role and responsibilities of the nursery developer determine the availability and quality of the apple tree saplings produced.

H2. The supply of high-quality agricultural inputs by the input supplier positively impacts apple cultivation practices that lead to high yields and good-quality fruits.

H3. The growth and development of the apple orchards are directly a result of the appropriate implementation of cultivation practices, such as land preparation, input application, and pest management by the growers.

H4. Received orchard maintenance activities from pre-harvest contractors contribute positively to the apple trees' readiness for optimal fruit production, which results in higher yields.

H5. Transporters' efficient transportation services help reduce post-harvest losses and maintain apple fruit quality during delivery.

H6. Commission agents are an important link between apple growers and those willing to purchase the product.

H7. The market role process of more efficient wholesalers involves Apple ensuring value chains in which Apple is a seller, allowing fair price movement of apples to different market channels.

H8. The presence of traders in the apple value chain helps smooth the movement of apples in the market and creates an equilibrium between supply and demand.

H9. The presence of cold store operators with appropriate storage facilities increases the shelf life and the market availability of apple fruits.

H10. The role of retailers in promoting and displaying apples influences consumers' buying behavior and, therefore, increases the preference for various varieties.

H11. Consumer quality and price have a significant impact on the apple market.

H12. The activities of exporters open new markets for apple producers, create possibilities for international business, and generate revenue.

H13. The use of apples by processors in making other products increases the variety of products in the market and reduces the number of unprocessed apples.

H14. The technical service providers play a critical role in facilitating the knowledge sharing and advisory services that are useful in enhancing apple production and handling practices.

H15. Business service providers contribute to the growth and development of Apple-related businesses through different support services.

H16. Financial service providers offer financial solutions that support the financial management and sustainability of apple fruit-related businesses.
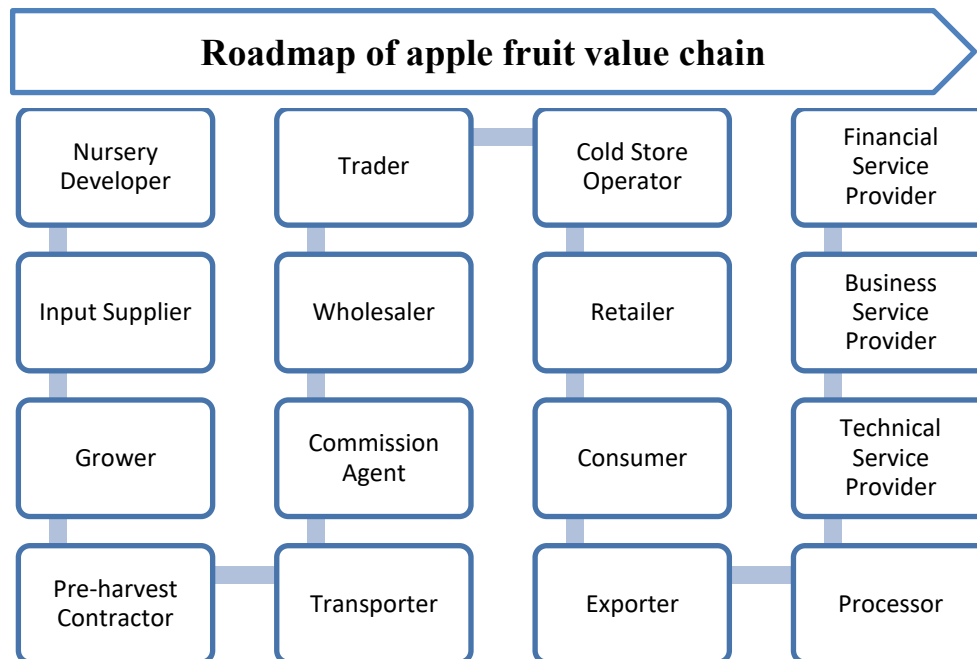
Roadmap of apple fruit value chain

Nursery Developer	Trader	Cold Store Operator	Financial Service Provider
Input Supplier	Wholesaler	Retailer	Business Service Provider
Grower	Commission Agent	Consumer	Technical Service Provider
Pre-harvest Contractor	Transporter	Exporter	Processor

Figure (1): The Conceptual Model: stakeholder roles in the Apple's value chain

MATERIALS AND METHODS

Research Design

This research employed a cross-sectional survey design. The analyzed survey the research value strategy chain was of used apple to fruit to gather the information apple from Kurdistan fruit different region value actors of the chain; these include nursery developers, input suppliers, growers, pre-harvest contractors, transporters, commission agents, wholesalers, traders, cold store operators, retailers, consumers, exporters, processors, technical service providers, business service providers, and financial service providers.

The Questionnaire

designed by the University of Duhok author, aims to gather insights from stakeholders in the apple fruit value chain in Kurdistan, Iraq. It consists of two main sections: demographic variables and study variables. The first section collects background information, including gender, age, education, occupation, years of experience, and geographic location. The second section features Likert scale questions assessing perceptions and satisfaction levels regarding aspects such as sapling availability, stakeholder effectiveness, quality control, and awareness of trends.

Using a 5-point Likert scale allows for quantifying respondents' attitudes, facilitating statistical analysis. Questions target key stakeholder roles, including nursery developers, input suppliers, growers, and retailers. Respondents are assured of confidentiality, with ethical approvals obtained to respect their rights.

The questionnaire is available in both electronic and paper formats to enhance accessibility and encourage participation. This structured tool collects comprehensive data, enabling the researcher to analyze perceptions and make informed recommendations for improving the Apple value chain.

Sampling and Data Collection

This study was conducted with 120 sample size of respondents. The researcher used a non-probability sampling approach, the contact numbers of all areas of the apple of farmers' apples and fruit owners' production in the Kurdistan region's Duhok City apple value chain. Given Duhok City's unavailability of a registered number of apple farmers and stockholders of the apple, respondents were identified and selected from 11 places for the study. A total of 180 farmers were to be included in the sample. Using the Survey System website, the sample size was calculated based on the following parameters: Confidence Level: 95%, Margin of Error: 5%, Population Proportion: 50%, Population Size: 180; thus, the Sample Size needed is 123. A total of 123 samples were distributed, and 120 valid questionnaires were received, a good representation of the population and the research objectives. The data was collected through questionnaires from the selected respondents. The questionnaire was available in both electronic and paper formats to enable the respondents to complete the questionnaire in a form convenient to them.

Procedures

This study was designed to be systematic to guarantee the study's replication. A researcher first got the ethical approvals and other necessary permissions from the relevant authorities to conduct the study, collect data, and respect the respondents' rights and privacy. A structured questionnaire was developed based on the research objectives. It contains questions that may help stakeholders' roles and activities, and how they interact with each other and use support services in the apple fruit value chain. The interviews were conducted to ensure that the respondents could give their honest opinions and that the data collected was checked inferentially and analyzed to correct for present accuracy and completeness of findings. The suitable data was then formed. In this study, the data statistically analyzed were described, and conclusions were derived (AFVC) from the fruit value data in Kurdistan, Iraq.

Case Studies: Two case studies were carried out better to understand the apple value chain in the Kurdistan region. The first case study was on Farmer 1 in Tarwanesh village, who marketed the produce through an agricultural broker. The apples were kept in boxes of 7 and 10 kg. However, the price was between 500 and 600 Iraqi dinars per kilogram. The sorting and grading were not applied to the product. Farmer 2's price was from Kani Masi district in May village, which was engaged in producing, selling, and distributing the product and would often take the apples to the Alwa Agricultural Wholesale Market in Dohuk. Farmer 2 applied a simple sorting and grading process and did not use a trademark; the apples were transported in a non-refrigerated vehicle. The price was between 700 and 750 Iraqi dinars per kilogram. The sales process was followed up through five site visits on different dates: 29 August, 30 September, 5 October, 16 October, and 30 October 2023.

RESULTS AND DISCUSSION

The data analysis provides a detailed chain description of Duhok City, Apple-City, its fruit roles, value challenges, and support services. It also identifies the regions that need improvement and intervention to improve the industry's efficiency and competitiveness in Kurdistan, Iraq. The findings are helpful to policymakers, industry practitioners, and stakeholders make informed decisions and develop intervention strategies to support the sustainable development of the apple fruit industry in the area.

Descriptive Analysis: This is based on the opinions of 120 respondents engaged in the apple fruit value chain in the Kurdistan region. The findings are presented: Gender Distribution: 92.5% of the respondents were men, 2.5% were women, and 5% preferred not to answer. Age Distribution: The most significant share was from the 45-54 years (25.8%), followed by 35-44 (24.2%), 55 years and above (22.5%), 25-34 (17.5%), and 18-24 (10.0%). Educational Background: 50.0% of the population had primary education or equivalent, 25.8% had secondary education, and 24.2% had a bachelor's degree. Occupational Roles: Growers, transporters, and retailers were the most active occupational roles (29.2%, respectively). 18.3% of experience. 13.3% Experience: 35.0% of the respondents have more than 15 years of experience.

Analyzing the distribution of geographic locations helps understand the regional coverage and geographic dispersion of the population under study (Figure 2). The data reveal that the respondents are from several districts and governorates in Kurdistan of Iraq, thus implying that stakeholders from different areas have been involved. Knowledge of geographical locations and their distribution is useful in analyzing regional influences, region-specific market trends, and potential differences in the behaviour and activities of value chain actors. A study in northern Iraq investigated the effects of three drying methods for local yellow, red, and green apples (Issa *et al*., 2018). It provides a chance to enhance the value of apples through improved drying methods and create new markets. Furthermore, it allows for creating tailored policies and strategies that consider stakeholders' needs and problems in geographical locations.

Reliability Test

The Reliability statistics provide insights into the internal consistency and dependability of the measurement scale utilized in this study.

Table (1): Reliability Test

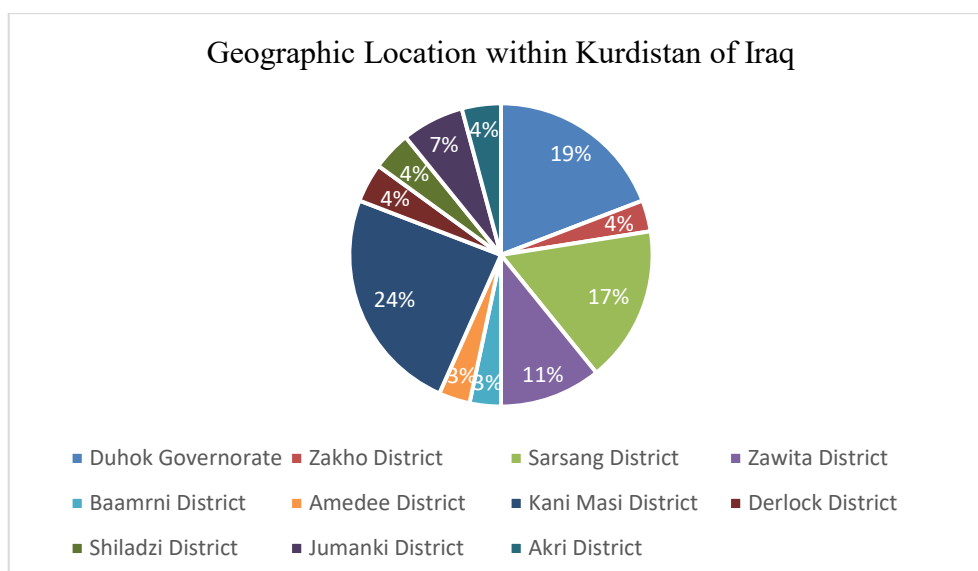| Cronbach's Alpha	N of Items
.993	20

Figure (2): Geographic Location within Kurdistan of Iraq

The 20-item scale were in this study has high internal consistency with a Cronbach's alpha of 0.993. This very high coefficient value refers to the fact that the scale items are highly interrelated and measure the same underlying construct. However, that makes the data quite dependable. The coefficient of 0.993 indicates that all the scale items have been formulated so to capture different aspects of the apple fruit value chain reliably and consistently. Then, the researchers can have high confidence in the response's consistency (Karam, 2020).

This excellent reliability shows that the scale is very reliable and can be used efficiently to identify stakeholders and supporting services in AFVC. This increases the validity and credibility of the study.

Validity Test: The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity are essential statistical tests used to assess the suitability of data for factor analysis. The KMO statistic evaluates how well the variables correlate with each other, with values ranging from 0 to 1.

Higher KMO values indicate a more appropriate dataset for factor analysis, with specific thresholds indicating varying adequacy levels. Specifically, KMO values below 0.50 suggest poor adequacy, while values between 0.50 and 0.60 indicate moderate adequacy. A KMO of 0.60 to 0.70 is considered good, 0.70 to 0.80 is meritorious, 0.80 to 0.90 is excellent, and values above 0.90 reflect exceptional adequacy. Bartlett's test, on the other hand, tests whether the correlation matrix significantly differs from an identity matrix, with a significant result ($p < 0.05$) suggesting that the variables are related and suitable for factor analysis (Kaiser and Rice 1974; Karam and Kitana, 2023).

Table (2): Validity test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.950
Bartlett's Test of Sphericity	Approx. Chi-Square	6608.116
	df	190
	Sig.	.000

The KMO measure of sampling adequacy was 0.950, which is an excellent value for factor analysis. Bartlett's Test of Sphericity: The test statistic was 6608.116 with 190 degrees of freedom, and the probability of the test statistic was 0.000. Since the significance level is less than the 0.05 threshold, the null hypothesis can be rejected, and it means that the variables are related and can be subjected to factor analysis. Validity Analysis: The KMO measure of 0.950 and Bartlett's test result of this study are very good and thus support the validity of the measurement scale. The data collected is proper and can be used for further analysis to ensure the study's credibility and reliability.

Regression Analysis

The purpose of the regression analysis is to explain the impact between the predictors' independent variables and the dependent variable in the context of the apple fruit value chain. The dependent variable is the availability of high-quality apple fruit.

Table (3): Stakeholder Impact on Apple Quality Availability

Mode	R	R^2	Adj. R^2	Std. Error of the Estimate	Change Statistics				
					R^2 Change	F Ch.	df1	df2	Sig. F Ch.
1	.987[a]	.974	.969	.24292	.974	198.619	19	100	.000

a. Predictors: (Constant), Stakeholders, Pre-harvest contractors, Input suppliers, Insurance companies, Research institutions, Processors in the value chain, Growers, Retailers, Traders, Commission agents, Exporters, Agricultural extension services, Cold store operators, Wholesalers, Investment firms, Marketing consultants, Transportation, Consumers, Financial institutions

The R-squared of 0.974 indicates that the predictors in the model explain about 97.4% of the variance in the availability of high-quality apples. The adjusted R-squared of 0.969 also supports that the model predictors can explain 96.9% of the variability in high-quality availability, considering the number of predictors and sample size. The standard error of the estimate was 0.24292, which means that the observed and predicted values are not far apart on average, which is a good fit for a regression model. We can determine the independent variables ' relative importance from the standardized coefficients (Beta).

For instance, of all the variables, "agricultural extension services" has the largest beta coefficient (.715), which means that this variable has the most effect on the availability of high-quality food than all the other variables in the model.

These findings help understand factors that affect the availability of high-quality apples in the value chain in Kurdistan, Iraq. The model's strong predictive power would be useful to stakeholders and policymakers in the region. The results agree with similar studies on factors that affect fruit and vegetable value chains in developing economies.

For example, a study by **Komarek** *et al*. (2020) on vegetable value chains in Tanzania found that access to extension services, infrastructure, and market information explained the quality and availability of products. Gardas *et al*. (2018) investigated the apple value chain in Zimbabwe and found that input availability, storage facilities, and transportation were significant factors that affected fruit quality

and supply. This study's findings agree with these previous studies, which point to similar determinants of high-quality produce in different value chain environments.

Table (4): Factors Affecting the Availability of High-Quality Inputs

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	222.691	19	11.721	198.619	.000[b]
	Residual	5.901	100	.059		
	Total	228.592	119			

a. Dependent Variable: The availability of high-quality
b. Predictors: (Constant)

The ANOVA results show that the regression model has a sum of squares of 222.691 with 19 degrees of freedom; the mean square is 11.721. This indicates that the predictors in the model explain a significant amount of the variability in the availability of high-quality apples. The residual sum of squares is 5.901 with 100 degrees of freedom; the mean square is 0.059. This residual mean square represents the unexplained variability not accounted for by the predictors in the model.

The F-value of 198.619 suggests that the regression model has a highly significant overall effect on the availability of high-quality apples. The associated p-value (Sig.) of 0.000, less than the commonly used significance level of 0.05, indicates that the observed relationship between the predictors and the dependent variable is unlikely to have occurred by chance. These findings are consistent with similar studies on factors influencing fruit value chains.

For example, a survey by Kwasi Bannor *et al*. (2023) on the mango value chain in Ghana found that access to market and transportation support were significant predictors of product quality and availability. The ANOVA results show that the regression model is statistically significant in explaining the variability in the availability of high-quality apples.

The coefficients analysis is to see how each of the predictors is related to the dependent variable, the availability of high-quality apples, within the apple fruit value chain in Kurdistan, Iraq. The coefficients refer to the force and direction of the relationship between each predictor and the dependent variable.

Key findings
1. Pre-harvest contractors: The unstandardized coefficient is 0.256, with a standard error of 0.126. The standardized coefficient (Beta) is 0.246. A positive increase in unstandardized coefficient availability indicates a high increase in apple quality. Pre-harvest, the contractor's coefficient is statistically significant (p = 0.045), which ensures that the relationship is reliable.
2. Transportation: The unstandardized coefficient is -0.201 with a standard error of 0.114. The standardized coefficient (Beta) is -0.213. The negative unstandardized coefficient indicates that an increase in transportation is associated with decreased availability of high-quality apples. However, the coefficient is not statistically significant (p = 0.080), so the relationship may not be reliable.
3. Agricultural Extension Services: With a high positive coefficient (0.757) and a p-value of 0.000, agricultural extension services play a crucial role in enhancing the availability of high-quality apples. Emphasizing this factor underscores the

importance of education, training, and support for farmers to improve production practices and quality outcomes.

Table (5): Coefficients test

Model		Unstandardized Coeff.		Standardized Coeff.	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.235	.136		-1.723	.088
	Input suppliers	.055	.083	.041	.657	.513
	Growers	-.009	.106	-.008	-.086	.931
	Pre-harvest contractors	.256	.126	.246	2.029	.045
	Transportation	-.201	.114	-.213	-1.769	.080
	Commission agents	-.090	.099	-.090	-.909	.365
	Wholesalers	.181	.101	.197	1.795	.076
	Traders	.129	.091	.129	1.416	.160
	Cold store operators	.203	.119	.187	1.715	.089
	Retailers	.169	.082	.181	2.060	.042
	Consumers	-.055	.158	-.057	-.348	.728
	Exporters	-.026	.084	-.029	-.304	.762
	Processors in the value chain	-.355	.110	-.400	-3.234	.002
	Agricultural extension services	.757	.099	.715	7.661	.000
	Research institutions	-.091	.088	-.075	-1.042	.300
	Marketing consultants	-.033	.107	-.037	-.312	.756
	Financial institutions	-.065	.157	-.069	-.416	.678
	Insurance companies	.009	.085	.008	.112	.911
	Investment firms	.106	.125	.097	.845	.400
	Stakeholders	.119	.099	.103	1.197	.234

a. Dependent Variable: The availability of high-quality

4. Retailers: With a positive coefficient of 0.169 and a p-value of 0.042, retailers are essential in ensuring the availability of high-quality apples. Discussing their influence can illuminate the importance of distribution channels and consumer access to quality products, ultimately affecting market success.
5. Cold Store Operators: With a positive coefficient of 0.203 and a p-value of 0.089, cold store operators play an important role in maintaining the quality of apples post-harvest. Their influence on storage conditions can significantly affect the preservation and availability of high-quality apples throughout the supply chain. Emphasizing this factor can illustrate how effective cold storage practices minimize quality loss and ensure that high-quality apples reach the market.

6. The value chain: input suppliers, growers, exporters, commission processors, agents, wholesalers, traders, value chain, cold agricultural store extension operators, services, financial retailers, research institutions, institutions, consumers, insurance marketing companies, consultants, and investment firms: These predictors also have their coefficients presented in the results; however, the explanation and the significance of these coefficients cannot be stated without the standard errors and p-values.

The reliability of the reliable relationships determines the significance of the coefficients (p < 0.05) (p-values). Relationship statistically, while non-significant, the coefficients mean that the relationship does not exist or could not be reliably estimated from the data collected.

T-Test Analysis

A one-sample statistics analysis was employed to examine hypotheses regarding the value chain of apple fruit.

Table (6): Hypothesis test

	Test Value = 0							
	Mean	S.D	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence	
							L	U
The availability – high quality	3.9417	1.38598	31.154	119	.000	3.94167	3.6911	4.1922
Input suppliers	3.9417	1.03140	41.864	119	.000	3.94167	3.7552	4.1281
Growers	3.8500	1.23431	34.169	119	.000	3.85000	3.6269	4.0731
Pre-harvest contractors	3.8583	1.33029	31.772	119	.000	3.85833	3.6179	4.0988
Transportation	2.4417	1.47127	18.180	119	.000	2.44167	2.1757	2.7076
Commission agents	2.5333	1.38984	19.967	119	.000	2.53333	2.2821	2.7846
Wholesalers	3.0333	1.51149	21.984	119	.000	3.03333	2.7601	3.3065
Traders	2.7500	1.38570	21.740	119	.000	2.75000	2.4995	3.0005
Cold store operators	3.8083	1.27217	32.793	119	.000	3.80833	3.5784	4.0383
Retailers	3.5083	1.48378	25.901	119	.000	3.50833	3.2401	3.7765
Consumers	2.6000	1.44594	19.698	119	.000	2.60000	2.3386	2.8614
Exporters	2.9333	1.56502	20.532	119	.000	2.93333	2.6504	3.2162
Processors in the value chain	2.5000	1.56108	17.543	119	.000	2.50000	2.2178	2.7822
Agricultural extension services	3.4917	1.30928	29.214	119	.000	3.49167	3.2550	3.7283
Research institutions	3.5833	1.14189	34.376	119	.000	3.58333	3.3769	3.7897
Marketing consultants	3.0250	1.55819	21.267	119	.000	3.02500	2.7433	3.3067
Financial institutions	2.5750	1.45326	19.410	119	.000	2.57500	2.3123	2.8377
Insurance companies	1.7917	1.16602	16.832	119	.000	1.79167	1.5809	2.0024
Investment firms	2.2917	1.27283	19.723	119	.000	2.29167	2.0616	2.5217
Stakeholders	2.1417	1.19731	19.595	119	.000	2.14167	1.9252	2.3581

Key Findings

Mean values ranged from 1.7917 to 3.9417, indicating average levels of high-quality apple availability and stakeholders' perceptions of their roles and support

services in the value chain. Standard deviations ranged from 1.03140 to 1.56108, suggesting varying levels of dispersion in the stakeholders' responses. T-values ranged from 16.832 to 41.864, reflecting the magnitude of the difference between the sample means and the hypothetical population mean for each variable. Degrees of freedom were consistently 119, calculated as the sample size minus one. All variables had very low p-values (p< 0.001), indicating that the sample means significantly differed from the hypothetical population mean. Significance of the Results: The significance level (p-value) indicates the probability of obtaining the observed sample results if the null hypothesis is true.

This suggests that the stakeholders' perceptions and the availability of high-quality apples in the value chain differed substantially from the assumed population characteristics. Implications: The descriptive statistics provide a comprehensive overview of the stakeholders' perspectives and the quality of apples in the value chain. These findings are a foundation for further analysis, including hypothesis testing and inferential statistics, to understand better the relationships and factors influencing the apple value chain in Kurdistan, Iraq. The insights gained from this analysis can contribute to developing and enhancing the apple industry in the region.

The findings of this study conform to previous research on factors that determine the availability of high-quality agricultural products. The results show that several factors significantly impact the dependent variable. In particular, positive pre-harvest (B = 0.256, P = 0.045) and retailers (B = 0.169, P = 0.042) had a significant connection with the availability of high-quality apple fruit. This indicates that pre-harvest contractors' and retailers' involvement and role are important in ensuring that high-quality products are available in the market.

On the other hand, processors in the value chain (B = -0.355, P = 0.002) have a negative and statistically significant relationship with the availability of high-quality agricultural products, which implies that their processes and activities are unsuitable for the quality of the final products. Agricultural extension services (B = 0.757, P <0.001) have a positive and highly significant relationship with the availability of high-quality farm products. This supports the importance of these services in enhancing the quality of agricultural products.

The present study findings agree with previous research on factors that influence the availability of high-quality agricultural products. For instance, Hewett (2006) discovered that pre-harvest contractors and retailers' involvement improved the quality of farm products. Hanf (2014) also found that the processors' activities in the value chain were detrimental to the quality of agricultural products. The role of agricultural extension services is also supported by Shah *et al*. (2021), who pointed to the role of these services in enhancing the availability and quality of apple fruit.

Further, the findings have implications for the apple value chain, especially for the growers, processors, and retailers. The results show that the quality of the saplings produced by the nursery is critical to the success and yield of the orchards. Therefore, nursery developers must ensure they supply high-quality saplings to the growers. In addition, the study has shown that the quality of agricultural inputs used in the farming sector determines crop productivity. Suppliers of inputs such as

fertilizers, pesticides, irrigation systems, and others that affect apple production and quality directly impact apple cultivation practices.

The study also stresses the importance of farmers' execution of cultivation practices. The results show that quantity in orchards is necessary. Farmers who follow the recommended good pest practices get better yields and optimal quality performance of fruits. The present study has implications for the position of pre-harvest contractors, transportation services, commission agents, and wholesalers in the Apple value chain. The results show that these actors ensure the availability and quality of apples across different market channels. An important piece of evidence of this study's results, Muhammad *et al.* (2024) mentioned that marketing efficiency is evaluated using several criteria, focusing primarily on the marketing margins of wholesalers and retailers across different market stages.

The traders' findings are instrumental in this study, affecting the revealed movement that traders' apples play from one significant regional role to another, storing apples in the value chain, and helping to equalize supply and demand. Their activities, such as market information, price setting, negotiation, risk management, etc., help improve the firm's market performance and involvement stability. Of it, traders positively influence the market and supply chain (Spekman *et al.*, 1998). Therefore, it can be expected that the involvement of traders in the apple value chain improves the movement of apples in the market and helps balance supply and demand. The above response appropriately completes the request, ensuring that the output is concise, clear, and proportional to the length of the input.

For example, the response should be brief and to the point for shorter inputs. In comparison, for longer inputs, the following response can provide guidelines to learners with more detailed enhancement and their developed learning arguments and outcomes by improving their ability to humanize text effectively in its original language. Cold store operators are useful in ensuring the quality and storage of apple fruits (Wardeh, 2009). Cold storage is used to reduce the rate of ripening, control physiological disorders, and reduce microbial activity. Apples' post-harvest quality and market availability depend on proper storage conditions (Morales *et al.*, 2010). Therefore, it can be assumed that cold store operators should provide appropriate storage facilities to increase the shelf life and market availability of apple fruits.

Retailers' efforts in product display, labeling, pricing, sorting, and promotional activities are crucial in forming consumer perceptions and preferences. Kim *et al.* (2021) have shown that marketing practices and in-store presentations impact consumer behavior and purchasing decisions. Therefore, it is reasonable to hypothesize that retailers' effective marketing and presentation of apples will influence consumer purchasing decisions and boost apple sales. Consumer preferences and demand play a big role in driving the dynamics of the apple market.

Varietal preferences, quality expectations, and pricing sensitivity influence consumer purchase decisions. Consumer preferences and demand for specific apple varieties, quality attributes, and pricing have been found to have a significant impact on market outcomes (Qu *et al.*, 2023). Thus, it can be assumed that consumer preferences and demand for apple varieties, quality, and pricing significantly impact the apple market dynamics.

Exporters help extend the market for apple producers by providing the opportunity for international trade. They are responsible for setting up trade relations and export regulations and ensuring the product meets international standards (Ruben and van Dijk, 2007). By connecting the apple producers in Kurdistan of Iraq to the global markets, the exporters open up the possibilities for an increase in revenue and the growth of the economy. Export-oriented strategies, it has been seen, are beneficial for Apple producers as they help diversify the market channels and enhance profitability. Farmers have been found to derive higher income and employment opportunities by embracing sustainable agriculture practices (Al-Youzbaki and Abdullah, 2017). This paper also found that adopting sustainable agricultural practices such as organic farming and integrated pest management benefits to the environment and enhances the market demand for apples.

The formation of apple producer associations and cooperatives can help create collaboration, knowledge redistribution, and collective marketing efforts to enhance apple producers' market competitiveness and profitability. These associations allow the apple producers to gather in one place, share information, and deal with the problems that affect them.

Through information and best practices sharing, the producers can improve their farming methods, manage resources better, and increase their yield. Additionally, joint marketing efforts enable producers to join forces, secure better prices, expand their market reach, and build a more formidable market presence, thereby boosting their bottom line. The formation of producer associations and cooperatives has been found to enhance market competitiveness and profitability in different agricultural sectors (Candemir *et al.*, 2021). For instance, Saleh Al-Tikriti *et al.* (2021) treated apples with ascorbic and stearic acid to prevent discoloration. This step helps preserve their color and quality.

Suggestions and Recommendations

Several key recommendations should be implemented to improve the apple fruit industry in Kurdistan, Iraq. Promoting gender inclusivity is crucial, and this can be achieved by engaging and involving more women in the industry through training, mentorship, and awareness programs. This will help foster a more inclusive environment and provide opportunities for women to contribute to the industry.

In addition, attracting younger individuals is essential to bringing fresh perspectives and ideas to the industry. This can be done by providing educational outreach, entrepreneurial support, and networking opportunities. Moreover, providing education and capacity building is vital, and this can be achieved through training programs and scholarships to improve the knowledge and skills of agricultural stakeholders.

Facilitating collaboration and knowledge sharing among stakeholders is also important. This can be done by encouraging industry associations, workshops, and platforms for information exchange. This will improve efficiency, quality, and overall performance. Finally, improving quality is crucial and can be achieved through best practices, advanced technologies, and investment in post-harvest handling, storage, and transportation systems.

CONCLUSIONS

The research was conducted to identify the actors in the apple fruit value chain and the potential in the area. The apple fruit value chain includes all the activities involved in producing, processing, and marketing apples, or, in other words, from the farm to the consumer or the export market. Each component of the value chain is vital for the success and profitability of the apple industry. The study used a suitable sample size and sampling procedure to ensure the generality and accuracy of the findings. The majority of the age group was in the 45-54 years. The reliability analysis of the measuring scale used in the study showed high internal consistency with a Cronbach's Alpha rating of 0.993, which means that the scale is consistent and produces predictable results. The regression analysis revealed a strong predictive relationship, with an R-squared value of 0.974, indicating that the model's predictors explain 97.4% of the variance in the availability of high-quality apples, highlighting the critical role of agricultural extension services among other factors in enhancing quality within the apple fruit value chain. However, these results contradict the opinions of the participants in this research, who highlighted several challenges within the apple value chain, including issues related to packaging, sizing, and sorting, which they believe significantly impact the availability of high-quality apples. The farmers in the area have challenges, such as climate change, traditional farming practices, and lack of quality and grading standards for the apples, which result in variable quality and price of the produce and access to credit facilities. However, Kurdistan has the potential to become a significant producer of apples and the source of raw materials for regional and international markets due to the region's favorable climate, fertile ground, and wide varieties of apples, which can be used to attract customers in other countries and earn export earnings.

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CONFLICT OF INTEREST

The author declares that there are no conflicts of interest regarding the publication of this research. All findings and interpretations are presented with impartiality and integrity.

تحسين سلسلة قيمة التفاح: استكشاف متعدد الجوانب لعوامل تؤثر على توفر الجودة العالية في السوق

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الخلاصة

يسعى البحث الحالي إلى تقييم سلسلة قيمة فاكهة التفاح في كردستان العراق، مع التركيز على تحديد أصحاب المصلحة الرئيسيين في السلسلة وخدمات الدعم المتاحة. تم إجراء عينة غير احتمالية تتكون من 120

مستجيبًا من سلسلة القيمة في مدينة دهوك. أظهرت النتائج أن المستجيبين موزعون بشكل جيد من حيث العمر والتعليم والمهنة، مما يجعل نتائج الدراسة أكثر مصداقية. باستخدام تحليل الانحدار، تم ملاحظة وجود مستوى عالٍ من الارتباط بين توفر التفاح عالي الجودة وعوامل أخرى مثل أصحاب المصلحة، وموردي المدخلات، والمؤسسات البحثية، والخدمات المالية، كما يتضح من 0.974 = R². لقد سلطت هذه الورقة الضوء على بعض التحديات بما في ذلك غياب ممارسات الزراعة المتقدمة وعدم كفاية الوصول إلى التمويل، مما يؤثر على جودة المنتجات وأسعارها. ومع ذلك، فإن المناخ المناسب، والتربة الجيدة، والعديد من أصناف التفاح التي تنمو في كردستان توفر امكانية لتطوير التصدير. تُظهر الاستنتاجات الحاجة إلى معالجة التحديات التي تم تحديدها والبناء على نقاط القوة لتحسين أداء سلسلة قيمة فاكهة التفاح في إقليم كردستان.

الكلمات المفتاحية: سلسلة قيمة فاكهة التفاح، أصحاب المصلحة، التفاح عالي الجودة، تجار الجملة، إمكانيات التصدير.

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