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RESEARCH PAPER

Benefits of Value Addition in Agricultural Produce on Land, Water and Labor Productivities under Arid Agriculture: Case of Dates in Oman

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فوائد إضافة القيمة في الإنتاج الزراعي على إنتاجية الأرض والمياه والعمالة في الزراعة الجافة: حالة التمور في عمان

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ABSTRACT. Oman is an arid country in the Middle East with water scarcity, and hence land and labor management issues hindering agricultural sustainability and food security. Value addition can minimize food wastes, which is crucial to achieve sustainability by improving the land, water and labor productiveness. This study aimed to evaluate and quantify the improvements in land, water and labor productivities through value addition in date cultivated under arid conditions in Oman. Five date factories and different value-added products of the most popular date varieties, Khalas and Fardh were selected for this study. The comparisons were made between productivity improvements of the value-added products and the raw products. Khalas dates value-added with nuts had the highest productivity ratio of 540%, the same for Fardh was 360% while the lowest were in Khalas value-added with flavors with 111% and in Fardh date paste with 129%. In Khalas, the best improvement by the value addition in average land, water and labor productivities from the base-values of 6.93 ton ha^{-1}, 0.57 kg m^{-3}, and 0.82 kg h^{-1} of the raw date were 25.05 ton ha^{-1}, 2.06 kg m^{-3}, and 2.95 kg h^{-1} in date with nuts, respectively; while in the Fardh, these were 18.82 ton h^{-1}, 1.55 kg m^{-3}, and 2.21 kg h^{-1} respectively of the same value-added product. The variations in productivity improvement of selected value-added products could be due to the availability and cost of the raw dates, cost of the value addition, market options and selling price. Value addition showed high potential for improving productivities under arid conditions and is worth making adoption efforts for achieving agricultural sustainability goals.

KEYWORDS: Arid region, postharvest losses, productivity, sustainability, value addition, dates.

الملخص:تعتبر عمان من الدول القاحلة في الشرق الأوسط التي تعاني من ندرة المياه، وبالتالي فإن المشاكل المتعلقة بإدارة الأراضي الزراعية والعمالة فيها تعيق استدامة الزراعة والأمن الغذائي. إن إضافة قيمة للمنتجات الزراعية يمكن أن تقلل من فاقد الغذاء، والذي من الممكن أن يكون مفتاحا لتحقيق الاستدامة من خلال تطوير إنتاجية الأرض والمياه والعمالة. هدفت هذه الدراسة إلى تقييم وتقدير التحسينات في إنتاجية الأرض والمياه والعمالة من خلال إضافة قيمة للتمور المزروعة في ظل الظروف الجافة في سلطنة عمان. تم اختيار خمسة مصانع للتمور للدراسة وتحديد مختلف المنتجات ذات القيمة المضافة من أصناف التمور الأكثر شهرة وهي الخلاص والفرض. تم إجراء المقارنات بين التحسينات الإنتاجية للمنتجات ذات القيمة المضافة والمنتجات الخام. كانت أعلى نسبة إنتاجية للتمور ذات القيمة المضافة هي التمور مع المكسرات لكلا الصنفين الخلاص والفرض بنسبة ٥٤٠٪ و ٣٦٠٪ على التوالي، بينما الأدنى من تمور الخلاص هي التمور بالنكهات بنسبة ١١١٪ ومعجون التمر من تمور الفرض بنسبة ١٢٩٪. في صنف الخلاص، أفضل تحسين في متوسط إنتاجية الأرض والمياه والعمالة من حيث القيم المضافة مقارنة بالقيم الأساسية من المواد الخام البالغة ٦٫٩٣ طن/هكتار، ٠٫٥٧ كجم/م^{٣} ، و ٠٫٨٢ كجم/ساعة كانت ٢٥٫٠٥ طن/هكتار، ٢٫٠٦ كجم/م^{٣} ، و ٢٫٩٥ كجم/ساعة في التمور مع المكسرات، بينما في الفرض كانت ١٨٫٨٢ طن/هكتار، ١٫٥٥ كجم/م^{٣} ، و ٢٫٢١ كجم/ساعة على التوالي من نفس المنتج ذي القيمة المضافة. يمكن أن ترجع الاختلافات في تحسين الإنتاجية للمنتجات ذات القيمة المضافة المختارة إلى توفر التمور الخام وتكلفتها، تكلفة القيم المضافة، خيارات السوق وسعر البيع. أظهرت القيم المضافة إمكانات عالية لتحسين الإنتاجية في ظل الظروف القاحلة وتستحق بذل الجهود لتطبيقها في تحقيق أهداف الاستدامة الزراعية.

الكلمات المفتاحية: المنطقة الجافة ، فاقد ما بعد الحصاد ، الإنتاجية ، الاستدامة ، القيمة المضافة ، التمور.

Introduction

Agricultural practices of most Middle Eastern countries have not been impressive in developing sustainability and achieving food security (Baumer, 1983; Brief, 2010; Mizyed 2013). Arid and semi-arid regions of the Middle East suffer from water scarcity and land mismanagement which causes an obstacle to achieve agricultural sustainability (Ahmed et al., 2001; Mizyed, 2013; Namara et al., 2007; Rahman, 1996). One of the important ways to improve sustainability and food security is to reduce postharvest losses (Kiaya, 2014). From another perspective, the impact of postharvest losses extends to the environment through attrition in the use of lands, water, energy and labors in producing non-consumable products (FAO, 2013). The importance of utilizing postharvest losses is to raise incomes for many farms, combat hunger and poverty,

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contribute to the global markets and raise the standard of living (Kiaya, 2014).

The decline in farm income due to intense competition in global markets has led to consideration for agricultural product development by incentivizing farmers to introduce value-added activities into their products to sustain in this competition (Evans, 2012). Value addition can contribute to offset the poor positioning of any agricultural product in the market, building up the quality and branding, improving the income and increasing employment (Choudhary et al., 2015). It is defined as an activity that agricultural producers may process to produce a new commodity outside the traditional frame to obtain higher returns (Evans, 2012).

Oman is one of the Middle East countries that encompasses an arid climate (Ampratwum and Dorvlo, 1999). Agriculture has represented the first source of life in Omani history (MAF, 2017) although climate change, water depletion, soil salinization and poor labor productivity pose weaknesses and threats in agricultural productivities (SARADS, 2016). Date palms and other fruits are considered as the permanent crops that cover huge cultivating lands with other vegetable crops (FAO, 2008b; MOI 2015). On the other hand, there is a high percentage of postharvest losses that may reach an average of 28% in fruits and 30% in vegetables (Al-Lawati et al., 2016). The Ministry of Agriculture, Fisheries and Water Resources has initiated several programs toward enhancing agricultural productivity per unit area, improving the quality and preserving the agricultural products especially the dates (MAF, 2011a). Therefore, this study was aimed to evaluate and quantify the improvements in land, water and labor productivities through value addition in date products cultivated under arid conditions in Oman.

Date palm is one of the main cultivated crops in Oman with around 50% of the total cultivated crops and 80% of other cultivated fruits and with over 250 varieties (Al-Yahyai and Khan, 2015; Ali, 2010). Oman is the eighth largest producer of dates in the world with about 377,000 tons annual productions in 2019 (Al-Yahyai and Khan, 2015; MAF, 2019b). Date palm trees cover about 35,000 hectares of agricultural land in Oman, which contains more than eight million trees (Ali, 2010; Ishag, 2017). The top ten date varieties in Oman are shown in Table 1 (MAF, 2019a).

The land productivity of dates in Oman has shown different statistics by deferent sources. Al-Mulla and Al-Gheilani (2017) reported that average date yield is about 6075 kg, on average, per one hectare with an average income of 1065 OMR. The Ministry of Agricultural, Fisheries and Water Resources indicated that about 6.930 tons of date are produced per one hectare (MAF, 2019b). FAOSTAT (2019) estimated the statistics of date production and land productivity from 2015-2019 as shown in Table 2. This contradiction may be due to over 200 varieties having different yields, use of different tree spacing and region specific or cultivar specific planting arrangements. The uses of local dates, with a determination of their quantity and the proportion of their use, are indicated in Table 3 (MAF, 2019b).

Table 1. The top ten cultivated date varieties in Oman (MAF 2019a)

Date variety	Date production (ton)	Percentage of production (%)
Naghal	37,167	9.86
Khisab	35,504	9.42
Khalas	35,225	9.35
Al-Mabsili	32,708	8.68
Umm Al-Salla	30,151	8.00
Fardh	24,847	6.59
Khunizi	21,152	5.61
Shahal	19,850	5.27
Abu Da'an	11,116	2.95
Madluki	10,877	2.89

The date palm is considered as the most water-consuming crops, with total consumption of 558 Mm^3 (Al-Mulla and Al-Gheilani, 2017) using scarce water resources (Al-Yahyai, 2006). Al-Mulla and Al-Gheilani (2017) estimated the water consumption for date palm of about 38% of the total water used for irrigation in Oman and around 31% of groundwater that facing about 316 Mm^3 of water deficit annually. Table 4 shows the comparison of the percentage water use with the percentage of cultivated area for open field crops. The percentage of cultivated area and the percentage water use for date palm are 30.2% and 42.5%, respectively (MAF, 2011b). Therefore, improving the water use efficiency in irrigation and water productivity has become a vital matter (Hamdy et al., 2003).

The Ministry of Agricultural, Fisheries and Water Resources indicated that the annual water productivity of 6.930 tons of dates is about 2045 m^3 in one hectare (MAF, 2011b). FAO (2008a) reported the annual water productivity of date palm in the range 0.150-0.210 kg m^{-3} as shown in Table 5. Al-Mulla and Al-Gheilani (2017) reported that water productivity can be increased from 0.570 to 1.560 kg m^{-3} with an average date price of 0.400 OMR, and in economic basis, the water productivity is increased from 0.230 to 0.630 OMR m^{-3}. Moreover, other studies indicated that the date water productivity is about 1 kg m^{-3} (Al Wahaibi, 2018), 0.350 kg m^{-3} (Joseph 2017), 0.440 kg m^{-3} (Chapagain and Hoekstra, 2008) and 0.489 kg m^{-3} (MAF, 2011b) and these discrepancies in productivity values may be due to the climate change, date palm characteristics, type of soil and other factors.

The average number of labors used for different cultivated crops, their annual labour hours and annual cost are shown in Table 6. Dates are categorized as trees

Table 2. The production and land productivity statistics of date in Oman from 2015-2019 (FAOSTAT 2019).

	2015	2016	2017	2018	2019
Production (tons)	344690	355332	360917	368808	372572
Area harvested (ha)	24120	24120	24617	25125	25382
Land productivity (tons ha^{-1})	14.291	14.731	14.661	14.679	14.679
Per palm yield (kg $palm^{-1}$)	114.3	117.2	117.3	117.4	117.4

and average labour productivity can be estimated as 0.815 kg h^{-1} (MAF, 2011b) of 6930 kg ha^{-1} of the average date production.

Table 3. The quantity and percentage of date consumption in Oman (MAF 2019b).

Consumption distribution	Quantity (ton)	Percentage (%) share
Total production	377,000	100.00
Human consumption	198,000	52.52
Export	21,000	5.57
Processed dates	15,000	3.98
Available for industry	144,000	38.20

Table 4. Comparison of the percentage water use with the percentage of cultivated area for open field crops (MAF 2011b).

Crop	Cultivated area (%)	Water use (%)
Field crops	3.9	1.2
Vegetable crops	17.6	13.3
Fruit crops	40.9	53.7
Fodder crops	37.6	31.8

Materials and Methods

Selected dates factories involved in value addition located in different areas of Oman were visited and the completed questionnaires were collected from the stakeholders. The questionnaire contained two main sections, firstly questions about raw dates, and secondly questions about the value-added products of different date varieties.

Subsequently, five-date factories were selected for the study and the two most popular date varieties were considered for studying the value-added process. Two varieties mostly used for value addition by the factories were Khalas and Fardh. Moreover, the selected value-added products of different varieties were compared among the five factories to determine the range of the data variation. The details of the selected factories, date varieties and type of value-added products are shown in Table 7 (Al Hinai and Jayasuriya, 2021).

The land, water and labour productivities of the selected value-added products are calculated using the following equations (Cai et al., 2011; Hamdy et al., 2003; Karamanos et al., 2005) to compare it with the productivities of raw date:

$$\text{Land productivity} = \frac{\text{Agricultural benefit}}{\text{Land use}} \qquad (1)$$

Where, Agricultural benefit (crop production) (kg), land use (m^2).

Table 5. Annual water productivities of date palm and associated crops for different Middle East countries (FAO 2008a).

Countries	Annual gross water use (m^3 $palm^{-1}$)	Annual gross water use (m^3 ha^{-1})	Productivity (kg m^{-3} of water)
Egypt	86-124	10,280-14,880	2.28-3.31
Saudi Arabia	150-350	18,180-42-600	0.15-0.37
Iran	102164	12,270-19,720	0.21-0.34
Algeria	43-210	5,200-25,400	0.14-0.67
Oman	183-240	21,950-29,320	0.15-0.21
Libya	183-240	7,200-29,700	0.15-0.21
Tunisia	100	12,000	0.28
Morocco	105-200	12,600-23,900	0.21-0.40
United Arab Emirate	130-173	15,500-20,740	0.20-0.26
Yemen	130-173	15,500-20,740	0.13-0.16

Table 6. Average number of labors used, their annual labor hours and annual cost (MAF 2011b).

	Number of labour	Number of months	Average monthly wage (OMR)	Average annual labour hour (h)	Average annual labour cost (OMR)
Cultivation of field crops (ha)	3.89	7.87	70	8,963	2,143
Fodder cultivation (ha)	4.02	9.19	70	9,262	2,586
Open cultivation of vegetables (ha)	5.52	7.59	76	12,718	3,184
The trees (ha)	3.69	9.70	70	8,502	2,506
Single greenhouse cultivation	3.36	8.79	75	7,741	2,215
Double greenhouse cultivation	3.38	7.19	75	7,788	1,823

Table 7. Data collection of date factories, date varieties and value-added products (Al Hinai and Jayasuriya 2021).

Factory code (Location)	Date variety	Type of value addition
A (Samail)	Khalas	Cleaned dates with packaging
		Date with nuts
	Fardh	Cleaned dates with packaging
		Date with nuts
		Syrup
B (Bahla)	Khalas	Cleaned dates with packaging
		Date with nuts
		Syrup
		Paste
		Date Halwa
	Fardh	Cleaned dates with packaging
		Date with nuts
		Syrup
		Paste
		Date Halwa
C (Nizwa)	Khalas	Cleaned dates with packaging
		Date with nuts
		Dates with saffron, Hill and cinnamon
	Fardh	Cleaned dates with packaging
		Date with nuts
		Syrup
D (Barka)	Khalas	Cleaned dates with packaging
		Date with nuts
		Paste
	Fardh	Cleaned dates with packaging
		Date with nuts
E (Ibri)	Khalas	Cleaned dates with packaging
		Date with nuts
		Paste
		Halwa
	Fardh	Cleaned dates with packaging
		Date with nuts

$$\text{Water productivity} = \frac{\text{Agricultural benefit}}{\text{Water use}} \qquad (2)$$

Where, Agricultural benefit (crop production) (kg), water use (m^3).

Table 8. The summarized results of the two most used date varieties from the five factories in Oman (Al Hinai and Jayasuriya 2021).

Value-added product	Cost for the raw product (OMR ton^{-1})	Cost of Value-Added product (OMR ton^{-1})	The selling price of value-added product (OMR ton^{-1})	Net income (OMR ton^{-1})	Productivity Ratio (Net profit basis) (%)
Khalas Dates					
Cleaned date with packaging	400-500	100	600- 1,500	100-900	125-280
Date with nuts	500-800	400-626	1,500 – 3,200	500-2,200	183-540
Syrup	2,400	100	5,000	2,500	204
Paste	500-600	100-300	850-1,200	150-400	130-180
Date halwa	600	850-900	2,000-3,000	500-1,550	183-358
Date with different flavour; saffron, Hill, and cinnamon	800	615.4	1,500	85	111
Fardh Dates					
Cleaned date with packaging	300-600	100	600-1,500	225-900	138-280
Date with nuts	400-800	350-872	1,500-3,200	400-834	183-360
Syrup	4,200-4,800	100	5,000-7,500	400-2,600	109-180
Paste	700	100	1,000	200	129
Date halwa	700	872	2,000	428	161

$$\text{Labour productivity} = \frac{\text{Agricultural benefit}}{\text{Average annual labour hours}} \quad (3)$$

Where, agricultural benefit (crop production) (kg), annual labour hour (h). The benefit of value-added products is calculated using the following equation (Lewbel 2003):

Net income=selling price (value added)-purchase price (raw)-value addition cost (4)

Where, selling price, purchase price and value-added product (OMR ton^{-1}). The net profit based productivity ratio is calculated using the following equation (Farooq et al., 2001):

$$\text{Productivity Ratio} = \frac{\text{Purchase price of raw product} + \text{Net income}}{\text{Purchase price of raw product}} \quad (5)$$

The key data of land, water and labor productivities of the raw date products estimated from the literature reviews and they are as follows: date palm planting density 125 palms h^{-1} (Kotagama et al. 2014), on average, raw date price 0.400 OMR (Al-Mulla and Al-Gheilani 2017) land productivity 6.930 ton ha^{-1} (MAF 2011b), water productivity 0.570 kg m^{-3} and the water productivity based on economics 0.630 OMR m^{-3}, and average labor productivity 0.815 kg h^{-1} (MAF 2011b).

Table 9. The improvements in land, water and labor productivities due to value addition in dates.

Value-added product	Land Productivity improvement from 6.930 (ton ha^{-1})	Water Productivity improvement from 0.570 (kg m^{-3})	Labour Productivity improvement from 0.815 (kg h^{-1})
Khalas Dates			
Cleaned date with packaging	8.660 – 19.400	0.713 - 1.596	1.019 - 2.282
Date with nuts	12.680 – 37.420	1.043 – 3.078	1.491 – 4.401
Syrup	14.140	1.163	1.663
Paste	9.010 – 12.470	0.741 – 1.026	1.060 – 1.467
Date halwa	12.680 – 24.810	1.043 – 2.041	1.491 – 2.918
Date with different flavour; saffron, Hill, and cinnamon	7.690	0.633	0.905
Fardh Dates			
Cleaned date with packaging	9.560 – 19.410	0.787 - 1.596	1.125 – 2.282
Date with nuts	12.680 – 24.950	1.043 – 2.052	1.491 – 2.934
Syrup	7.550 – 12.470	0.621 – 1.026	0.888 – 1.467
Paste	8.940	0.735	1.051
Date halwa	11.160	0.918	1.312

Results and Discussion

The productivity results of the two selected date varieties from the five-date factories in Oman are summarized in Table 8 (Al Hinai and Jayasuriya, 2021) that shows the selected value-added product, cost of the raw date, cost of the value-added product, net income of the value-added product, and the productivity ratio through the value-added product.

The results of the value-added productivity ratio of the two date varieties in Table 9 were used to determine the improvements in land, water and labour productivities from the base values 6.930 ton ha^{-1} (MAF, 2011b), 0.570 kg m^{-3} (Al-Mulla and Al-Gheilani, 2017) and 0.815 kg h^{-1} (MAF, 2011b) respectively as shown in Table 9.

The results showed that Khalas, Fardh varieties are the most widely used by the selected five factories for value addition process. This is due to the availability, relatively higher production, variation in sugar content (Fardh has less sugar content than Khalas), low purchase cost, more economic value, and the good texture for forming and filling with different nuts and flavors during the value addition process.

In Khalas variety., date with nuts has the highest productivity ratio that may reach up to 540% because there is a considerable difference between the selling price and the production cost (raw date cost and value-added cost) for about 3,000 OMR/ton that makes the net income higher as shown in Table 8. The second highest productivity ratio was date halwa 358%, followed by a cleaned date with packaging 280%, date syrup 204%, date paste 180% and finally, date with saffron and other flavours 111%.

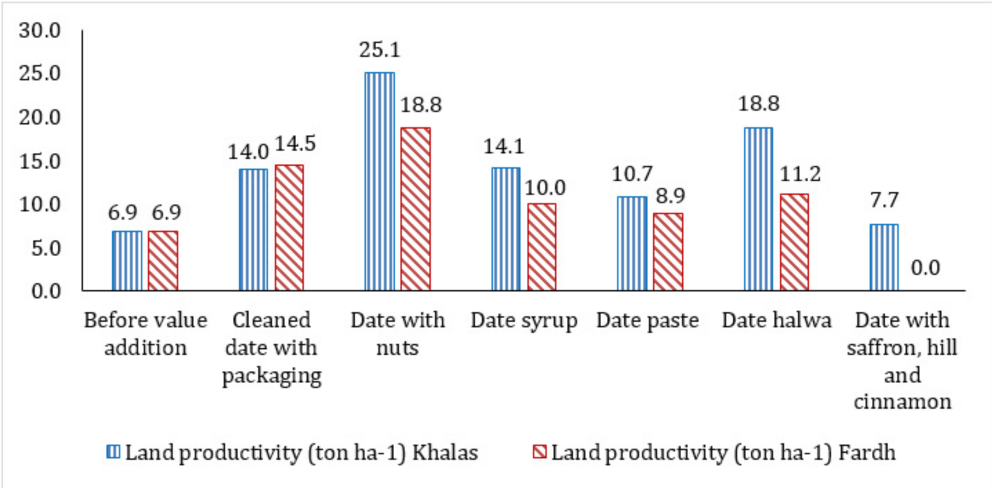
In Fardh variety., consistent with Khalas variety., date with nuts has the highest productivity ratio that may reach up to 360% but it is less than the productivity ratio of Khalas variety. due to the high cost of the value-added operations as shown in Table 8. Cleaned date with packaging is the second-highest productivity ratio 280%, followed by date syrup 180%, date halwa 161% and finally, date past 129%. Factories are not making value-added products of Fardh dates with saffron and other flavors.

Date with nuts value-added products of the two date varieties got the highest productivity improvement compared to the other value-added products because of the highest productivity ratio. Table 9 shows that the date with nuts in Khalas and Fardh has about 37.42 and 24.95 ton ha^{-1} maximum value in land productivity improvement from the 6.93 ton ha-1 of the raw date products respectively. Besides, the improvement of water productivity in date with nuts is up to 3.078 kg m^{-3} in Khalas and 2.052 kg m^{-3} in Fardh compared to the water productivity of the raw date 0.57 kg m^{-3}. Moreover, the maximum value of the improvement in labor productivity of date with nuts is about 4.401 kg h^{-1} in Khalas and 2.934 kg h^{-1} in Fardh compared with the 0.815 kg h^{-1} labor productivity of the raw date. The average improvement productivities of the value-added products of the two varieties comparison prior value addition dates are summarized in Figure 1.

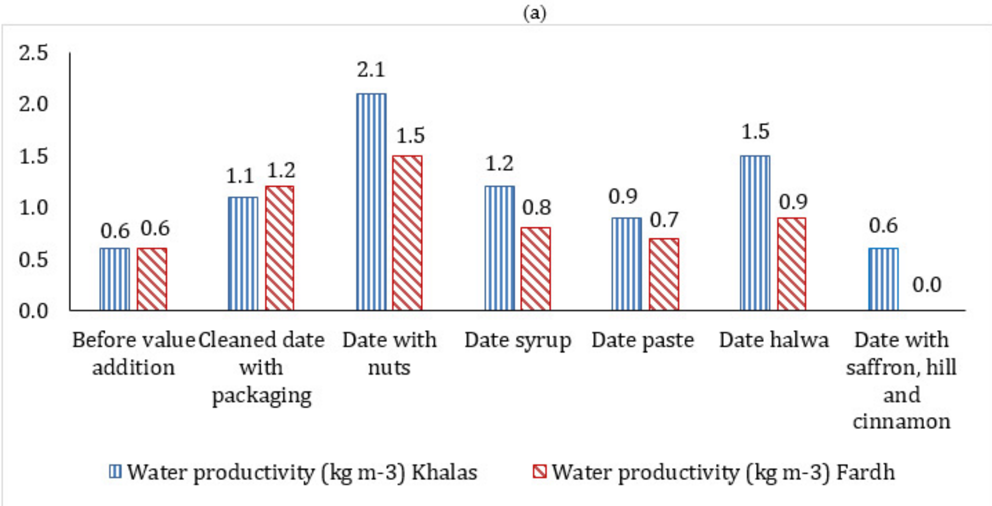
In general, the variation of the land, water and labour productivities of the selected value-added products of two date varieties (Khalas and Fardh) are mainly due to the cost of the raw dates (before value addition), cost of the value-added process and selling price of the value-added products. The cost of the raw date is varied among the five selected factories in different regions of Oman. In addition, differences in dates selling prices can be explained by the retail sale from suppliers and the quality of dates. The cost of the value-added process was also varied among the factories and this was because of the types of machines used (machine type and capacity), labour cost and other manufacturing processes. These two main costs of production (raw and value-added processing) lead to variation in the selling prices of the different value-added products at different factories to achieve the desired net income.

Conclusion

Oman is one of the arid countries in the Middle East, its agriculture sector is suffering from scarcity of arable lands, water and labour resources which has not been supportive in achieving sustainability and food security. Value addition can be one of the best options to achieve sustainability goals, minimize food wastes and improve product quality and exports by improving the land, water and labor productivities. The government of Oman aims to increase agricultural production, improve the quality and preserving the agricultural products especially the dates, which is most grown crop in Oman. Therefore, different value-added products from five different date factories in Oman were selected for the study with considering two date varieties, Khalas and Fardh. Results revealed that the improvement of land, water and labor productivities can be achieved through value addition. Among the most common value-added date products, date with nuts achieved the highest productivity improvement (540%) especially in Khalas variety followed by date halwa, cleaned date with packaging, syrup, paste, and date with saffron and different flavours. Moreover, in Fardh variety., date with nuts also obtained the highest productivity improvement (360%) followed by a cleaned date with packaging, syrup, date halwa and paste. The improvements in land, water and labor productivities were compared from the base values obtained 6.930 ton ha^{-1}, 0.570 kg m^{-3} and 0.815 kg h^{-1} respectively and similar trend were observed as the productivity ratios developed. The variations in the productivity ratio of the selected value-added products are mainly due to the cost of the raw date, cost of the value-added process and selling price of the value-added products that may take into consideration for the future improvement in productivity.



(a)



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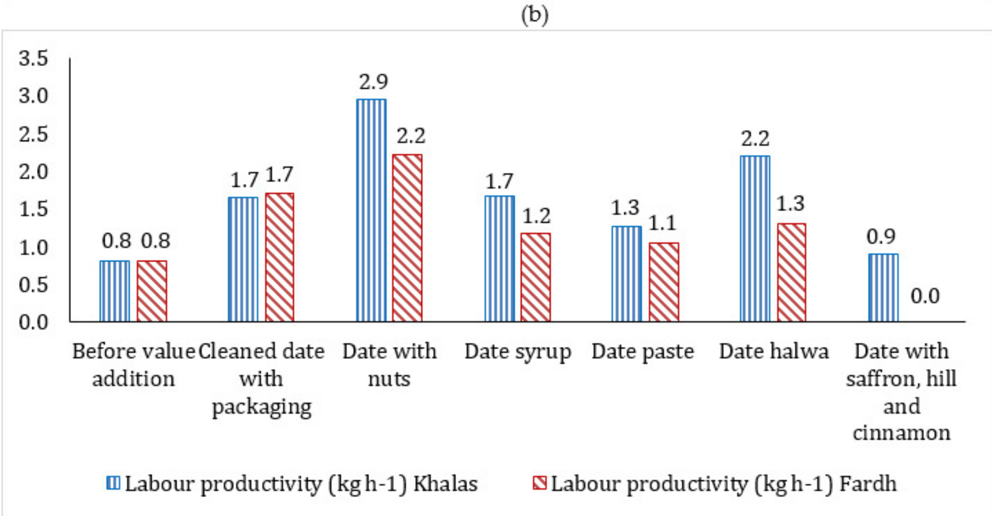

(c)

Figure 1. The average productivity improvement of land, water and labour at different value-added date products of two varieties (a) land productivity improvement in kg m^{-3} (b) water productivity improvement in kg m^{-3} (c) labour productivity improvement in kg h^{-1}.

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