Impact of Processing Technology in Hilly Region: A Study on Extraction of Apricot Kernel Oil

Anil Kumar Dixit[a]*, P.C. Sharma[b], S.K. Nanda[a] and S.K. Aleksha Kudos[a]
[a]Central Institute of Post Harvest Engineering and Technology, Ludhiana - 141 004, Punjab
[b]YS Parmar University of Horticulture and Forestry, Solan - 173 230, Himachal Pradesh

Abstract

The paper has studied the impact of improved technology (developed under AICRP on PHT) for extraction of apricot kernel oil from apricot stone. Economic surplus model has been applied in a closed economic framework with the assumption of no spillover effects. The economic efficiency indicators such as NPV (486), IRR (44%) and BCR (21.83) have been found quite attractive. The technology (mechanical decorticator, kernel separator, oil extraction and filtration) has been found superior to conventional practices (traditional *kolhu*) on account of higher recovery of 11 per cent and cost reduction by 22.41 per cent. Overall, net profit per unit in the case of improved technology has been estimated to be Rs 1.34 lakh, which leads to a saving of Rs 55446 over the conventional practices. The mechanical decortications and separation could not only save time and money but also reduced women drudgery (due to manual breaking of stones to separate kernel). The technology has been found suitable for promotion of entrepreneurship on the processing of apricot oil from apricot kernel in the production catchment, which otherwise is not properly utilized.

Introduction

Agriculture is a dominant activity in the hill economy, but is poorly performed. Besides, factors such as diverse regional typologies, extreme vulnerability, poor physical infrastructure (pre- and post-harvest) and socio-economic status; least attention was given in the past towards development of proven technology for processing agricultural produce and its by-product utilization.

Apricot is an important stone fruit grown abundantly in the temperate regions of the country such as Himachal Pradesh, Uttrakhand, Jammu & Kashmir and some parts of North-Eastern states. Traditionally, the fruit stones left after utilization of edible parts of apricot through processing or drying, are thrown as a waste but can be utilized for extraction of kernel oil which may be used in various edible, cosmetic and industrial preparations. Manual breaking of stones to separate kernel and oil extraction through traditional *kolhu* (oil-expeller) is a tedious, time consuming and unhygienic process, which results in very low yield and poor quality of extracted oil. In this backdrop, All India Coordinated Research Project on Post Harvest Technology (AICRP on PHT), Solan Centre, has developed a technology for extraction of apricot kernel oil from apricot stones (seeds). The technology consists of breaking of apricot stones by using mechanical decorticator, separation of kernels and oil extraction. The present paper has estimated of impact of apricot kernel oil technology.

Methodology

The technology was commercialized during 2008-2009 and 8 units have been established so far. Field survey was carried out during 2010 with the help of a structured scheduled for adopters and non-adopters (practising traditional *kolhu*, n=5). The cost economics was worked out for improved technology as well as traditional practices. Besides, economic surplus model was used to estimate the economic benefits of the technology developed/upgraded under AICRP on PHT. The model was applied in a closed economy framework

* Author for correspondence,
  Email: poojanilwe@gmail.com

with the assumption of no spillover effect on international market. It was assumed for the ease of analysis that output supply function was unitary elastic and linear with a parallel research-induced supply shift, and the demand function was linearly inelastic. The assumption of linear supply and demand functions with parallel shift, have been applied in most of the earlier studies on research benefits (Alston *et al.*, 1995; Ilyas *et al.*, 2004; Mruthyunjaya *et al.*, 2004). The average annual cost of the technology was computed by considering the salaries of scientific and other staff proportionate to the time allocated for the development and refinement of the technology, and the contingent and extension expenditure incurred. The incremental benefits of the technology over traditional (*kolhu* system) were estimated. Since the full adoption is yet to take place, the measured benefits are ex-ante estimates. These incremental benefits have been compared with the research cost for the period required for development and refinement of the technology. Net present value (NPV), internal rate of return (IRR), and benefit-cost ratio (BCR) were then computed using the above estimates of benefits and research cost inclusive of extension cost.

Change in total surplus $= K_t\, P_0\, Q_0\, (1 + 0.5\, Z_t\, \eta)$

where,

Z_t = $K_t\, [\varepsilon / (\varepsilon + \eta)]$
K = Vertical shift in supply function,
ε = Elasticity of supply,
η = Elasticity of demand,
P_0 = Base year output price (average of 2009 and 2010), and
Q_0 = Base year output quantity.

Data and Parameters

Estimation of economic surplus generated by a technology requires data on technological and economic parameters. The data pertaining to recovery advantage, labour cost reduction, to cost economics (breaking of stones to separate kernel and oil extraction), cost of technology (research and extension cost) were collected from the established entrepreneurs in this business using well-structured schedules. A period of 18 years was considered for the economic analysis of developing the cost-benefit stream. The data on economic variables like elasticities (estimated by Srinivasan, 2005), input prices, and availability of apricot

kernel in the target domain were obtained from the published sources. The firm gate prices of apricot oil for 2009 and 2010 and prices fixed by YS Parmar University of Horticulture and Forestry, Solan, were found in close proximity; therefore, we took the average price for computing the value of apricot kernel oil. A discounting factor of 8 per cent was used for estimating the present value of costs and returns. Livelihood impact indicators (such as human capital, financial capital and physical capital) developed by Rovere and Dixon (2007) were utilized.

Results and Discussion

Technical Efficiency and Cost Economics of Apricot Kernel Decorticator and Oil Expeller

The technology consisting of breaking of apricot stones/seeds by using mechanical decorticator with breaking efficiency of 80-100 kg stones per hour against manual crushing of 3.2-4.6 kg stones per hour was optimized. Specific gravity separation by dipping the decorticated mass in 20 per cent salt solution (1.888 specific gravity) and collection of floated kernels was found optimum for the separation of kernels. The kernels after sun drying were passed through 'Table Oil Expeller' for oil extraction with an oil yield of 43.5 per cent against the recovery of 32.5 per cent through traditional *kolhu* (Table 1). A superior quality, clear and transparent oil was obtained in the case of improved technology.

A comparison of cost economics (Table 2) showed that the fixed cost per unit was higher in the case of improved technology but variable cost, particularly on mechanical breaking of stone and separation of kernel had reduced substantially, by 94.87 per cent and 80.0 per cent, respectively, for processing of equivalent raw material. The manual breaking of stone and separation of kernel was found time consuming, and tedious and had women drudgery — as women were involved in these operations. From 10 tonnes of apricot kernel, the recovery of oil was found to be 1408 litres under improved technology and 1254 litres in the traditional practice (Table 2). The net profit per unit of improved technology was estimated as Rs 1.33 lakh per annum. Overall, mechanical decorticator, kernel separator, oil extraction and filtration had led to reduction in cost by 22.41 per cent and saving of an amount of Rs 55446 per unit per annum over the conventional practices.

Table 1. Benefits of improvement technology over conventional practices

Particulars	Improved technology	Conventional practice
Stone decortication/ Breaking	Mechanical decorticator	Manual breaking
Decortication capacity (kg/hour)	90 (±10.0)	3.9 (±0.3)
Kernel separation	Specific gravity separation	Manual separation
Separation capacity (kg/hour)	6.5 (±0.5)	0.66 (±0.05)
Oil extraction	Table oil expeller	Traditional *kolhu*
Oil yield (%)	43.5 (±1.5)	32.5 (±1.5)
Filtration	Filter press	Decantation/ Settling
Capacity (L/hour)	2.5 (±0.5)	-
Oil quality after filtration	Clear and transparent	Turbid with sediments

Source: Experimental data and field survey, 2010

In addition, the entrepreneur could realize benefits through custom hiring, though not substantial. The estimated benefits from custom hiring were found to be Rs 1000 (mechanical decortications @ Re 1/kg), Rs 600 (kernel separation @ Rs 2/kg) and Rs 1122 (oil extraction and filtration @ Rs 5/L). Conclusively, results could not speak about the scope of custom hiring, as data collected pertained to the initial year of establishment. However, the country has potential of apricot oil production of about 270 tonnes (Appendix 1) from apricot stone (17920 t). Hence, the scope of custom hiring needs to be explored.

Economic Impact

It would be appropriate to infer that the improved technology for extraction of apricot kernel oil had significant yield advantage. Interestingly, the cost per unit of production had reduced substantially, from Rs 248 to Rs 193/L. The quantified economic pay-offs in terms of NPV, IRR and BCR of the technology have been found quite attractive. The NPV of incremental benefits was Rs 486 lakh, IRR was 44 per cent and B-C ratio was 21.83 (Table 3). The R&D lag was found to be reduced by 10 years.

Other Impact and Feedback from Entrepreneurs

The opinion of the respondents was ascertained and rated on the scale of 1-5 (highly disagreed to highly agreed) to know whether the technology was acceptable, sustainable and environment-friendly. It is evident from Table 4 that the improved technology was highly acceptable as it helped in reduction of women drudgery, had lower health hazards (pressed fingers and nails during manual breaking of stone), and was labour-friendly (no back pain) with overall mean score of 5.0. Similar kind of findings by Goletti *et al*. (1999) that improved processing technology resulted in reduction of women stress in their workload.

The sustainability of technology was rated in terms of enhancement of livelihood assets (Pandey and Mruthyunjaya, 2004; Walk *et al*., 2008). As far the improvement in human capital was concerned, the respondents only 'slightly agreed' that their technical skill had improved. In the case of improvement in financial capital, improvement in saving rated very high (5.0). However, regarding credit availability and insurance, the responses were in favour of 'neither agree nor disagree'. The physical capital (tool, machinery and infrastructure) had improved as a result of adoption of improved oil processing technology and was rated between 'slightly agree to highly agree' (Table 4). The results further revealed that the technology provided superior quality product, was environmentally safe and contributed towards maintaining hygienic conditions. The technology may be considered as green technology, though other requirements for green technology are yet to be studied.

Conclusions

The technology for extraction of apricot oil from apricot kernel developed and commercialized by AICRP

Table 2. Cost economics of improved technology vis-à-vis conventional technology for extraction of apricot kernel oil

Sl No.	Cost/ Benefits	Improved technology (mechanical decorticator, kernel separator, oil extraction and filtration)			Conventional technology (*kolhu* system)		
A	Total fixed cost (machineries and equipments including installation charges) (Rs)	190000			55000		
i	Cost of land and buildings (on rent basis)	12000			12000		
ii	Depreciation on main machinery @ 10 per cent per annum after deduction of salvage value (Rs)	16500			3000		
iii	Interest on fixed capital @ 10 per cent per annum (Rs)	19000			5500		
	Sub- total (i+ii)	47500			20500		
B	Variable cost						
iv	Cost of raw material	Qty (tonnes)	Price (Rs /kg)	Total cost (Rs)	Qty (tonnes)	Price (Rs /unit)	Total cost (Rs)
		10	20	200000	10	20	200000
v	Repair and maintenance (Rs/year)			2000			500
vi	Fuel and electricity charges (Rs)	Units	Charge (Rs/unit)	Total cost (Rs)	Units	Charge (Rs/unit)	Total cost (Rs)
		3000	3.50	10500	1000	3.5	3500
vii	Labour charges for different operations	Quantity (kg)	Rate/cost (Rs/unit)	Total (Rs)	Quantity (kg)	Rate/cost (Rs/unit)	Total (Rs)
	Decortication (stones)	10000	0.11	1100	10000	2.11	21100
	Kernel separation	3200	2.67	8544	3200	13.40	42880
	Oil extraction, filtration, packaging, labelling, etc. (human days)	200	110	22000	185	110	20350
viii	Other expenses (Rs)(antioxidants, packaging, etc.)			15000			10900
	Sub- total B (iv to viii)			259 144			299230
C	Total cost (i+ii+iii+B)			271144			311230
D.	Returns						
a.	Final product (main) Apricot oil	Qty (L or kg)	Rate (Rs/unit)	Total (Rs)	Qty (L or kg)	Rate (Rs/unit)	Total (Rs)
		1408	300	422400	1254	300	376200
b.	By product (press cake)	1792	10.00	17920	2176	10.00	21760
	Total returns D (a+b)	-	-	440320			397960
E	Profit (D-C)			133676			78230
F	Cost of production (Rs/L)			193			248
G	Reduction in unit cost of production (%)	22.41					
H	Saving over conventional practice (Rs/annum)			55446			

Source: Survey results, 2010

Table 3. Adoption-related parameters and returns from improved technology developed

Sl No.	Name of the technology	Oil extraction from apricot stone*
1	Yield advantage (%)	11
2	Reduction in per unit cost of production (%)	22.41
3	Reduction in R&D lag (years)	10
4	Ceiling level of adoption (%)	70
5	Probability of success (%)	95
6	Supply shift (k value)	0.008
7	Target domain	Himachal Pradesh, Jammu & Kashmir, and Uttarakhand
8	Base value of production of apricot kernel oil (average of 2009 and 2010) (in lakh Rs)	858
9	NPV (in lakh Rs)	486
10	IRR (%)	44
11	B-C ratio	21.83

Note: *It consisted of mechanical decorticator, kernel separator, oil extraction and filtration unit

Table 4. Opinion of the entrepreneurs regarding acceptability and sustainability of improved technology

Scale (1 to 5)

	Mean score
Social acceptability	
Labour-friendly	5.0
Reduction in women drudgery	5.0
Reduction in health hazard	5.0
Increase in consumer demand	4.0
Sustainability	
Livelihood assets	
a) Human capital	
- Improved technical knowledge/ skill	4.0
- Labour availability	3.5
b) Financial capital	
- Credit availability	3.0
- Easy insurance	3.0
- Improved saving	5.0
c) Physical capital	
- Upgraded tool and machinery	5.0
- Improved infrastructure (housing)	4.5
Green technology	
i) By-product utilization	5.0
ii) Less noise	4.0
iii) Saving of water	3.0
iv) Environmentally compatible	5.0
v) Maintained hygienic conditions	5.0

Note: Highly agreed (5), slightly agreed (4), neither agreed nor disagreed (3), slightly disagreed (2), highly disagreed (1)

on PHT, Solan centre, was found superior to traditional practices (breaking of stone and separation of kernel with hand and extraction of oil in conventional *kolhu*) in terms of higher recovery of oil and reduction in unit cost of production. The quantified economic pay-offs in terms of NPV, IRR and BCR of the technology have been found quite attractive. None of the selected parameters for social acceptability and sustainability has been rated below 3.0, suggesting that the entrepreneurs are satisfied from the performance of the improved technology. It can be concluded that the technology is technically feasible, economically viable, environmentally compatible and socially acceptable, and has implications for entrepreneurship development in production and consumption catchments of apricot.

References

Alston, J.M., Norton, G. and Pandey, P. (1995) *Science under Scarcity: Principles and Practices for Agricultural Research Evaluation and Priority Setting*. Cornell University Press, Ithaca. 585 p.

Goletti, F. and Wolff, Christiane (1999) *The Impact of Postharvest Research*. International Food Policy Research Institute, Washington, MSS Discussion Paper No. 29.

Ilyas, S.M., Gangwar, L.S., Goyal, R.K., Bhati, D.K. and Kumar, Sandeep (2004) *Impact Assessment of Post Harvest Technologies Developed under NATP and AICRP on PHT*. Central Institute of Post Harvest Engineering and Technology (CIPHET), Ludhiana, 76 p.

Mruthyunjaya, Pal, S., Pandey, L.M. and Jha, A.K. (2004) Impact of selected technologies refined under NATP. *Agricultural Economics Research Review*, **17** (Conference issue): 1-13.

Pandey, L.M. and Mruthyunjaya (2004) *Impact Assessment of Agricultural Technology from Simple Efficiency Analysis to Sustainable Livelihood Framework*. NATP PME Note 14.

Rovere, La and Dixon, J. (2007) Operational guidelines for assessing the impact of agricultural research in livelihoods. CIMMYT, *http://ageconsearch.umn.edu/ bitstream/56180/2/iaguidelines.pdf*

Srinivasan, P.V. (2005) Impact of trade liberalization on India's oilseed and edible oils sector. IGIDR-ERS/USDA Project report. http://www.igidr.ac.in/pdf/publication/PP-051.pdf

Walker, T., Maredia, M., Kelley, T., Rovere, R. La, Templeton, D., Thiele, G. and Douthwaite, B. (2008) *Strategic Guidance for Ex Post Impact Assessment of Agricultural Research*. Consultative Group on International Agricultural Research (CGIAR) Science Council, 100 p.

Appendix 1

Production potential of apricot kernel oil

Particulars	Production of apricot* (t)	Apricot stone**	Apricot kernel**	Expected production of oil**
Himmachal Pradesh	6170	902.45	289.66	134.83
India (Jammu & Kashmir, Himmachal Pradesh and Uttarakhand)	13280	17921.20	572.50	268.30

* Complied from Department of Horticulture, Govt. of Himmachal Pradesh, Govt. of J&K and Govt. of Uttarakhand (2009)
** Estimated figures