Research Article

Quality Characteristics of Castor Bean Oil (*Ricinus communis* L.) under Sub-Tropical Divergent Pothwar Environment of Pakistan

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Abstract | Oil quality and quantity in oil seed crops are very much influenced by environmental conditions. Fatty acid composition of Castor bean (*Ricinus communis* L.) reflects its oil quality. Consequently, the purpose of this study was to see the Pothwar environmental condition effects on quality of castor bean oil. For the purpose, castor bean oil (*Ricinus communis* L.) two years experimental data from the stand point of oil content and oil quality were collected and analyzed having four sowing dates 15th July, 30th July, 15th August and 30th August using four varieties (DS-30, PR-7/1, PR101, Local) crop planted at National Agricultural Research Center, Islamabad. Randomized complete block design (split plot) having three replications was followed by sowing dates and varieties. Castor bean oil was analyzed for fatty acid profile and oil content by using soxhlet extr action apparatus and gas chromatography. Results revealed significant differences among oil quality components among castor cultivars and differ significantly ($p<0.05$) from the view point of oil content, linoleic acid, stearic acid, palmitic acid and protein but indicated no difference significantly ($p>0.05$) in oleic acid and ricin oleic acid. Among cultivars, DS-30 showed maximum oil content (49.356 %) and ricin oleic acid (87.978%). The most important component of castor oil the ricin oleic acid% was found highest by sowing date 15th July in all the varieties while highest oil content was also obtained with sowing date 15 July. The present research is the first report on oil contents and its quality extracted from the castor grown under climate of Pothwar area of Pakistan.

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Introduction

Caster beans (*Ricinus communis* L.) is a medicinal non-edible oil seed crop grown widely in semi-arid tropics and sub tropics of low rain fall regions (Vanaja *et al*., 2008). Caster crop is an important oil producing for various industrial purpose more than 400 commercial usages such as medicines, cosmetics as well as production of bio-diesel, *etc*. (Anjani, 2010). Worldwide caster production was about 1.76 million tons during the year 2010, whereas in Pakistan it is a neglected crop. In Pakistan, the area under castor has been decreasing since 1979. Area under caster bean is permanently decreasing as in 2006 it was 5066 hectares and in 2010 it reduces to 3390 hectares.

Castor bean oil versatile applications in different pharmaceutical, cosmetic, chemical, biodiesel, sanitary and recently in food industry because the reason of its unique physiochemical properties led

castor oil in main stream research projects. The oil of castor constitutes about 1-5% saturated fatty acids, 2-4% oleic acid, 3-6% linoleic acid and 80-90% ricin oleic acid (Ibrahim and Onwualu, 2005). Very high viscosity and density of castor oil is the main reason of high ricin oleic acid content. High stability, hygroscopicity and solubility in alcohol is also a distinguishing character of Castor oil, that effects the reaction of transesterification (Scholoz and Da Silva, 2008). New caster bean high yielding varieties developed in world needed to be introduced after inspecting their performance in domestic climatic conditions (Ghorttapeh *et al*., 2012).

Castor is very rich in unique hydroxyl fatty acid; ricin oleic acid and is reported by many researchers, almost 87 to 90 percent (Puthli *et al*., 2006), over 89 percent (Ogunniyi, 2006). Characteristics of caster from China, India, Brazil and Africa have been studied. Different genotypes of castor bean when evaluated in varying stressed and unstressed environments, it was observed that qualitative and quantitative parameters were greatly affected by environmental conditions (Myandoab *et al*., 2012). Physiologically castor bean is highly responsive to environmental condition which shows its ability to survive under changing environmental conditions and its chances of improvement in quantitative and qualitative traits under the predicted new environmental conditions (Vanaja *et al*., 2008).

Physiochemical properties of castor bean oil can be determined by a combination of fatty acids, triacyl Glycerol and oil content which are highly depending on seed varieties and some other characters like soil type and weather conditions (Ogunniyi, 2006). No work has been done in Pakistan and this is the first reported work done concerning its yield and oil quality of this none-edible oil cash crop. This study will also be valuable considering the ability of castor plantation and its sustenance in view point of oil quality under Pakistani climatic conditions and to investigate the crop suitability in the prophesied new ecological circumstances of Pothwar area.

Materials and Methods

Samples

Experiments were conducted at National Agricultural Research Center, Islamabad with longitude and latitude 33.738045 and 73.084488. Four cultivars of caster bean (DS-30, PR-7/1, PR101, Local) were utilized. Plant material was sown in loam soil with 5 rows having one-meter plant to plant and row to row distance grown on 9 meters long rows. Soil was loam type and standard field operations (Three ploughings with pulverization were done to provide satisfactory environment for optimal crop growth). Crop was grown in arid condition without irrigation. Recommended rate of N and P were applied @ 31kg N and 62kg per Hectare. Sowing dates of crop were 15 july, 30 July, 15 Aguste and 30th August. Two types of parameters were studied for this experiment i.e. agronomic parameters and quality parameters. In laboratory grains were cleaned and dried until moisture 8% and then ground for oil extraction. Randomized Complete Block Design for the experiment was followed.

Oil contents

Oil extraction was made following the procedure of soxhlet apparatus (Ranganna, 1979). The lower end of extraction tube was attached to flask of soxhlet apparatus having nearly 100 ml petroleum (anhydrous ether) at a temperature 40- 60^{o}C. Oil content was extracted from the samples for 16 hours on a water bath. The thimble was removed from the apparatus on the completion of the extraction time, and most of the ether was distilled off and collected in the soxhlet tube. When the tube was nearly full, the ether was dispensed off. It was poured into a small, dry, (previously weighed) beaker through a small funnel containing a plug of cotton when the ether reached to a small volume. Using several small portions of ether, the flask was rinsed and filtered thoroughly. On a steam bath at low heat under air current, the Ether was evaporated. The extractions were dried at 100^{o}C for a period of 1 hour and weighed after cooling. From the difference in weight indicate the fat and fat-soluble materials in the sample.

Fatty acid composition

The composition of Fatty acids (palmitic, oleic, stearic, linoleic and ricin oleic) in seed oil was determined using gas chromatograph by methylating the fatty acyl-esters.

Then chromatographic analysis of the methyl esters through capillary column DB-WAX (J &W, Scientific, California) of 30-meter length with ID.0.53 mm (Mega bore) of 1 Micron film of Poly Ethylene Glycol as stationary phase and Flame Ionization Detector

(FID) on UNICAM series 610 Gas Chromatograph. The samples were prepared by dispensing 0.1 ml of methylating solution and 0.05 ml hexane into 4 ml vials. Then added 1 ml of oil from samples to each of vials and left stand at room temperature for 10 minutes. Afterwards added 0.1 ml Sodium phosphate buffer to each vial and injected 1 ul of upper layer from each vial into injector. The temperature of injector and detector was kept at 220°C and column temperature was maintained 180°C. The composition and identification of fatty acid was carried out by the relative retention times of the standards.

Statistical analysis

The data of the parameters recorded during study were analyzed by using RCBD two factor factorial method through Fisher's analysis of variance technique using Duncan's Multiple Range Test at 5% probability level for comparison of means (Steel and Torrie, 1980). The linear statistical model used is described below:

$$Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk}$$

Where; Y_{ijk}=kth observation where A is at the ith level and B is at the jth level μ=overall mean, α_i effect of the ith level of the row factor A, β_j = effect of the jth level of column factor B, and $(\alpha\beta)_{ij}$ = effect of the interaction between A and B and ε_{ijk} = independently and normally

The two years data of sowing date trial were pooled into one by using the technique described by the Gomez and Gomez (1984). According to the technique, the homogeneity of data was checked by analyzing both years' data separately. The bigger error mean square was divided by smaller one and the answer was not three fold in majority of the cases as explained by Gomez and Gomez (1984). So, the data were considered homogeneous and pooled into one year.

Results and Discussion

Table 1 shows oil fatty acid composition of caster bean samples collected from different cultivars. Results obtained shows significant difference among performance of caster bean cultivars regarding mean values (p<0.05) of the fatty acids except Oleic and Ricin oleic acids in the samples analyzed which shows non-significant results (p>0.05). Quality characteristic of castor oil of studied cultivars shows highly significant differences under the local climatic conditions (temperature and moisture) as highest oil content was recorded for DS-30 which is 49.978% and lowest 47.871in case of Local variety. While highest protein content (16.280 %) was recorded in case of Local variety Table 1. These findings are in conformity with the observations of (Koutroubas *et al*., 1999) who reported oil content in castor bean varies from region to region in a range between 47-53% and others reported oil function range between 40-60% (Weiss, 2000).

Data in Table 1 revealed that oleic acid and ricin oleic acid which are also the most important determinants of castor oil quality not differ significantly among varieties which show that proportion of these two fatty acids remains alike among varieties. On the other side varieties with low oil content contains high palmitic acid and protein contents. This effect provides evidence of differences between plant species with regard to microbial biomass in soil and activities related to C and N mineralization in soil plant species which significantly affect seed yield and oil quality (Chatzakis *et al*., 2011). These results are also supported by the findings of (Alirezalu *et al*., 2011) who stated that the oil function is life seed function and is dependent to plant variety, climate and the interaction between these two factors.

Table 1: *Mean data of fatty acid composition in different castor bean cultivars.*

Varieties	O.C[1]	S.A[2]	O.A[3]	R.A[4]	L.O[5]	P.A[6]	P.R[7]
DS-30	49.978 a	1.344 b	4.007 *	87.183 *	3.678 c	2.024 c	15.078 b
PR-7/1	48.318 b	1.417 a	3.977	86.684	3.237 d	2.126 b	13.169 c
PR-101	47.736 c	1.408 a	4.001	86.868	3.964 b	2.149 b	15.718 a
local	47.871 c	1.392 a	3.924	86.863	4.342 a	2.298 a	16.28 a
LSD	0.4246	0.0297	NS	NS	0.1847	0.0612	0.6163

Means having different superscripts within the column are significantly differ at p<0.05. [1: -7 Oil Content (%), 2: Stearic (%), 3: Oleic Acid (%), 4: Ricin oleic (%), 5: Linoleic (%), 6: Palmitic (%)] Acids 7: Protein (%)]. LSd= least significant difference.

Table 2 shows fatty acid composition of caster seed oil in different countries. The ricin oleic acid comprises over 84% of total fatty acid composition which is the most important component in castor oil quality. Other fatty acids present are linoleic 3.67%, palmitic 2.02%, stearic 1.34% and oleic acid 4.0%. High contents of ricin oleic acid confirm that Pakistan can produce high quality castor oil for industrial use. Salimon *et al.*, 2010 also stated that in most cases castor bean oil consists mainly of 12- hydroxy-9-octadecaenoic acid (ricin oleic acid). Presence of hydroxyl groups and double bonds make castor oil suitable for industrial use and luckily it is available in sufficient quantity in crop grown under Pakistani environment.

Table 2: *Fatty acid comparison of castor seed oil with castor oil producing countries.*

Fatty acid	Percentag			
	Malaysian	Brazil	India	Pakistan
Ricin oleic	84.2	90.2	89.3	87.183
Linoleic	7.3	4.4	4.2	3.67
Palmitic	1.3	0.7	1.0	2.02
Stearic	1.2	0.9	1.0	1.34
Oleic	5.5	2.8	2.3	4.0

Source. *FAO, Stats. 2010.*

While comparing other fatty acids of castor seed oil India, Brazil and Malaysia shows more percentage 4.2% to 7.3% in case of linoleic acid while low 0.7-1.3% palmetic, 0.9-1.2% stearic and 2.3-2.8 % oleic acids (Deligiannis *et al.*, 2009; Salimon *et al.*, 2010). Thus, results in Table 2 confirmed that Pakistani climatic conditions have potential to produce high quality castor seed oil for industrial usage and if consider this crop seriously in our cropping pattern by promotion and extension tools, forex can also be earned by export of this valuable superior quality castor bean oil. These results are in line with (Salimon *et al.*, 2010) who stated that presence of high percentage of these fatty acids makes castor bean oil of more superior quality.

Table 3 prevailing data of sowing dates and varietal interactions in castor bean reveals significant influence of sowing date on qualitative characters of castor bean oil with the exception of oleic and stearic acids which showed non-significant influence of sowing dates and varietal interactions. These findings are in certainty with Turhan *et al.*, 2010 who observed significant influence of environment on percentages of major fatty acids linoleic, palmitic and stearic acids in sunflower oil. Oil content in castor was highest by sowing date 15 July which confirms the observations recorded by Nagabhushanam and Raghavaiah (2005), who described early seeding of castor crop induced significantly higher oil content as compared to the crop sown late. Similar results were established by by Öztürk *et al.* (2014) and Celián Román *et al.* (2020) Hence, two results are confirmed through this experiment that oil produced under Pakistani environment is of good quality for industrial use having maximum quantity of ricin oleic acid and secondly earlier sowing of crop in Pothwar region i.e. First fortnight of July have good impact on castor oil quality.

Table 3: *Effect of sowing dates oil content, oleic acid and ricin oleic acid.*

SD	Variety	OC	OA	RA	LA	PR	PA	SA
15 July	DS-30	50.91 a	4.24*	87.41 ab	3.67 cdef	14.53 cd	1.98 e	1.35*
	PR-7/1	49.07 abc	4.00	86.68 bc	3.20 ef	13.27 de	2.14 cde	1.31
	PR-101	48.17 bc	4.00	86.98 abc	4.04 abcd	16.07 ab	2.18 abcd	1.45
	Local	48.70 abc	3.95	86.68 bc	4.44 ab	16.49 ab	2.35 ab	1.40
30 July	DS-30	50.68 ab	3.95	87.33 ab	3.73 bcdef	15.32 abc	2.04 de	1.45
	PR-7/1	48.51 abc	3.96	86.67 bc	3.17 f	13.13 de	2.14 cde	1.39
	PR-101	48.10 bc	3.89	86.30 bc	3.88 abcdef	15.41 abc	2.15 bcde	1.37
	Local	48.52 abc	3.86	86.01 c	4.56 a	15.69 abc	2.37 a	1.34
15 Aug	DS-30	49.51 abc	3.91	87.16 ab	3.69 cdef	15.32 abc	2.09 cde	1.35
	PR-7/1	48.21 bc	3.96	86.61 bc	3.31 def	13.41 de	2.16 bcde	1.41
	PR-101	47.60 c	4.09	87.08 ab	4.02 abcd	15.43 abc	2.19 abcd	1.38
	Local	47.00 c	3.95	88.01 a	4.19 abc	16.25 ab	2.28 abc	1.39
30 Aug	DS-30	48.81 abc	3.91	87.01 abc	3.60 cdef	15.13 bc	1.97 e	1.35
	PR-7/1	47.49 c	3.98	86.76 bc	3.26 ef	12.84 e	2.05 de	1.40
	PR-101	47025 c	4.00	87.10 ab	3.90 abcde	15.96 abc	2.05 de	1.41
	Local	47.07 c	3.91	86.73 bc	4.17 abcd	16.67 a	2.19 abcd	1.42
CV (%)		1.37	1.59	0.27	2.71	1.72	2.32	3.44

SD: Sowing dates, CV (%): Coefficient of Variation. OC: Oil Content (%), OA: Oleic Acid (%), RA: Ricinoleic Acid.

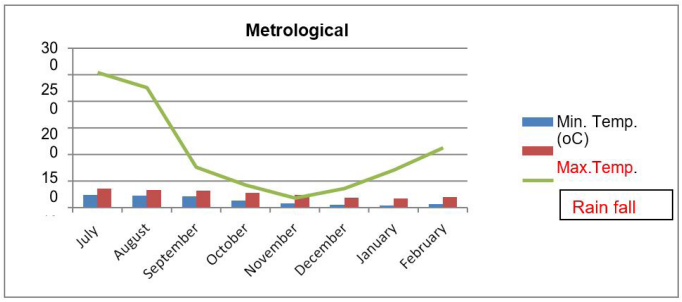

Figure 1: *Meteorological data (Rainfall and average temperature) for Pothwar area during the growth period of castor bean.*

Conclusions and Recommendations

Present study clearly indicates that oil quality of castor grown under Pothwar environment is good for industrial having more percentage of ricin oleic acid and it is plausible to recommend castor bean as a very suitable crop for this region to meet our industrial and energy requirements. At the same time experiment shows that crop sowing in early July have good quality oil. Hence, study revealed that castor seed oil can be a potential local source of ricin oleic acid for further exploitation.

Novelty Statement

The study under this paper is first and novel study to analyze oil quality of different castor bean varieties under different areas of Pothwar region for its industrial use.

Author's Contribution

Nasir Mahmood Cheema: Designed, collected data and prepared maximum of write up.
Ghulam Shabbir: Analysed the data and helped in finalizing writ up.
Nazakat Nawaz: Helped in data collection and gathering of references.

Conflict of interest

The authors have declared no conflict of interest.

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