

Study of oil quality and fatty acid composition of some castor genotypes

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ABSTRACT

Fourteen castor genotypes including three checks GCH 7, DCS 9 and DCH 177 were studied for oil quality and fatty acid profile comparison. The castor spikes were harvested at physiological maturity. The highest value of 100 seed weight i.e. 33.5 g was determined in genotype MCI 13 whereas, the seed yield was found maximum in ANDCH-11-01 (1936 kg/ha). The seed oil content was determined maximum (50.4%) in ANDCH-11-01 followed by PCH 288 and MCI 13 genotypes which has 49.5% and 49.5%, respectively. Ricinoleic acid, the predominant monounsaturated fatty acid in castor oil, varied from 85.33 (MCI 13) to 88.13 (RHC 247) among castor genotypes. The ricinoleic acid content was significantly negatively correlated with oleic acid ($r = -0.745^{**}$) and linolenic acid ($r = -0.719^{**}$). The present study is vital for developing castor hybrids for better oil yield and high ricinoleic acid content.

Keywords: Castor oil, Ricinoleic acid, Fatty acid, Oil stability index, GCH 7

Castor (*Ricinus communis* L.) is non edible oilseed crop of *Euphorbiaceae* family otherwise grows as a wild plant almost all over the country. Castor is key non-edible oilseed crop. High productivity, suitability under marginal land and in semiarid climate, the crop area is expanding especially in irrigated condition. Castor production is synonymous to India in general, Gujarat in particular. India leads in the international castor oil and its derivatives trade. Castor is one of the oldest cultivated crops but commercial cultivation started hardly a century ago. Castor oil production in India hovers between 250,000 and 350,000 tons per year. Gujarat followed by Rajasthan and Andhra Pradesh contributing approximately 86% of castor seed production in India. In Gujarat, areas of Mehsana, Banaskantha, and Saurashtra/Kutch are major castor production areas.

Castor oil can be extracted from castor beans by mechanical pressing, solvent extraction, or a combination of pressing and extraction. Apart from castor oil (41-52%), the de-oiled cake (DOC)/meal is used as an organic fertilizer (Shah *et al.*, 2017). The castor oil is very crucial and important for specialty chemical industry all over world due to commercial and natural source of a hydroxylated fatty acid. The high content of ricinoleic acid (12-hydroxy-octadec-cis 9-enoate) with its three functional groups of hydroxylcarboxylate and carbon-carbon double bond (alkene) is the main reason of its versatile application in chemical industries (Mutlu *et al.*, 2010). The midchain hydroxyl group of ricinoleic acid imparts physical and chemical functionality making castor oil uniquely useful as a chemical and industrial feedstock. Castor oil is used as emulsifiers in food, cosmetic and pharmaceutical preparations. Transformation of castor oil due to

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several chemical reactions like halogenation, dehydration, alkoxylation, esterification, and sulfation allows it suitable for paints, coatings, inks, and lubricants (Dunford NT *et al.*, 2012). Castor oil is also used in modern drug delivery system (Gradishar WJ *et al.*, 2005). Unique uses of castor oil and its derivatives include nylon-6, 10 from sebacic acid, nylon-11 from 11-aminoundecanoic acid (Omari *et al.*, 2015).

MATERIALS AND METHODS

Fourteen castor genotypes were grown under irrigated condition at Castor-Mustard Research station, S.D.A.U., Sardarkrushinagar, Gujarat (India). Recommended agronomic practices were adopted to obtain optimum crop production. The seeds were harvested at stage of their physiological maturity. The quality parameters of seeds like 100 seed weight (g), seed oil content (%), seed yield (kg/ha), oil yield (kg/ha) were determined as per standard methods.

Seed oil content (%)

Seed oil content of castor seeds were calculated on Nuclear Magnetic Resonance Spectroscopy (MQC model, Oxford instruments) as per method described by Yadav and Murthy (2016).

Oil extraction and oil quality parameters

Castor seed oil was extracted using Soxhlet apparatus by petroleum ether (60-80°C) as solvent. (AOAC, 1951). The oil quality parameters like specific gravity, refractive index, acid value and free fatty acid (FFA) value were determined as per standard methods described by AOAC, (1990).

Fatty acid composition

Fatty acid profile of oil from different genotypes of castor were performed on Thermo Gas chromatography (GC-FID, Trace GC Ultra) with processed Fatty Acid Methyl Esters (FAMES) of castor oil as described by FSSAI, 2015. The ricinoleic acid yield (kg/ha) was also computed.

Oil stability index

Oleic and Linoleic acid (O/L) ratio were computed, as oil stability index.

RESULT AND DISCUSSION

Seed and oil quality parameters:

Seed quality parameters are the one of the most important quality parameters which governs the market price of seed. Under the present study among fourteen AVHT genotypes, the 100 seed weight ranged from 24.2-33.5g. The maximum 100 seed weight (33.5g) was found in genotype MCI 13. The maximum seed yield (1936 kg/ha) was found in genotype ANDCH-11-01 followed by RHC247 (1672 kg/ha) and PCH 294 (1652 kg/ha). The seed yield has significantly positive correlation with oil yield ($r=0.994^{**}$) and ricinoleic acid yield ($r = 0.994^{**}$). The oil content varied from 44.6% to 50.4% (Table 1). The maximum oil content (50.4%) was reported in genotype ANDCH-11-01. Genotypes PCH288 (49.5%) and MCI 13 (49.5%) had oil content more than control i.e. GCH 7 (49.3%), DCS 9 (45.2%) and DCH 177 (48.5%). Oil yield (kg/ha) was ranged between 331 kg/ha to 976 kg/ha. Genotype ANDCH-11-01 has given the maximum oil yield (976 kg/ha). The better oil yield makes industrial practice of oil recovery a profitable venture (Abitogun *et al.*, 2009).

Specific gravity and refractive index value did not differ much among the fourteen genotypes studied. Specific gravity ranged between 0.95-0.96 and refractive index value varied between 1.47-1.48. Specific gravity has significantly positive correlation with refractive index ($r=0.548^{*}$) and ricinoleic acid ($r = 0.573^{*}$). The higher specific gravity of castor oil was attributed to presence of hydroxyl group in its main fatty acid composition. The acid value ranged from 1.03-2.4 (Table 2). The maximum acid value found in PCH 288 whereas the minimum value was reported in ANDCH-11-05. The acid value has significant positive correlation with free fatty acid ($r=0.997^{**}$) and significant negative correlation with ricinoleic acid ($r = -0.563^{*}$). Free fatty acid (FFA) content varied from 0.5% to 1.19%. ANDCH-11-05 genotype shows minimum free fatty acid whereas PCH288 had maximum free fatty acid value. Free fatty acid has significantly negative correlation with ricinoleic acid ($r = -0.557^{*}$).

Fatty acid profile:

Ricinoleic acid, the key constituent of castor oil, content varied from 85.33% (MCI 13) to 88.13% (RHC 247) among the genotypes tested. In

the present study, the ricinoleic acid content was significantly negatively correlated with oleic acid ($r = -0.745^{**}$) and linolenic acid ($r = -0.719^{**}$). The hydroxyl functionality of ricinoleic acid (RA) makes the castor oil a natural polyol providing oxidative stability to the castor oil, and a relatively high shelf life compared to other oils by preventing peroxide formation.

When computed for yield of ricinoleic acid, genotype ANDCH-11-01 observed ricinoleic acid yield of 976 kg/ha leads compared with rest of the genotypes. Rest of the saturated fatty acids viz. palmitic and stearic acids did not differ much among the genotypes. The mono unsaturated fatty acid varied from 3.68% to 5.90% (Table 3). Whereas, the polyunsaturated fatty acids linoleic acid and linolenic acid ranged from 4.73% to 5.03% and 0.81% to 1.22%, respectively. The linolenic acid has positive correlation with palmitic acid ($r = 0.579^{*}$), stearic acid ($r = 0.753^{**}$) and oleic acid ($r = 0.688^{**}$).

Oleic and Linoleic acid (O/L) and Oleic and Ricinoleic acid (O/R) ratios:

Castor oil from genotype MCI 13 has shown maximum value of Oleic and Linoleic acid (O/L) ratio (1.23), which is an oil stability index (Table 4). The O/L ratio was significantly negatively correlated with specific gravity ($r = -0.533^{*}$) and ricinoleic acid ($r = -0.758^{**}$) and positively correlated with oleic acid ($r = 0.995^{**}$). However, the maximum value of Oleic and Ricinoleic acid (O/R) ratio (0.07) was found in genotypes MCI 13 and PCH 294. O/R ratio has significantly positive correlation with oleic acid ($r = 0.959^{**}$) and negative correlation with ricinoleic acid ($r = -0.644^{*}$). High oleic and low ricinoleic acid content in castor oil could have industrial uses requiring high oxidative stability such as bio fuel applications requiring lower ricinoleic acid percentages than the standard castor oil (Rajoseet al., 2004). High O/L ratio indicated higher oil stability of genotype (Shah et al., 2014). Castor oil can be stored for long periods without appreciable deterioration for periods up to two years.

CONCLUSION

On the basis of present study it can be concluded that among the genotypes studied, the maximum weight of 100 seeds was 33.5 g in MCI 13, while maximum oil content was 50.4% in ANDCH-11-10. The higher seed yield was 1936 kg/ha in ANDCH-11-10, 1672 kg/ha in RHC 247 and 1652 kg/ha in PCH 294. Genotype

ANDCH-11-01 has given the maximum oil yield (976 kg/ha). The maximum value of ricinoleic acid was 88.13% recorded in RHC 247 genotype. The present study is of vital importance for the selection of male parents for high ricinoleic acid castor hybrid with high seed and oil yields.

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Table 1 Seed and oil parameters of castor genotypes

Name of genotype	100 seed weight (g)	Oil content in seed (%)	Seed Yield (kg/ha)	Oil yield (kg/ha)
NCH-1	29.9	46.8	1503	703
SKI 346	26.4	47.5	1150	546
PCH 288	27.8	49.5	1306	646
ANDCH-11-01	29.4	50.4	1936	976
MCI-13	33.5	49.5	0906	448
RHC-268	29.4	48.0	1314	631
PCH-282	25.9	47.5	1195	568
SKI 343	28.1	45.9	1104	507
RHC-247	30.2	46.8	1672	782
ANDCH-11-05	29.7	44.6	0744	332
PCH-294	26.7	46.9	1652	775
GCH 7	29.1	49.3	1447	713
DCS-9 (C)	24.2	45.2	0978	442
DCH-177 (C)	31.6	48.5	0697	338
Min.	24.2	44.6	697	331
Max.	33.5	50.4	1936	976
Mean	28.7	47.6	1257	601

Table 2 Oil quality parameters of castor genotypes

Name of genotype	Sp. gr.	R.I.	Acid value	FFA (%)
NCH-1	0.96	1.47	1.52	0.72
SKI 346	0.96	1.47	2.13	1.05
PCH 288	0.96	1.47	2.40	1.19
ANDCH-11-01	0.96	1.48	1.92	0.91
MCI-13	0.95	1.47	1.73	0.79
RHC-268	0.96	1.48	1.19	0.55
PCH-282	0.95	1.47	2.19	1.05
SKI 343	0.96	1.48	1.33	0.64
RHC-247	0.96	1.48	1.45	0.68
-	0.96	1.48	1.03	0.50
PCH-294	0.96	1.48	1.36	0.66
GCH 7 (C)	0.96	1.48	1.55	0.75
DCS-9 (C)	0.96	1.48	1.33	0.61
DCH 177 C)	0.96	1.48	2.27	1.10
Range	0.95-0.96	1.47-1.48	1.03-2.4	0.5-1.19

Sp.gr. – Specific gravity, R.I. – Refractive Index, FFA- Free Fatty Acid

Table 3 Fatty acid profile of castor genotypes

Name of genotype	Fatty acid profile (%)						Ricinoleic acid yield (kg/ha)
	Palmitic acid	Stearic acid	Oleic acid	Linoleic acid	Linolenic acid	Ricinoleic acid	
NCH-1	1.17	1.30	4.38	4.84	0.87	87.27	614
SKI 346	1.17	1.32	4.59	4.85	0.94	86.72	474
PCH 288	1.13	1.26	4.40	4.86	0.86	86.11	557
ANDCH-11-01	1.22	1.29	4.16	4.91	0.88	87.78	857
MCI-13	1.35	1.33	5.90	4.81	1.22	85.33	383
RHC-268	1.23	1.29	4.49	4.84	0.91	87.69	553
PCH-282	1.39	1.33	4.90	4.73	1.16	86.41	490
SKI 343	1.26	1.27	4.96	4.88	0.89	87.11	441
RHC-247	1.27	1.28	4.08	5.03	0.86	88.13	690
ANDCH-11 – 5	1.24	1.27	4.83	4.74	0.88	87.74	291
PCH-294	1.31	1.27	5.77	4.84	0.93	86.31	669
GCH 7 (C)	1.27	1.26	4.60	4.83	0.88	86.96	620
DCS-9 (C)	1.31	1.29	3.68	4.86	0.81	87.83	388
DCH 177 C)	1.46	1.31	4.88	4.80	1.00	86.27	292
Range	1.13-1.46	1.26-1.33	3.68-5.9	4.73-5.03	0.81-1.22	85.33-88.13	291-857

Table 4 Oil stability indices in castor genotypes

Name of genotype	O/L	O/R
NCH-1	0.90	0.05
SKI 346	0.95	0.05
PCH 288	0.91	0.05
ANDCH-11-01	0.85	0.05
MCI-13	1.23	0.07
RHC-268	0.93	0.05
PCH-282	1.04	0.06
SKI 343	1.02	0.06
RHC-247	0.81	0.05
ANDCH-11 – 5	1.02	0.06
PCH-294	1.19	0.07
GCH 7 (C)	0.95	0.05
DCS-9 (C)	0.76	0.04
DCH 177 C)	1.02	0.06
Range	0.76-1.23	0.04-0.07