Abstract

Quantity of the particular set of fatty acids is a key determinant of the quality of dietary fat or oil for human consumption. In spite of their immense importance, the fatty acid profiles of seed storage lipids from widely-cultivated oilseed crops are nutritionally imbalanced. The rice bran oil (RBO) contains the essential ω-6 and ω-3 fatty acids in a ratio of approximately 25:1 as the proportion of ω-3 linolenic acid (C18:3) is almost negligible. Whereas, mustard oil naturally contains a very low level (<10%) of saturated fatty acids along with ~45% nutritionally undesirable erucic acid (C22:1). Moreover, with a steep decrease in arable land, scarcity of irrigation water and alteration in agro-climate, there is a pressing need to increase the yield of storage lipid having suitable fatty acid profile to meet the calorific demand by the escalating global population. This urgent necessity of improving the quality and quantity of oilseeds compels the use of metabolic engineering strategies to up- or down-regulate the crucial enzymes involved in fatty acid biosynthesis. Therefore, to improve the nutritional quality of the RBO, the *BjFad3* (*Brassica juncea* Fad3 desaturase) gene was heterologously expressed in rice bran tissues resulting in up to 10-fold increase of C18:3 content in storage lipid, upgrading the nutritionally desirable ω-6:ω-3 ratio (from ~25:1 to ~2:1) in the engineered rice-bran oil. Secondly, to shift the fatty acid flux towards the production of C18:0 at the expense of C22:1, the *MlFatB* (*Madhuca longifoila* fatty acyl-ACP thioesterase B) gene was expressed heterologously in seed tissues of *B. juncea*. This resulted in up to 16-fold increase in C18:0 along with concomitant reduction in the C22:1 content up to 71% in the seed oils of transgenic *B. juncea* lines. However, this increase in C18:0 content was found to be associated with reduced seed germination and decrease in seed lipid content. Further, to enhance the total lipid content of *B. juncea* seeds, an attempt was made by simultaneous expression of *AtWRI1* (*Arabidopsis thaliana* Wrinkled1) and silencing of endogenous *BjAGPase* (*B. juncea* ADP-glucose pyrophosphorylase) to shift the carbon flux from starch to lipid biosynthesis. The transgenic *B. juncea* lines exhibited a significant increase in the seed lipid content up to 16.9% without any detrimental effect on the structure and viability of the transgenic seeds. Taken together, the present study documented that the adopted metabolic engineering strategies not only steered to improve the quality and quantity of two oilseeds but also revealed the unique physiological role of fatty acid composition in the maintenance of seed quality and viability as propagules.