Claims

1. A host cell comprising one or more vectors comprising a polynucleotide sequence encoding:

    one or more genes of the mevalonate pathway;

    one or more genes of the lycopene pathway;

    one or more genes of the α-ionone pathway; and

    one or more hydroperoxide reductase or catalase genes.

2. The host cell according to claim 1, wherein the one or more genes of the mevalonate pathway are selected from the group consisting of *hmgS*, *atoB*, *hmgR*, *mevK*, *pmk*, *pmd* and *idi*, optionally wherein the *hmgR* gene is truncated.

3. The host cell according to claim 1 or 2, wherein the one or more genes of the lycopene pathway are selected from the group consisting of *crtBI*, *crtB*, *crtI*, a farnesyl diphosphate synthase gene and a geranylgeranyl diphosphate synthase (GGPPs) gene.

4. The host cell according to claim 3, wherein the GGPPs gene is isolated from a prokaryote, wherein the prokaryote is archaea comprising *Methanocaldococcus jannaschii or Methanococcus maripaludis*, or bacteria comprising *Methanobacterium* or *Deinococcus radiodurans*.

5. The host cell according to claim 4, wherein the bacterium is a methanobacterium.

6. The host cell according to any one of claims 1 to 5, wherein the one or more genes of the α-ionone pathway are selected from the group consisting of a lycopene cyclase gene and a CCD gene.

7. The host cell according to any one of claims 1 to 6, wherein the one or more vectors further comprises a polynucleotide sequence encoding one or more additional carotenoid cleavage dioxygenase (CCD) genes of the α-ionone pathway.

8. The host cell according to claim 6 or 7, wherein the CCD gene is a CCD1 or CCD4 gene, or a combination thereof.

9. The host cell according to claim 8, wherein one or more of the CCD1 genes is isolated from a plant selected from the group consisting of *Osmanthus fragrans*, *Arabidopsis thaliana*, *Vitis vinifera* and *Petunia hybrid* or combinations thereof.

10. The host cell according to claim 9, wherein the one or more of the CCD1 genes is isolated from *Osmanthus fragrans*, optionally wherein the one or more of the CCD1 genes isolated from *Osmanthus fragrans* (OfCCD1) is fused with an N-terminal fusion partner, optionally wherein the one or more of the OfCCD1 genes comprises the polypeptide sequence set forth in SEQ ID NO: 1.

11. The host cell according to claim 10, wherein the one or more of the OfCCD1 genes is mutated at one or more amino acid positions at the loop of the active site, wherein the mutation is a substitution of lysine at position 425 with serine, a substitution of aspartate at position number 424 with asparagine or a substitution of lysine at position number 428 with alanine, optionally wherein the one or more of the mutated OfCCD1 genes comprises the polynucleotide sequence set forth in SEQ ID NO: 2.

12. The host cell according to any one of claims 10 to 11, wherein the N-terminal fusion partner is selected from the group consisting of small ubiquitin-like modifier protein, maltose binding protein and thioredoxin (trxA), optionally wherein the N-terminal fusion partner is trxA.

13. The host cell according to claim 12, wherein the one or more of the OfCCD1 and trxA genes is overexpressed.

14. The host cell according to any one of claims 6 to 13, wherein the lycopene cyclase gene is a lycopene epsilon-cyclase (LCYe) gene.

15. The host cell according to claim 14, wherein the LCYe gene is isolated from a plant selected from the group consisting of *Lactuca sativa*, *Arabidopsis thaliana*, *Nicotiana tabacum* and *Brassica oleracea var*. *capitata*.

16. The host cell according to claim 14 or 15, wherein the LCYe gene isolated from *Lactuca sativa* is truncated at the N-terminal.

17. The host cell according to claim 16, wherein the LCYe is truncated from amino acid positions 1 to 50, optionally wherein the truncated LCYe comprises polynucleotide sequence set forth in SEQ ID No: 3.

18. The host cell according to any one of claims 1 to 17, wherein the hydroperoxide reductase or the catalase gene is isolated from a prokaryote, optionally wherein the prokaryote is *Escherichia coli*.

19. The host cell according to claim 18, wherein the hydroperoxide reductase isolated from *Escherichia coli* is alkyl hydroperoxide reductase (*ahpC/F*), wherein the catalase isolated from *Escherichia coli* is catalase G (*KatG*).

20. The host cell according to claim 19, wherein the *KatG* or *ahpC/F* is overexpressed.

21. The host cell according to any one of claims 1 to 20, wherein the one or more genes are operably linked to one or more inducible promoters, wherein the inducible promoter is a T7 promoter, optionally wherein the T7 promoter is TM1, TM2 or TM3.

22. The host cell according to any one of claims 1 to 21, wherein the host cell is modified to not express at least one gene involved in amino acid synthesis, wherein the at least one gene involved in amino acid synthesis is *aroA*, *aroB*, *aroC* and *serC*.

23. The host cell according to any one of claims 1 to 22, wherein the host cell is a bacterial cell.

24. The host cell according to claim 23, wherein the bacterial cell is an *Escherichia coli* cell.

25. A method of producing one or more apocarotenoids comprising culturing the host cell according to any one of claims 1 to 24 in a culture medium.

26. The method according to claim 25, wherein the one or more apocarotenoids is selected from the group consisting of α-ionone, β-ionone, psi-ionone, 6-methyl-5-heptene-2-one, hydroxy-ionone, retinol and retinal.

27. The method according to claim 25 or 26, wherein the culture medium comprises an inducer and one or more carbon substrates, optionally wherein the culture medium comprises at least one antibiotic.

28. The method according to claim 27, wherein the inducer is IPTG or lactose, wherein the one or more carbon substrate is glucose, glycerol or both, and wherein the at least one antibiotic is selected from the group consisting of ampicillin, chloramphenicol, kanamycin and spectinomycin.

29. The method according to any one of claims 25 to 28, wherein the host cell is cultured in the culture medium at a shaking speed of between 50 rpm and 2000 rpm.

30. The method according to any one of claims 25 to 29, wherein the yield of α-ionone in the fed-batch fermentation culture medium is at least 500 mg/L, optionally wherein the yield of α-ionone is at least 700 mg/L.

31. The method according to any one of claims 25 to 30, wherein the yield of α-ionone in the batch culture medium in the flask and the fed-batch fermentation culture medium

is determined by titer per OD600 (titer/OD600), optionally wherein the titre per OD600 is between 3-5 mg/L/OD_{600}.

32. A kit for producing one or more apocarotenoids, wherein the kit comprises the host cell according to any one of claims 1 to 24 with instructions for use.

33. The kit of claim 32, wherein the host cell is dissolved in solution or lyophilized.

34. The kit of claim 33, wherein the host cell is preserved by deep freezing.