Co-Production of Polyhydroxyalkanoates and Carotenoids by *Haloferax mediterranei* DSM 1411

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Abstract

Polyhydroxyalkanoates (PHA) are naturally occurring biopolymers that possess high performance material properties such as biodegradability and biocompatibility. PHA can be produced from renewable carbon sources. However, the industrial production of PHA is still hindered by the costly feed materials. Co-production of other high-value products in addition to PHA can be helpful in alleviating overall production of PHA. In this work, the effect of temperature on PHA and carotenoids co-production by *Haloferax mediterranei* DSM 1411 was investigated using 1% glucose as carbon source. Under batch fermentation at 37 °C, *Haloferax mediterranei* synthesized 3.37 g L^{-1} PHA with concomitant production of 0.76 mg L^{-1} of carotenoids at 144 h. The maximum dry cell weight (DCW) was 6.54 g L^{-1} and PHA content was 51.6%, with 3-hydroxyvalerate (3HV) fraction of 8.01 mol%. By increasing temperature to 42 °C, an increase in PHA and carotenoids production was noticed reaching a maximum of 3.99 g L^{-1} and 0.92 mg L^{-1}, respectively, at 120 h. Likewise, DCW was increased to 7.06 g L^{-1} and PHA content was 56.5%, with 3HV fraction of 8.42 mol%.

Introduction

Petrochemical-based plastics are widely used because of their good mechanical and thermal properties, constancy, and durability. However, the accumulation of these nonbiodegradable plastics in the landfills may have negative health and environmental impacts. Recently, many research has focused on the development and production of microbial-derived biodegradable polymers due to their low toxicity and high sustainability that will help to reduce plastic waste accumulation in the environment [1]. Among bioplastics, microbial polyhydroxyalkanoates (PHA), a class of bio-based polymer with properties very similar to synthetic plastics, have attracted research and commercial interests worldwide because of their renewability, biocompatibility, and complete biodegradability [2].

One of the marine archaea that can produce PHBV through fermentation is *Haloferax mediterranei*. PHBV is accumulated under conditions of excessive carbon content and limited nutrients (such as nitrogen, phosphorus, dissolved oxygen, and other microcomponents). The monomer ratio of PHBV affects the mechanical and physical properties of biopolymers [3].

Objectives

The objective of this work was to investigate the effect of temperature on PHA and carotenoids co-production by *Haloferax mediterranei* DSM 1411 using glucose as carbon source.

Materials and methods

- Microbial cultures were prepared by inoculation of single colonies of bacteria in 20 mL of *Halobacterium* broth in separate flasks and incubated at two different temperatures (37 °C and 42 °C) in shaking incubator at 200 rpm.
- Batch fermentation was carried out in 500 mL Erlenmeyer flasks containing 200 mL of sterile *Halobacterium* broth medium supplemented with 10 g L-1 of glucose. 10% v v^{-1} of microbial culture was then inoculated into the flasks before being incubated at different temperatures (37 °C and 42 °C).
- PHA content was determined using gas chromatography (GC, Agilent 6890A) while carotenoids were quantified using UV-Vis spectrophotometer at 476 nm.

Results and Discussion

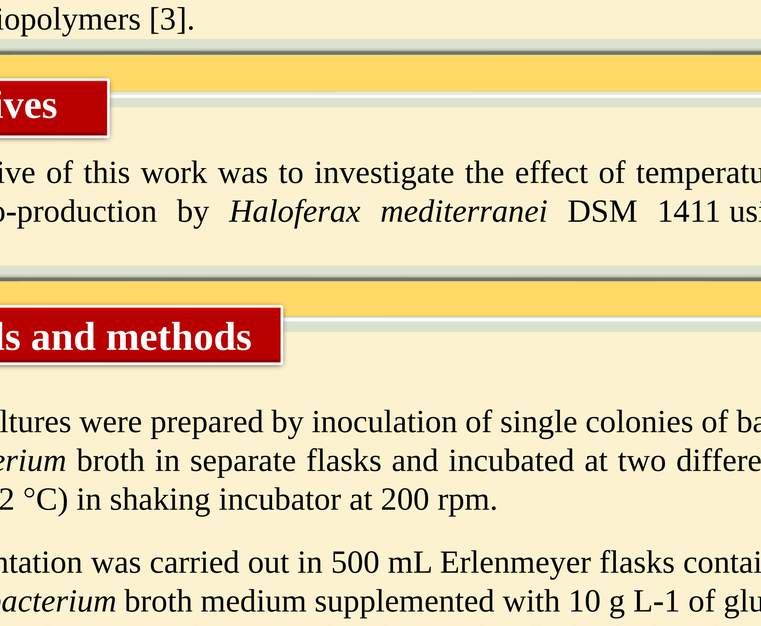

Figure 1. Effect of temperature on the growth of *Haloferax mediterranei* DSM 1411 using glucose as carbon source

Results and Discussion

As shown in **Figure 1**, a maximum OD value of 21.8 was noticed at 120 h for *Haloferax mediterranei* culture incubated at 42 °C. This value was 26% higher than that recorded for *Haloferax mediterranei* culture incubated at 37 °C.

A gradual increase in cell growth of *Haloferax mediterranei* DSM 1411 was observed simultaneously with decreasing glucose content demonstrating the ability of the investigated microorganism to use glucose as carbon source. A maximum DCW of 6.54 g L^{-1} was obtained at 144 h of cultivation with PHA accumulation of 3.37 g L^{-1} (51.6% of DCW) with 3HV fraction of 8.01 mol%, and carotenoids production of 0.76 mg L^{-1} (**Figure 2)**.

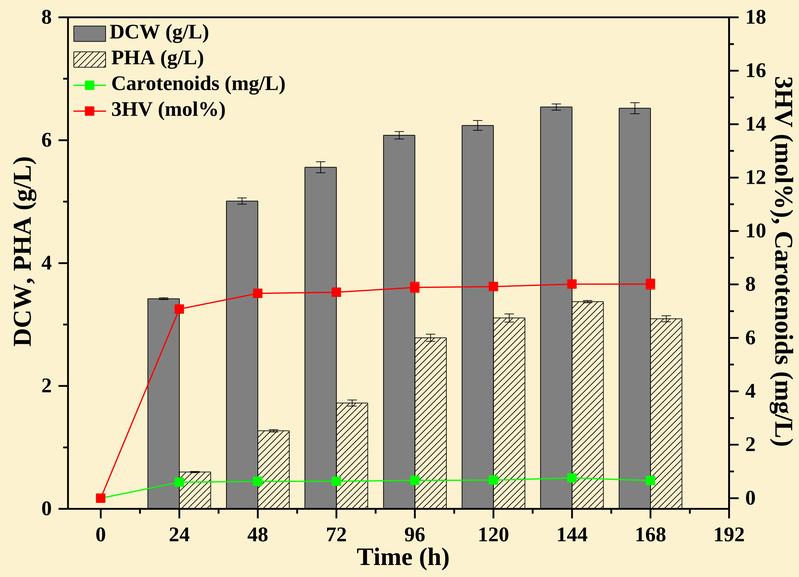

Figure 2. Time profile of DCW, PHA, 3HV, and carotenoids production by *Haloferax mediterranei* DSM 1411 cultivated at 37 °C using glucose as carbon source.

As shown in **Figure 3**, increasing temperature from 37 °C to 42 °C led to an increase in both PHA and carotenoids production reaching a maximum of 3.99 g L^{-1} and 0.92 mg L^{-1}, respectively, at 120 h. Likewise, DCW was increased to 7.06 g L^{-1} and PHA content was 56.5%, with a 3HV fraction of 8.42 mol%.

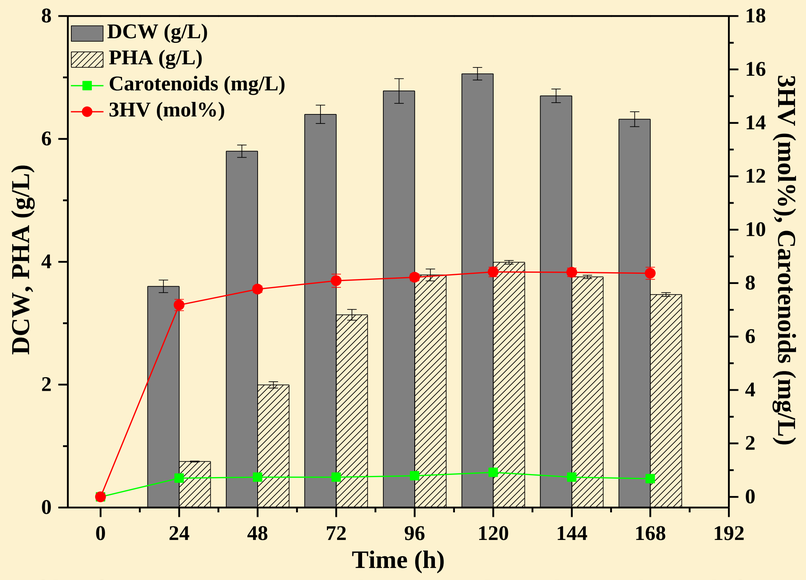

Figure 3. Time profile of DCW, PHA, 3HV, and carotenoids production by *Haloferax mediterranei* DSM 1411 cultivated at 42 °C using glucose as carbon source.

Conclusion

This study underlines the efficiency of *Haloferax mediterranei* DSM 1411 when cultivated at 42 °C in converting glucose into PHA and carotenoids . However, further improvement in the fermentation strategies including the use of co-substrates and metabolic flux balance is required to achieve higher yields for both PHA and carotenoids.

References

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