Pigments produced by the bacteria belonging to the genus *Arthrobacter*  
Nuthathai Sutthiwong, Yanis Caro, Mireille Fouillaud, Philippe Laurent, A. Valla, Laurent Dufossé

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Pigments produced by the bacteria belonging to the genus *Arthrobacter*

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For several decades, pigments have been used as a taxonomic tool for the identification and classification of bacteria. Nowadays, pigment producing microorganisms attract wide interest in many scientific disciplines because of their biotechnological potential. With the growing concern in microbial pigments because of factors such as production independent from seasons and geographical conditions, novel combinations of microorganisms and pigments that can be extracted from the biomass or the culture medium are being evaluated.

**Carotenoids**

Two psychrophilic bacteria, *Arthrobacter glaciobacter* and *Arthrobacter flavus* sp. nov., have been discovered as yellow pigments producers. Their pigments were characterized as three *C₆₀*–carotenoids with molecular formulae *C₅₀H₇₄O₆* (Fig. 2). More recently, *Arthrobacter aralensis*, one of the major bacterial species found at the surface of smear-ringed cheeses, has been reported as a yellow pigment producer, pigments which were tentatively identified as carotenoids. Furthermore, the carotenoids excreted by this strain may also belong to the *C₅₀* subfamily.

**Indigoidine**

Brilliant blue in color and water-insoluble pigments produced by *Arthrobacter actrocyaneus* and *Arthrobacter polychromogenes* were identified as indigoidine and its derivatives (Fig. 3).

Another strain which produces a blue pigment related to indigoidine is *Arthrobacter crytaketoepides*, although colonies of this *Arthrobacter* appear brilliant green in color. The strain *Arthrobacter oxydans* has also been reported that it produces the blue pigment which is also related to indigoidine.

**Porphyrins**

Many bacteria in the genus *Arthrobacter* produce red pigment porphyrins. A compound belonging to the family of red extracellular pigments porphyrin was isolated in *A. phototrophus*, *A. phagophilus* and *A. aurinae*, and identified as coproporphyrin III, *C₅₅H₇₄N₄O₃* (Fig. 5). Another form of porphyrin was also described from pigment excreted by *A. lividus*. This pigment was identified as uroporphyrin IV, *C₅₅H₇₄N₄O₃* (Fig. 6).

**Carotenoids**

Red-carotenoids accumulation in *Arthrobacter agilis*, a psychrophilic bacterium isolated from Antartic sea ice, has been investigated. The pigments were identified as a series of geometrical isomers of the *C₅₀* carotenoid bacterioruberin (Fig. 7). Another *Arthrobacter*, *Arthrobacter roseniae* sp. nov., has been also reported to produce red-carotenoids.

**Indochrome**

Apart from indigoidine, other chromatophores of the water-soluble pigments produced by *A. atrocyaneus* and *A. polychromogenes* were identified as indochromes with chemical formulae *C₅₀H₇₄N₄O₃* (Fig. 4). These pigments were released into the culture liquid only by indigoidine-producing bacteria.

**Riboflavin**

Riboflavin *Arthrobacter polychromogenes* isolated from soil excreted a yellow pigment during exponential growth, pigment which was identified as riboflavin, *C₅₀H₇₄N₄O₃*, also known as vitamin B₂ (Fig. 1).

**The genus Arthrobacter**

The genus *Arthrobacter* is one among the most diverse microbial groups which have been found to produce pigments. Most of bacteria in this genus produce a range of pigments with orange, yellow, blue, green or red hues. At the present time, 80 species in this genus have been accepted by taxonomists. However, the purification and characterization of pigments produced by bacteria belonging to the genus *Arthrobacter* have not been frequently conducted up to the complete description of the chemical structures and the role(s) of pigments in these strains.

**Conclusion**

Pigments produced by microorganisms gain interest from the scientific community not only as a taxonomic tool to identify and classify the microorganisms but also for a commercial purpose. The utilization of natural pigments in manufacturing has been increasing since the nineties due to the consumer awareness to the toxicity problems linked to synthetic pigments. Microorganisms seem to be a reasonable choice for colorant production due to biotechnological advantages e.g. production regardless of season and geographical conditions; controllable and predictable yield. The genus *Arthrobacter* is one among diverse microorganisms which has been found to produce pigments with several hues. Furthermore, these bacteria have been commonly found in various environments. By these advantageous points, the study of the bacteria belonging to the genus *Arthrobacter* might lead to the discovery a novel source of natural colorants.
PIGMENTS PRODUCED BY THE BACTERIA BELONGING TO THE GENUS ARTHROBACTER

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1 Agricultural Technology Department, Thailand Institute of Scientific and Technological Research, Pathum Thani, Thailand
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Abstract
Since several decades, pigments have been used as a taxonomic tool for the identification and classification of bacteria. Nowadays, pigment producing microorganisms have been also widely interested in scientific disciplines because of their biotechnological potential. With the growing interest in microbial pigments because of factors such as production regardless of season and geographical conditions, novel microorganisms which their pigments can be extracted are being evaluated. In the nature, a numerous number of microorganisms e.g. yeast, fungi, algae and bacteria produce pigments. The genus Arthrobacter is one among diverse microorganisms which has been found to produce pigments. Most of bacteria in this genus produce a range of pigments. Several previous studies show that pigments produced by bacteria belonging to the genus Arthrobacter have various hues depending on the chromophore which is present, e.g. yellow by carotenoid and riboflavin, green and blue by indigoidine and indochrome, and red by porphyrins and carotenoids. Since long time numerous strains in this genus have been reported that their colonies are colored; however, the purification and characterization of their pigments were not frequently conducted until well know chemical structures and role in these strains. Consequently, a study of pigments produced by the genus Arthrobacter may be worthy to play attention for discovering a novel source of natural colourants.

References
7th International Congress on Pigments in Food

June 18-21, 2013
Novara, Italy
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                Institute of Food Chemistry, TU Braunschweig, Braunschweig, Germany |
| 18.00 - 18.20 | INTRAMOLECULAR AND INTERMOLECULAR FACTORS AFFECTING THE DEGRADATION KINETICS OF XANTHOPHYLL ESTERS
                Jarén-Galán M., Hornero-Méndez D., Pérez-Gálvez A.
                Food Biotechnology Department, Instituto de la Grasa (CSIC), Sevilla, Spain |
| 18.20 - 18.40 | ANALYTICAL AND TECHNOLOGICAL ASPECT OF CAROTENOIDS FROM RED-BELL PEPPER
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<td></td>
<td>¹ Institute of Sciences of Food Production, CNR, Lecce, Italy; ² Department of Sciences and Technologies for Agriculture, Forestry, Nature and Energy, Tuscia University, Viterbo, Italy</td>
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<td>¹ Department of Plant Biology and Ecology, University of Basque Country, UPV/EHU, Bilbao, Spain</td>
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<td>Food Biotechnology Department, Instituto de la Grasa (CSIC), Sevilla, Spain.</td>
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<td>(Siran Vocational School, Gumushane University, Gumushane, Turkey)</td>
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<td>OXIDATION ROUTES FOR BETACYANINS</td>
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<td>¹Department of Analytical Chemistry, Cracow University of Technology, Cracow, Poland; ²Chemistry Research, FutureCeuticals Inc., Momence, IL, USA; ³Applied BioClinical Inc., Irvine, CA, USA.</td>
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| 14.40 - 15.00 | INFLUENCE OF SOME OAK WOOD COMPONENTS ON STABILITY OF MALVIDIN-3-GLUCOSIDE AND CHROMATIC CHARACTERISTICS IN MODEL WINE SOLUTIONS  
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Agrarian Higher School, Polytechnic Institute of Viseu (CI&DETS), Viseu, Portugal. |
| 15.00 - 15.20 | STABILIZATION OF ANTHOCYANIN–METAL CHELATES WITH HYDROCOLLOIDS FOR THEIR APPLICATION AS BLUE FOOD COLORANTS  
Buchweitz M., Kammerer D. R., Carle R.  
Institute of Food Science and Biotechnology, Chair Plant Foodstuff Technology, Hohenheim University, Stuttgart, Germany. |
| 15.20 - 15.40 | STABILISATION OF BEETROOT DERIVED BETANIN THROUGH INTERACTION WITH AN EXTRACT FROM BARBADOS CHERRY  
Kendrick A.  
Diana Food Division, Rennes, France. |
| 15.40 - 16.20 | Plenary LECTURE Prof. G. CRAVOTTO (University of Turin, Italy)  
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<td>NATURAL HYDROXYANTHRAQUINOID PIGMENTS: CURRENT SITUATION AND FUTURE OPPORTUNITIES IN FOOD Caro Y., Fouillaud M., Laurent P., Dufossé L. Laboratoire de Chimie des Substances Naturelles et des Sciences des Aliments, Université de la Réunion, Sainte-Clotilde, Ile de la Réunion, France</td>
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Schweiggert R.M.\(^1,2\), Kopec R.E.\(^2,6\), Cooperstone J.L.\(^2\), Villalobos-Gutierrez M.G.\(^3\), Högel J.\(^4\), Young G.S.\(^5\), Francis D.M.\(^7\), Quesada S.\(^8\), Esquivel P.\(^9\), Schwartz S.J.\(^2\), Carle R.\(^1\) |
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Department of Food Science, University of Campinas, Campinas, Brazil. |
| 10.00 - 10.20 | | A MINI REVIEW ON THE COLOURLESS CAROTENOIDS PHYTOENE AND PHYTOFLUENE. ARE THEY INVISIBLE BIOACTIVE COMPOUNDS?  
Meléndez-Martínez A. J.\(^1,2\), Mapelli Brahm P.\(^2\), Stinco C.M.\(^2\) and Wang X-D.\(^1,3\)  
\(^1\)J. Mayer USDA Human Nutrition Research Center on Aging at Tufts University, Boston, MA; \(^2\)Food Colour & Quality Laboratory, Department of Nutrition and Food Science, Universidad de Sevilla, Sevilla, Spain; \(^3\)Department of Nutritional Science, Gerald J. and Dorothy R. Friedman School of Nutrition Science and Policy, Tufts University, Boston, MA. |
| 10.20 - 10.40 | | DISSECTING THE PHARMACOPHORE OF CURCUMIN: TWO CASE STUDIES  
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| **P 03**: Effect of esterification on thermal stability and antioxidant activity of zeaxanthin  
Pintea A., Bunea A., Socaciu C. |
| **P 04**: Measurement of enzymatic hydrolysis of lutein esters from dairy products during *in vitro* digestion  
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| **P 05**: Oil bodies as a potential microencapsulation carrier for astaxanthin stabilization and safe delivery  
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| **P 06**: Microencapsulation of astaxanthin oleoresin from *Phaffia rhodozyma*  
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| **P 07**: Effect of genotype and growing conditions on lutein and β-carotene content of green leafy *Brassica* species  
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| **P 08**: Effect of processing on content of vital carotenoids in new vegetable puree  
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| **P 09**: Effect of addition of sodium erythorbate and urucum on the lipid oxidation in pork meat  
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| **P 10**: Identification of *Cionosicyos macranthus* carotenoids  
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| **P 12**: Evaluation of carotenoids and capsaicinoids content in powder of chilli peppers during one year of shelf-life  
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| **P 13**: Carotenoids in red fleshed sweet oranges  
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| **P 14**: Colour changes in heat-treated orange juice during ambient storage  
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| **P 15**: Carotenoid deposition and profiles in peach palm (*Bactris gasipaes* Kunth) fruits, and their implication on its nutritional potential  
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| **P 16**: Deposition of lycopene, β-carotene, and β-cryptoxanthin in different chromoplast substructures in papaya fruits  
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| **P 17**: Evaluation of quality parameters and carotenoid content of three cultivars of mango (*Mangifera indica* L.) from Réunion island  
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| **P 18**: Genuine profiles and bioaccessibilities of carotenoids from red- and yellow-fleshed *Mamey sapote* (*Pouteria sapota*) fruits  
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| **P 19**: Transgenic tomatoes and their carotenoid and flavour profiles  
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