Physical properties of gelatin active films incorporated with cellulose nanocrystals and Pitanga leaf extract encapsulated into double emulsion

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Edible films are thin and flexible materials produced from biopolymers. When carrying different components, such as active compounds (i.e., plant extracts with antioxidant and/or antimicrobial activities or encapsulated systems) and reinforcement nanoparticles, they are considered as active nanocomposites. The aims of this study were to produce active gelatin composite films by incorporation of “Pitanga” leaf extract (PLE) not encapsulated (NE) and encapsulated in W/O/W emulsion (DE) and of cellulose nanocrystals (NC) extracted from soy straw. The active nanocomposite films were produced by the casting method, using 4g gelatin/100g film-forming solution, 25g glycerol/100g gelatin, 0.25g NE or DE/100g gelatin and 4.5g NC/100g gelatin. Therefore, 6 treatments were produced: (i) Active films with NE without NC (F-NE) and with NC (F-NE/NC), and with DE without NC (F-DE) and with NC (F-DE/ NC), and (ii) control films without PLE and without NC (F-C) and with NC (F-NC). All treatments were then characterized in terms of microstructure, physicochemical, mechanical, and UV/Vis light barrier properties and antioxidant activity (AA). The results obtained were submitted to analysis of variance (one-way and two-way) and Tukey's test. The internal structure of the films (thickness ~80µm, $p>0.05$) was smooth and homogeneous in the films without DE and without NC, and less smooth and homogeneous in the DE and/or NC films. The presence of DE and NC decreased the water vapor permeability (WVP) of the films, especially in F-DE/NC, which showed lower WVP ($p<0.05$). The F-DE and F-DE/NC showed higher ($p>0.05$) tensile strength (80.5 and 150.0MPa, respectively) than the other treatments. The films showed good UV/Vis light barrier properties, being F-DE/NC>F-DE>F-NE/NC>F-NC>F-NE>F-C. The addition of NE and DE conferred AA to the films, and the F-DE kept the highest ($p<0.05$) AA. As conclusion, the addition of PLE activated gelatin films and mainly improved the mechanical and barrier properties to UV/Vis light, especially when PLE was encapsulated in W/O/W emulsion and combined with cellulose nanocrystals.