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Editorial

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Role of the Rheology in the New Emerging Technologies as 3D Printing

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Nowadays, the thermo-rheological measurements are essential for all processing technologies, being critically relevant in those emerging technologies as 3D printing, as indicated in several comprehensive works [1,2]. Monitoring of the thermo-rheological behaviour of the materials during processing is a key factor in their manufacturing [3]. The current trends in rheological measurements for 3D printing are: steady-shear flow curves (apparent viscosity *vs.* shear rate), oscillatory data (viscous and elastic moduli *vs.* angular frequency), creep and recovery curves (compliance modulus *vs.* time), temperature sweeps (apparent viscosity or viscoelastic moduli *vs.* temperature) or tri biological profiles. Above measurements have been extensively used to characterize materials and select suitable candidates for 3D-printing [4]. In this context, relations between materials mechanical characteristics and 3D printability have been intended [5].

It should be highlighted that 3D printing is more than just an innovation – it is the future of the manufacturing industries [6]. Most of the research works on emerging printing technologies for non-food applications has been developed based on oil printing materials, which are still employed since they have a higher softening point and make more flexible models that will bend before they break [7]. Namely, oil-based printing materials have been extensively used in 3D printing for non-food applications because their adequate mechanical features, as aforementioned [7]. For applications as those from food industry, where oil-based materials are not suitable, noteworthy efforts have been made to achieve/pre-process materials suitable for 3D printing and raise their thermal stability features during the post-processing. In this line, in a recent comprehensive review [8] the available printing materials were classified into two categories based on their printability characteristics: natively printable and non-printable traditionally materials. All 3D printing applications are an enormous challenge, with potential applications in a broad range of fields such as industrial design, aerospace, medical, tissue engineering, architecture, pharmaceutical and even food [7,9]. This emerging technology has the potential to revolutionize not only the non-food industries but also the food production by boosting culinary creativity, food sustainability and nutritional customizability [10], but still many research works are necessary to extend their versatility and overcome the scientific and technical barriers, transforming the challenge in reality.

An optimum thermo-rheological characterization of different mixtures commonly used in 3D printing is crucial to select the best processing conditions and extend the understanding framework of these materials applications [9], consequently the rheological features of printable materials must be carefully monitoring during processing to a successful manufacturing [3]. It should be remarked that the preparation of inks with proper rheology performance is critically relevant for extrusion based 3D printing as reported elsewhere [5]. In order to make the ink mixture printable, proper rheology performance is required. Latter authors indicated that the ink should possess shear-thinning properties, allowing smooth extrusion from the nozzle under shear, and the extruded ink must be strong enough to maintain its shape and withstand the weight of post-extruded inks at rest stage.

In a comprehensible review [3], it was explained that the melt polymers processing is highly dependent on their rheological properties. Moreover, it was pointed out that the rheological measurements should be considered as a more central part of the material characterization tool box when selecting suitable candidates for 3D printing. Later on, it was also indicated that the ability to control the materials rheology yields a flexible manufacturing route to fabricating 3D metal parts with full density and complex geometries [1]. It should be noted that especially important is the study of the rheology of bubbly liquids in order to obtain light printable structures or aerated foodstuff with optimal mechanical properties [11]. Mainly, for non-Newtonian materials, since they have been scarcely studied under aerated conditions due to their complexity of these materials and the existent theories for Newtonian ones cannot be applied. However, the relations between the thermo-rheological characteristics of hydrogels and 3D materials printability have not been extensively investigated [4]. Some recent works have suggested, as a relevant tool, the use of Computational Fluid Dynamics models to establish a connection between the paste thermo-rheology, printing parameters and the line profile [12].

To conclude this editorial, we should show that this rapidly developing technology has huge potential in order to improve the population wellbeing, being critically relevant the selection of suitable printable materials and the corresponding thermo-mechanical characterization. In this context, further research into new materials, as biopolymers, suitable for 3D printing and the corresponding thermo-rheological measurements is essential in order to improve the current mechanical properties of available products and extend the possibilities towards innovative applications. The future of biopolymer materials lies in demonstrating that plant-based materials from natural, underused and renewable sources can outperform their traditional, oil-based counterparts. Biopolymers have recently gained attention for new manufacturing technologies as 3D printing since they are much easier to work with during processing, and are food safe and odour free [12]. Particularly, 3D biopolymer-based food printing provides an enormous potential for preparing customizable foods with improved nutritional features through enriched foods, tailored to the needs of specific target groups such as people with food intolerances, athletes, astronauts, baby's or elder people. The social experience in the design freedom a new food is also essential, because social media will support recipes and cooking pre- and post- fun communities.

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