particles mentioned by Bhandari [37] since the pectin's nature, and the number of dispersed particles are determinants in the flow pulps properties. This pseudoplastic behavior can be explained by breaking a reticular structure of polysaccharide molecules during shearing; consequently, a lower viscosity results from the increase in the deformation rate [28]. In the developed mechanical spectrum, the variation of the melon pulp viscosity to temperature does not significantly differ, allowing it to be used in different industrial processes that include temperature variations for the development of new products from this raw material.

Results with similar behavior have been previously found in studies of the squash pulp (Cucurbita moschata) [38], papaya pulp (Carica papaya) [11], the jew's ear *(Auricularia auricula-judae*) [39], and in mango, papaya and peach purees [40]. Due to the rheological behavior presented by the melon pulp (Cucumis melo), the given values of viscosity vs. shear rate were adjusted to the Carreau-Yasuda model (equation 2) [41], which presented a minimum correlation coefficient R^2 of 0.97264.

$$\eta = \eta_\infty + (\eta_0 + \eta_\infty)[1 + (\lambda_c \gamma)^a]^{\frac{n-1}{a}} \quad (3)$$

When subjected to low deformation velocities, this model describes fluids that behave like Newtonian fluids, being treated as constants. When they undergo a considerable increase in deformation speeds, they begin to behave like a non-Newtonian fluid, in such a way that their viscosity decreases, which is described by the law of power. On the other hand, when they begin to reach very high deformation speeds, it tends to be constant to behave like a Newtonian fluid [42]. This model consists of five parameters, where η_0 corresponds to the Newtonian viscosity at low deformation speed values, η_∞ is the Newtonian viscosity for values of deformation speed when it tends to infinity, λc is a Carreau time constant, a is the Transition control factor that is a dimensionless constant, n corresponds to the parameter of the power-law model. In the case that n = 1, the model is reduced to the linear Newtonian model, for example, the Navier-Stoke equation. For fluidifying liquids, n <1, the viscosity decreases with the increase in deformation speed, indicating viscosity dependence on shear rate [43].

The parameters used to adjust the Carreau-Yasuda model are shown in Table 1. The results proved that the "shear-thinning" re-fluidizing behavior, since the flow behavior index values were lower to unit n <1, for different temperature conditions. The viscosity decreases with the speed of deformation. Therefore, it is not considered an increase or decrease in the fluidifying character of the pulps. However, temperature changes affect viscosity values. The model adequately adjusts the steady flow behavior of melon pulp (Cucumis melo), with an average of correlation coefficients ($R^2 = 0.9866$).

As the melon pulp (*Cucumis melo*) presents similar rheological behavior to other food materials, it can also be adjusted to other rheological models that allow the flow description, mainly fruit pulps. Among the models used for this characterization, we find the mathematical model of the power law of Ostwald de Waele, which is the case of a squash (Cucurbita moschata) and sesame (Sesamum indicum) cream [44], some beet pulp homogenized under pressure [45], the *nispero* pulp (*Achras sapota*) [21], varieties of guava pulp (Psidium Guajaba L.) [46], among other things. Among the models, the one that best adapts to describe inelastic fluids independent of time is the model of Herschel and Bulkley as in the case of taro homogenized pulps (Colocasia esculenta (L). Schott) [47]. The temperature effect on the apparent viscosity of fluids in food (at constant cutting speeds) could be explained by the Arrhenius equation [48], which is expressed:

$$\eta = Aexp\left(\frac{E_a}{RT}\right) \quad (4)$$

TABLE II
RHEOLOGICAL PARAMETERS OF THE CARREAU-YASUDA MODEL FOR THE MELON PULP VISCOSITY AT DIFFERENT SHEAR RATES, AT TEMPERATURES OF 10-60°C.

Temp.	η_0	η_∞	λ_c	a	n	R^2
10°C	13745.73	4.30×10^{-4}	2164.56	0.90	0.08	0.997
20 °C	27147.06	2.0×10^{-3}	5111.16	6.96	0.12	0.972
25°C	14898.33	4.21×10^{-3}	1000.19	2.12	0.02	0.981
40°C	21211.88	1.79×10^{-4}	4096.10	0.80	0.09	0.993
60°C	24492.24	2.5×10^{-2}	4721.49	3.01	0.10	0.987

Where A is the pre-exponential factor and Ea the activation energy, which is a parameter that evaluates the thermal dependence, for the same temperature increase, when the value of activation energy is higher, then the effect it produces is more significant (J / mol), R is the gas constant (8.314 J / mol K), and T is the temperature (K). In which the apparent viscosity decreases in an exponential function with temperature [49]. The deformation velocity of 17 s^{-1} was selected for this case, considering that the flow operations (mixing and agitation) in pipes oscillate in speeds ranges of shear of 10-1000 s-1 [50]. Likewise, it observed that the melon pulp is appropriately adjusted by the Arrhenius equation (4) because the values of correlation coefficients (R^2) were higher than 0.92.

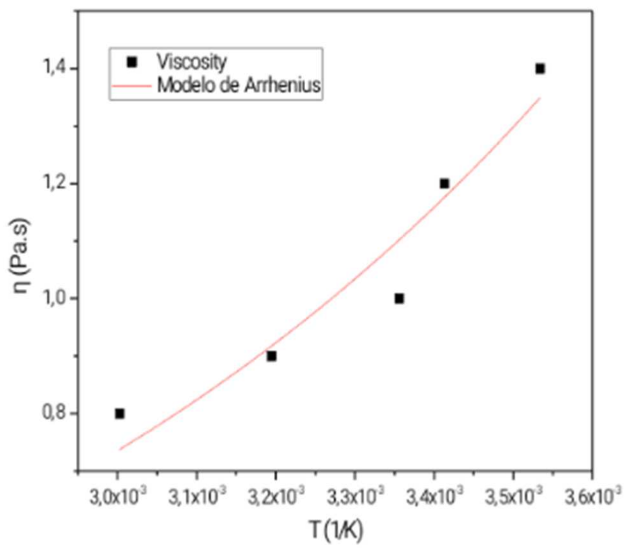

Fig. 2 Variation of the values of η obtained at 17 s-1 as a function of temperature and adjustment to the Arrhenius equation.

Activation energy values for melon pulp (*Cucumis melo*) in this case (Ea = 20601 J / mol) was higher than those reported in plum pulp (Ea = 15080 J / mol) [51].; papaya pulp (Ea = 10500 J / mol) [11] and tomato paste (Ea = 8600-13000 J / mol) [52]. The value of activation energy indicates how strong is the interaction between polysaccharide chains and internal molecular interactions. The higher the activation energy, the better the temperature sensitivity [53]. Therefore, the melon pulp's internal structure is more sensitive to temperature than those pulps fruit cited. The activation energy is necessary for the molecules' movement when the liquid's temperature increases; they decrease more easily due to the higher activation energy at high temperatures. In this case, an increase in temperature causes a decrease in the liquid phase's viscosity, increasing the suspended particles' movement and causing a decrease in the pulp viscosity [54].

IV. Conclusion

The temperature changes did not significantly affect the melon pulp's viscosity in the range of strain rate studied, facilitating the use of this raw material in different pulp transformation processes. It was found that the activation energy is high compared to different fruit pulps studied, which means that its high content of water and fiber. Therefore, care must be taken when reaching high temperatures close to 100 °C, which can cause unfavorable changes that significantly affect the rheological and nutritional properties.

The results provide relevant information on the rheological behavior of melon pulp that could have a potential application in the agro-industrial sector for the design of processes that include the elaboration of products with added value and specialized equipment design to process melon pulp, controlling variables such as pH, temperature, humidity, among others.

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