DESCRIPTIVE STATISTICAL ANALYSIS OF VEGETABLE OILS COMBUSTION IN A COMMERCIAL BURNER TO ESTABLISH OPTIMAL OPERATING CONDITIONS

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ABSTRACT: This work studies the combustion of raw and refined sunflower (VSfO and RSfO) and raw rapeseed oils (VRpO) for heating purposes, in a low-pressure auxiliary air fluid pulverization burner. Firstly, the fatty acid profile as well as physical properties of these biofuels were determined by standard methods. Then, the authors performed the combustion tests selecting different fuel flow and airflow rates. Variations of CO, NOx and CxHy as well as combustion performance proved that raw and refined vegetable oils evidence similar behavior in the combustion processes. With the aim of determining the significance of the control parameters, fuel flow and airflow rates, on the experimental variables (CO, NOx, CxHy and η) an analysis of the variance ANOVA was performed. This study showed that both, airflow and fuel flow rates, have a statistical significant effect on the dependent variables (CO, NOx and combustion performance) except for CxHy. Optimal operating conditions were established from the interaction plots for the highest combustion performance and pollutant emissions below the limits legally established. The authors found, that emissions of CO and NOx displayed opposite trends, and extremely low NOx emissions and good combustion performance was achieved under conditions of fuel flow C6 and airflow Amin.

1. Experimental facility

1: Burner
2: Valve system
3: Tank for Vegetable Oils
4: Diesel fuel tank
5: Combustion chamber
6: Refrigeration air
7: Gas analyzer

1: AR-CO model BR 5. It is appropriate for burning liquid fuels with kinematic viscosities ranging from 26 to 112 $mm^2 \cdot s^{-1}$ (at 50 °C)

2. Fatty acid composition (% $m \cdot m^{-1}$) obtained by GC

Fatty acid		VSfO	RSfO	VRpO
Myristic	C14:0	0.07	0.07	0.05
Palmitic	C16:0	6.1	6.0	4.6
Palmitoleic	C16:1	0.1	0.1	0.2
Margaric	C17:0	0.04	0.04	0.05
Stearic	C18:0	4.3	4.1	1.7
Oleic	C18:1	25.3	29.5	62.9
Linoleic	C18:2	61.9	58.5	20.3
Linolenic	C18:3	0.12	0.1	7.6
Arachidic	C20:0	0.32	0.3	0.6
Gadoleic	C20:1	0.2	0.2	1.2
Behenic	C22:0	1.0	0.8	0.3
Lignoceric	C24:0	0.3	0.3	0.1

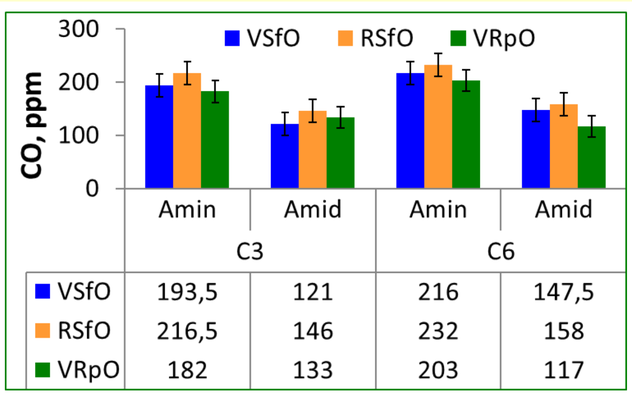
3. Physicochemical Properties

- The VOs produced in Spain from oleaginous plants are Rapeseed, RpO and Sunflower, SfO.
- VOs contain no organic nitrogen and sulphur compounds.
- The highest viscosity values, highest heating value and highest percentage of carbon corresponded to VRpO.

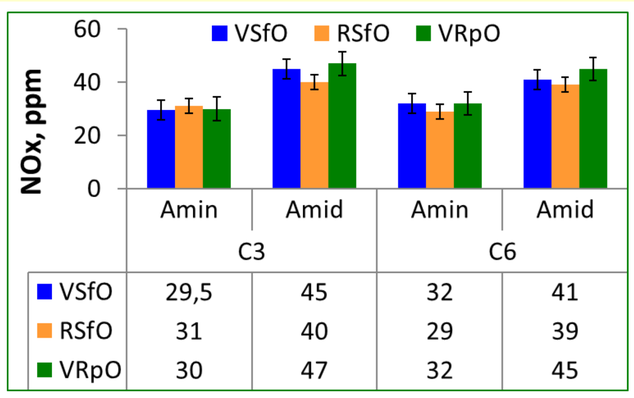
4. Experimental Procedure

- Tests were carried out selecting two **fuel flow rates** (C3, C6) and two **secondary airflows** (Amin, Amid)
- Three measurements were taken in each of the burner operating conditions

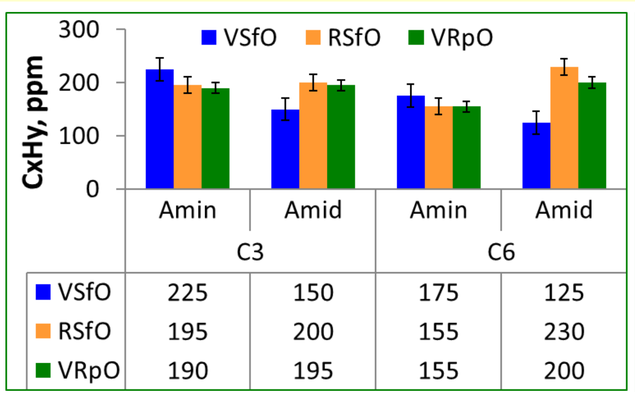
5. Variations of CO, NOx, CxHy emissions, in ppm, and combustion performance, in %, with fuel flow (C3 and C6) and secondary airflow (Amin and Amin) of each VO studied.



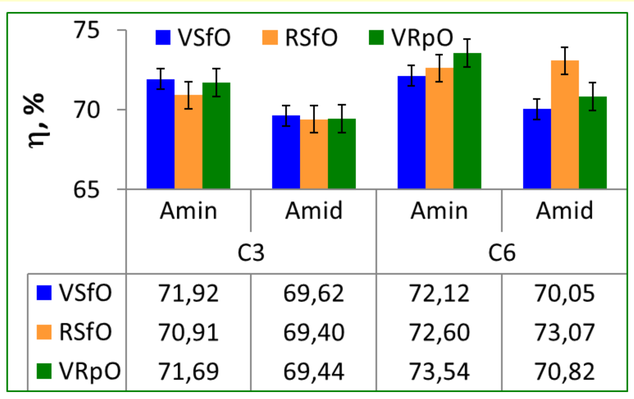
	C3 Amin	C3 Amid	C6 Amin	C6 Amid
VSfO	193,5	121	216	147,5
RSfO	216,5	146	232	158
VRpO	182	133	203	117



	C3 Amin	C3 Amid	C6 Amin	C6 Amid
VSfO	29,5	45	32	41
RSfO	31	40	29	39
VRpO	30	47	32	45



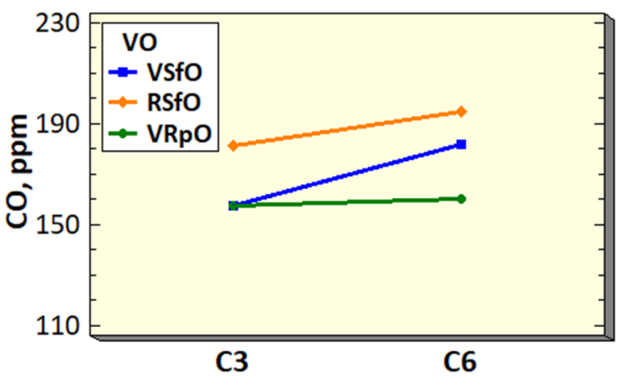
	C3 Amin	C3 Amid	C6 Amin	C6 Amid
VSfO	225	150	175	125
RSfO	195	200	155	230
VRpO	190	195	155	200

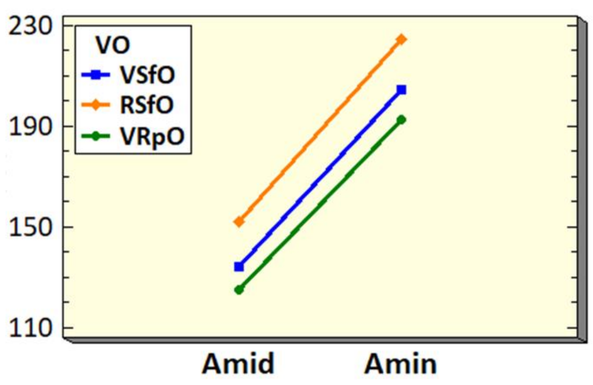


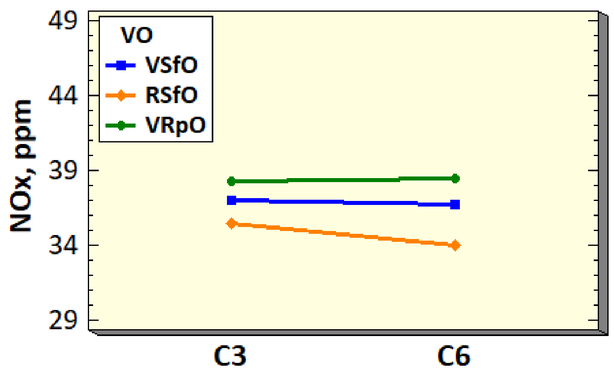
	C3 Amin	C3 Amid	C6 Amin	C6 Amid
VSfO	71,92	69,62	72,12	70,05
RSfO	70,91	69,40	72,60	73,07
VRpO	71,69	69,44	73,54	70,82

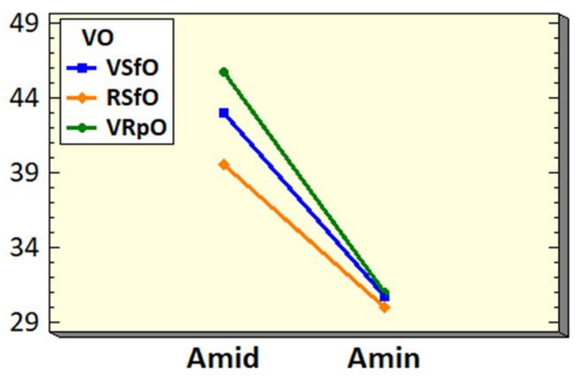
VSfO, RSfO and VRpO evidence similar behaviour in the combustion processes

6. Interaction plots of the variability of CO, NOx, CxHy emissions, in ppm, and combustion performance, in %, for VSfO, RSfO and VRpO with the factors fuel flow (C3, C6) and airflow (Amid, Amid) rates.

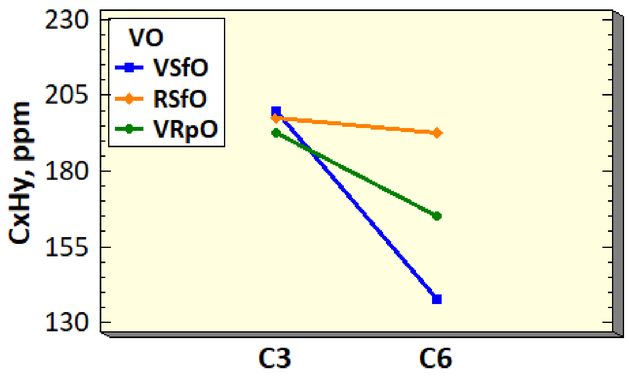


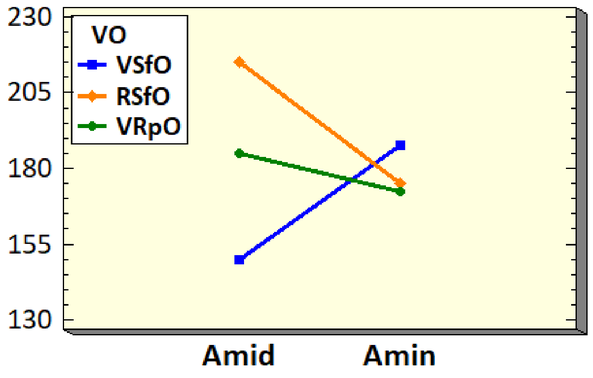


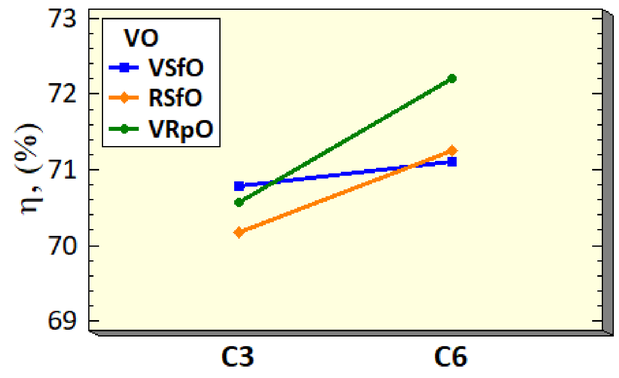


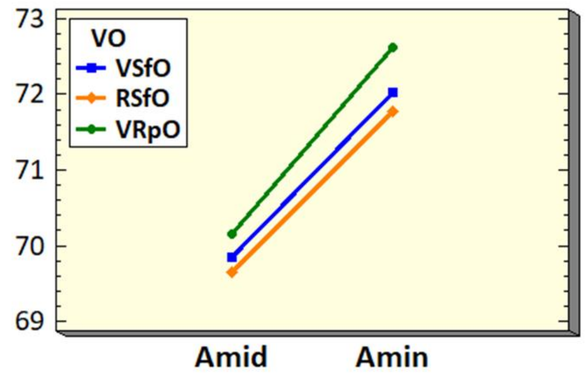


CO emissions increased when the airflow was reduced for all VOs. NOx emissions varied inversely and decreased when the airflow was reduced









CxHy emissions decreased as the fuel flow increased. Combustion performances increased as the airflow was reduced and the fuel flow increased

CONCLUSIONS:

- **The emulsion burner is suited to performed combustion of raw vegetable oils:**
  - ✓ **This represents a major economic saving, since no refining process is required.**
- **ANOVA results showed that,**
  - ✓ **Airflow and fuel flow have a statistically significant effect on CO and NOx emissions as well as for combustion performance.**
  - ✓ **For CxHy, only fuel flow proved to have a significant effect.**

From the interaction plots,

- **The optimal operating conditions for good combustion performance and low NOx emissions were C6 and Air min for all VOs studied**
- **Extremely low NOx emissions were obtained in all tests performed (< 49 ppm).**
- **CO emissions below the lowest limit allowed by the European legislation were obtained.**

ACKNOWLEDGMENTS: The financial support for this work provided by the Junta de Castilla y León (ERDF, Ref.: VA272P18) is gratefully acknowledged.

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