Milk Pasteurization system with TLUD stove as a combustion device
Sample system 500L milk pasteurization system

System overview:

A two pipe concentric tube heat exchanger, a double vat, water pumps and 2 TLUD stoves of each of 150 Litre capacity. Each stove holding up to 12kg of papyrus fuel and pasteurization occurs within one hour. System efficiency ranges from 25 to 34% and temperatures at the stove outlets can reach up to 800°C.

Fuel: Papyrus

- Availability: Dominates 3600 square kilometres of permanent wetland area in the country
- Crop cycle: 150 days (grows up to 5cm a day)
- Average packing factor in TLUD stove to ensure a smooth burn: 70- 80g/L
- Packing arrangement: Papyrus stocks at least 95% of the length of the fuel chamber are placed into the stove vertically

Energy savings:

Processing 2000L of milk for cheese making using a direct heating method with charcoal as a fuel uses an average of 5 bags (each about 50kg) of charcoal daily .The heat exchanger TLUD combination will result in up to 50% in energy savings: For 500L one requires less than 25kg of papyrus for pasteurization within a period of one hour.

Daily production capacity [L]	Fuel	Mass of fuel [kg]	Cost/kg in UGX	Daily cost UGX
2000L	Papyrus	~100(12.5kg/stove)	Assume 340 (250)	34000
2000L	Charcoal	~250 (50kg/bag)	340	85000

Thermal efficiency $\in = \frac{(m_m \Delta T_m + m_w \Delta T_w)C}{m_f E_C}$

Assumptions: The specific heat capacity and density of are equal to that of water

Constants	Mass of milk	m_m[kg]	500
	Energy content	Charcoal	Papyrus
	E_C [MJ/kg]	30	15
	Specific heat capacity	C [kJ/kgK]	4.217
Temperatures	T_{final}	$T_{initial}$	ΔT[˚C]
Milk vat	65	28	37
Water jacket	80	25	55
		Charcoal system	TLUD system
Mass of water in jacket	m_w[kg]	150	150
Mass of fuel	m_f[kg]	50	25
	$\in$	**0.07**	**0.29**

Matching a TLUD to a Heat exchanger:

Dimensionless number Heat exchanger to gasifier (HTG) was defined as the ratio

$$\frac{\text{effective heat transfer surface area of the heat exchanger} \times \text{the inner diameter of the air pipe of the heat exchanger}}{\text{volume of the fuel cylinder of the TLUD gasifier}}$$

Through experimentation the optimum number was found to be

$$\mathbf{15} \leq \boldsymbol{HTG} \leq \mathbf{1.7}$$

Combustion device Comparisons:

Volume fuel chamber [L]	Concentrator hole[m]	Outer diameter [m]	Primary intake $[m^2]$	Secondary intake $[m^2]$
3	0.08	0.15	0.003	0.008
30	0.09	0.36	0.010	0.012
150	0.14	0.56	0.008	0.014

Ratios

$$\frac{Cross-sectional\ Area\ between\ cyclinders}{Primary\ intake} = 4.3 \qquad \frac{Secondary\ intake}{Primary\ intake} = 2.5$$

$$\frac{\text{Diameter of lid}}{\text{Diameter concentrator hole}} = 3$$

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