Analysis of work time and workers capacities in "culurgione's" production

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Abstract
In the alimentary tradition of the Sardinia a few types of pasta production reached a international notoriety, i.e. malloreddus, sebadas and culurgiones produced exclusively by hand. Unfortunately the production is not able to satisfy all the demand of the modern commercial distribution which often, orients towards other markets and products. The study, was carried out in one of the most important plant for the production of "culurgiones" and were compared two work cycles: traditional and partially mechanized. The last five phases of production (rolling, breaking, moulding, forming and cutting) are in total over the 77% of the working time and furthermore reduce considerably the number of workers in use in the product closing phase forcing the producer to destine two of this in the lengthening and in the foil cut by hand. With the introduction of this equipment, the incidence of the last two phases was reduced on the operating time of 5% and was increased the number of the workers, from four to six, employed in the final phase (close) of "culurgiones" productions and the working time of this phase increased. The work capacity increased in term of journey production and in term to worker capacity per hour of work.

Keywords: fresh pasta, "culurgiones", time analysis, workers capacities.

Introduction

In the pasta tradition of Sardinia (for instance Malloreddus) issue a few types of international notoriety pasta, as pure other typologies of pastries elaborated with the use of local traditional ingredients, as for instance Sebadas and Culurgiones (fig.1) produced exclusively to hand. Above all this last format makes use of preparation modes rigidly based on the manual dexterity, modes which determine the characterization and the originality of product form. This very manual dexterity, deeply codified in the Sardinian popular culture, some foil about the stuffing gives Culurgiones a few important properties also of technological, especially as regards the operations of folding and envelopment nature, with a sequence of movements of the fingers which allow to obtain a longitudinal closing with the replicate foil margins inward the format; under the point of view specifically technical that allows to obtain a strong structural resistance of culurgiones during the cooking phase, in practice the stuffing avoiding the risk which because of the thermal and mechanical solicitations caused by the water boil, the format can open and therefore disperse in water of cooking itself, besides, obviously, getting deformed changing his original form to completed cooking. The both national and international diffusion of this Sardinian typical pasta is subject to the necessity of producing culurgiones in quantities and

Figure 1. The "culurgiones" are formed by fresh pasta with inside, potato, recotta cheese, and other ingredients

would be incompatible with the manual product preparation, not only for the high costs would and would carve in an excessive way on his commercial to price, but also give the product itself the microbiologic and biochemical stability necessary for extending shelf life, in a way compatible with the times and the rhythms of the modern commercial distribution and the dilated with respect to the current one diffusion in the market worlds.

Material and method

The study was carried out in one of the most important plant for the production of "culurgiones" and were compared two work cycles: traditional and partially mechanized. The first, where all the phases of production was completed by hand and a another one where two types of machinery was inserted and used: moulder and a hand formed. The working capacity of the plant, the efficiency of the workers, and the electricity consumed per unit of production were calculated by measuring the following parameters: the theoretical working capacity of all the machines used according to the manufacturer's specifications, the total work time in each phase of production, the real total production, the number of workers, the energy consumed, and the quantity of electricity used in each phase of production. In order to reach their daily production targets, two productive cycles were necessary in the traditional plant and three in the semi-industrial plant. Each cycle included all the phases of the production process. In the traditional plant there was a further work cycle so that the samples used in the statistical analysis were uniform. The work capacity of the individual workers was calculated as: Work capacity per worker (kg/h) = Operational Capacity (OC)/number of worker in the phase where OC (operational capacity in the single phase) was calculated as a function of OT (Operational Time) and AT (Additional Time). OT is the working time of the worker and was calculated as the sum of the effective time (ET) and the additional time (AT). Both of these were taken analytically. AT was equal to 5% to 10% of OT and was the range of variations of extra time for each single phase. Daily consumption or (Dc) was determined on the basis of the Electrical Power Installed (EPI = kW) and the operating time (OT) for each single phase $Dc = EPI$ (kW) $\times$ OT. The energy used for the daily production (Wh/kg) was calculated by dividing the daily consumption (kWh/day) by the quantity of product produced. The incidence (I) was calculated as the relationship between the energy for unit production (EUP) in each single phase and the total consumption of energy $I = \frac{EUP}{Eenergy(total)}$.

Results and discussion

Labour Used

The number of labours used (table 1) was different and in each phase depended on the operational capacity of the production line, even though 16 workers were used in each plant. In the traditional plant, daily production was 50.0 kg and the workers were employed equally in all phases of production, with the exception of closing, where only 4 worker was used. In the semi-industrial plant the work force was mainly employed in closing of the "culurgiones" (6 workers), so the planned daily production was 250 kg/day.

Table 1. Production phases, number of workers, work time and incidence percentage of the phases in the two work cycles

Phases of production	Workers used in the phases		Work time		Incidence	
	traditional (A) (n)	semi-industrial (B) (n)	(A) (h)	(B) (h)	(A) (%)	(B) (%)
ingredients preparation	4	4	0,28	0,28	3,21	3,21
kneading	1	1	0,33	0,33	3,78	3,78
stuffing preparation	3	3	0,83	0,83	9,51	9,51
rest	-	-	0,50	0,50	5,73	5,73
rolling	-	-	0,67	0,67	7,67	7,67
breaking	1	1	0,50	0,50	5,73	5,73
moulding	2	-	0,83	-	9,51	-
forming	1	1	1,42	1,00	16,27	11,45
closing	4	6	3,37	4,62	38,60	52,92
total	16	16	8,73	8,73	100,00	100,00

Work Time and Working Capacity

The total time for each single operation (table 1) shows that there were substantial differences in the time used for each operation in the two types of plants. Daily capacity in the traditional and in the semi-industrial was reached after 8.73 h, even though the amount of "culurgiones" produced was almost five times as great. Looking, in more detail, at the time taken for each single operation, it becomes clear that moulding and closing were the two most important and most time consuming operations in both types of plants. In the traditional plant 16.27% and the 38.60% of the total time was used for this, while in the semi-industrial this figure rose to 11.45% and 52.92%. The preparation of the ingredients was the most rapid part of the operation: 3.21% of the total time. Moulding in the traditional and in the semi-industrial plant, took 3.73 h per day when maximum daily capacity was reached. In other words, 75,0% and 62,5% of the work power was employed in the first seven phases of the production but it use only the 45.15% of the total work time in the traditional and the 36.35% in the semi-industrial one. Forming and closing took 1.00 h in the semi-industrial plant and 1.42 h in the traditional. In this case the number of workers employed certainly made a difference: seven in the semi-industrial plant and five in the traditional one because the 54.85% and the 63.65% of the total work time was used in these two phases. There was a significant difference between the two plants in the operating capacity for the single operations. Preparation of ingredients took place at 40 kg/h in the semi-industrial plant and at 30 kg/h in the traditional plant and mixture at 100 kg/h in the semi-industrial plant and at 50 kg/h in the traditional one (table 2). Mouding, forming and closing of the "culurgiones" in the traditional plant also took place at 12.00 kg/h, 3.00 kg/h and 7.00 kg/h. Hourly production of the workers was: 7.5 kg/h for the preparation of ingredients, 50.0 kg/h for the kneader, 25.5 kg/h for preparation of the stiff, 40.0 kg/h for

moulding, 12.0 kg/h in the braking and forming and 3.0 kg/h and 8 kg/h for printing and closing (table 2). The hourly production per worker during moulding were also lower in the traditional plant than in the semi-industrial one (7.50 kg/h vs 10.00 kg/h).

Table 2. Total time, and working capacity in the two plants

Work phases	Plant	Total time (h)	Capacity Operating (kg/h)	Capacity per worker (kg/h)
ingredients preparation	Traditional	0,28	30,00	7,50
	Semi-industrial	0,28	40,00	10,00
kneading	Traditional	0,33	50,00	50,00
	Semi-industrial	0,33	100,00	100,00
stuffing preparation	Traditional	0,83	25,00	8,33
	Semi-industrial	0,83	50,00	16,67
rest	Traditional	0,50	-	-
	Semi-industrial	0,50	-	-
rolling	Traditional	0,67	40,00	40,00
	Semi-industrial	0,67	75,00	75,00
breaking	Traditional	0,50	12,00	12,00
	Semi-industrial	0,50	22,00	22,00
moulding	Traditional	0,83	12,00	12,00
	Semi-industrial	-	22,00	22,00
forming	Traditional	1,42	3,00	3,00
	Semi-industrial	1,00	7,00	7,00
closing	Traditional	4,62	8,00	2,00
	Semi-industrial	3,37	18,00	3,00

Energy consumption

Energy consumption varied greatly from machine to machine (table 3). Greatest consumption was by the moulders, which consumed 4.75 kW in the traditional plant and 4.50 kW in the semi-industrial one, and lowest by the rolling and small mixers for ingredients, which consumed 0.37 kW in the traditional plant and 0.45 kW in the semi-industrial plant. Daily energy consumption was linked to how long the machines worked and how much energy they consumed. In the traditional plant it varied from 0.25 kWh/day for the small mixer to 3.19 kWh/day for the forming. Similar results were found for the semi-industrial plant. The rolling consumed the least energy (300.00 Wh/day) and the used the most energy (970.90 Wh/day). The energy consumption per unit of production was as follows: from a minimum of 6.25 Wh/kg for the rolling to 256.83 Wh/kg for the forming in the traditional plant, and from 4.00 Wh/kg for the rolling to 125.0 Wh/kg for the moulding in the semi-industrial plant. Thus the moulding consumed most energy in both plants. The next highest consumer was the small mixer used for the preparation of the ingredients (32.67 Wh/kg) and the moulder in the

traditional plant (31.35 Wh/kg) and the small mixer in the semi-industrial plant (15.50 Wh/kg.).

Table 3. Electrical Power Installed (EPI), daily energy consumption (Dc) per machine, and energy used per unit of production (EUP), for each phase in the two plants

Machine	Plant	Electrical Power		EUP
		Installed (kW)	Dc (kWh/day)	(Wh/kg)
ingredients	Traditional	3.50	0. 98	32.67
preparation	Semi-industrial	2.20	6.20	15,50
kneading	Traditional	4.75	1.56	31.35
	Semi-industrial	4.50	1.49	14.90
stuffing	Traditional	0.45	0.38	15.20
preparation	Semi-industrial	0.45	0.38	7.60
rest	Traditional	-	-	-
	Semi-industrial	-	-	-
rolling	Traditional	0.37	0.25	6,25
	Semi-industrial	0.45	0.30	4.00
breaking	Traditional	a mano	-	-
	Semi-industrial	a mano	-	-
moulding	Traditional	2.20	3.19	256.83
	Semi-industrial	2.75	2.75	125.00
forming	Traditional	-	-	-
	Semi-industrial	-	-	-
closing	Traditional	-	-	-
	Semi-industrial	-	-	-

Conclusions

The machinery and plant that are used at present in small- and medium-enterprises cause discontinuities in the process. These affect the work capacity and thus also the productivity of the workers. Thus introducing plant and processing systems which can incorporate different phases of the production process would result in concrete rationalisation of working capacity, of productivity of the workforce and of electricity consumption. The introduction of the correct criteria when deciding which machines to use would resolve the problems linked to increasing hourly productivity of the plant and the workforce. Actually, the last five phases of production (rolling, breaking, moulding, forming and cutting) are in total over the 77% of the working time and furthermore reduce considerably the number of workers in use in the product closing phase forcing the producer to destine two of this in the closing. With the introduction of the equipment, the incidence of the phase to forming was reduced on the operating time of 5% and the phase of closing was increased respect to the

traditional plant to the 9.5% with a number of the workers, from four to six, employed in the final phase (closing) of "culurgione's". The productions for worker in the phase of forming increased from 3kg/h in the traditional plant to 7kg/h in the semi-industrial and for the final phase from 2kg/h in the traditional to 3kg/h in the semi-industrial one.

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