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Research Article

ERGONOMICS FOR WORK IMPROVEMENT IN SELECTED FOOD PROCESSING ENTERPRISES

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ABSTRACT

Major health hazards encountered at selected Papad and Vermicelli enterprises were accidents of finger cut off, muscles pain and discomfort. Workstation analysis checklist score was negative for these enterprises which showed that workstations were lacking in essential requirements. Risk factors associated with Papad making by machine were posture, repetition, contact stress and task duration WERA score of physical risk factors was highest for Papad making by automatic machine (35.37) followed by Papad making by rolling machine (34.42) and Vermicelli making by machine (34.8). Conceptual frame work of product intervention package was developed based on checklist, muscle fatigue and WERA analysis. Product intervention process was effective in reducing low back pain and MSD experienced by women workers in selected food processing units. Change due to intervention was measured in terms of perception of respondents for comfort, speed and safety in work. Product intervention in Papad dough making and Papad making was effective by 15 to 93 percent. Time and work study of selected food processing activities indicated that time required for collection of Papad was significantly reduced by 50 percent (reduction of one man day/ql). Time required for manual dough making (per ql) was reduced by 20 percent followed by Papad making by rolling machine (14.28%). Hence it can be concluded that developed intervention package for Papad and Vermicelli making enterprises was effective for improving Posture, Speed of work and Product Output & was acceptable by all women workers.

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INTRODUCTION

Food processing includes many forms of processing foods, from grinding grain to make raw flour to home cooking to complex industrial methods used to make convenience foods. Women entrepreneurs in rural & urban parts of Maharashtra are bringing about a steady and silent change in the health sector with agro-based products such as papad & vermicelli. The Papad making industry is one of the home based processing units which has provided ample opportunity of employment to the women of low socio-economic status. Majority of the food units are in primary processing. The papad and vermicelli making business is generally a women-centric business in India and mostly done in the rural areas

METHODOLOGY

Ergonomic evaluation of selected entrepreneurial activities

The food processing units in which participation of women was more than 60 percent were selected for the study

Location of the study	: Paralgavan, Parbhani, Vasmathand Majalgaon
Type and no. of the food processing enterprises	: Papad making Automatic papad making machine enterprise (5) Papad rolling machine enterprise (3) Vermicelli making machine enterprise (4)

Healthy female workers at selected Papad and Vermicelli making enterprises working for 6 – 8 hrs/ day were selected for the study.

Mode of data collection

No. of female workers: 25
Field trials/Replications: 03
No. of entrepreneurial activities: 08
No. of methods: 02

Equipments used for the study

Polar heart rate monitor, Goniometer, Anthropometry kit, Sphygmomanometer, Grip dynamometer, Hygrometer, Thermometer, Noise level meter, Lux meter and Weighing balance

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Measurement of Parameters: Following Measurement Parameters were used while making questionnaire for the study

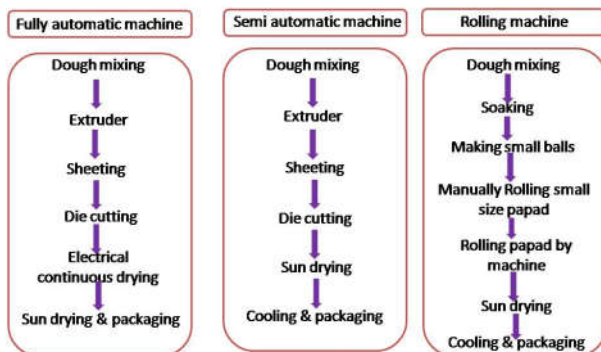
- Average working and peak Heart Rate ($b.m^{-1}$), Average & peak energy expenditure ($kj.m^{-1}$), Total cardiac cost of work (TCCW), Physiological cost of work (PCW)
- Workstation check list
- Low back pain assessment tool for assessment of legs & back pain,
- Muscle fatigue score by muscle fatigue analysis tool (S.H. Rodgers, 1992)
- Work Place Ergonomic Risk Assessment (WERA) tool, [M. Rahman *et al* (2011)] for assessment of physical risk factors
- Musculoskeletal disorders (MSD)(Varghese *et al*,1994)

Intervention process

Types of interventions were given based on ergonomic principles for different activities in different types of household processing units viz. automatic Papad making machine, Papad rolling machine and Vermicelli making machine.

The intervention process involved the identification of problems, selection of product, modification of product to suit the needs of workers and giving them the product for use. The difficulties identified by the respondents during their performance of the activities helped to improve work.

Papad making by machine



Product Intervention

The problems faced by the respondents were related to space interaction, use of dough making machine, placement of electrical switch and other objects, functionality of the furniture and equipment. Intervention questionnaire was designed based on the selected aspects of the product such as dimensions, comfort-ability, functional effectiveness and ease of use, safety and security.

The needs of the respondents were identified and the following products were given for the study

1. Apron, Hair cap and Rubber/polyethylene hand gloves: These were provided to maintain hygiene. Apron was provided to avoid entangling of sareepallu in motor or fan.
2. Measuring jug: Measuring jug was provided to use exact quantity of water for dough making to avoid stress and reducing time.
3. Upholster chair: The existing chair design was not

suitable to workers, hence cushions were provided to increase the sitting height of the worker.

4. High round stool: Round stool was provided for sitting as they were performing work of picking up continuously in standing position
5. Low stool: This stool was provided near the dryer of the fully automatic machine while collecting Papads
6. Plastic dispenser: Water filled dispenser was provided near dough making machine for the safety of the workers.
7. Wooden spatula and round handle presser was provided for safety to the worker while pressing flour inside the hopper.
8. Plastic lawn floor covering: It was provided to increase comfort level and avoiding slips and falls.
9. Table and winnowing tool/ tray: It was provided near the Papad making machine for collection of Papad. It reduced time & energy of workers
10. Dust controlling mask: It was provided while dough making to avoid sneezing due to dust of masala.
11. Placement of electrical switch: Electrical switch for machine was fixed high on the wall. Hence, change in the placement of switch board was suggested within the reach of women workers.
12. Stainless steel wire for drying: Change in material was suggested for maintenance of hygiene and safety.
13. Fixing oil can to the machine: This was suggested to avoid spill out of oil on floor.

Post Intervention

The data was collected after the products were given to the respondents for a period of month. The respondents were asked to compare the existing products given for intervention. The post intervention data was collected using the same questionnaire and seven aspects of products were studied. The pre and post test data was analyzed using paired 't' test to study the effect of given interventions. Seven aspects were used for evaluating intervention products such as ergonomic compatibility, safety, comfort-ability, suitability, Satisfaction level, Functional effectiveness and easy to use. Views of the respondents were collected based on three point Likert scale and scores were compared to find out change due to intervention.

- a. Ergonomic compatibility: 1. With ease, 2. with difficulty 3. Cannot use
- b. Views about safety: 1. Very safe 2. Safe 3. Not safe
- c. Views about comfort- ability: 1. Very comfortable 2. Comfortable 3. Not Comfortable
- d. Views about suitability of the product: 1. Suitable 2. Partially suitable 3. Not suitable
- e. Functional effectiveness of the product: 1. Effective 2. Less effective 3. Not effective
- f. Ease of use: 1. Easy to use 2. Difficult to use 3. Cannot use
- g. Satisfaction level: 1. Satisfied 2. Partially satisfied 3. Not satisfied

RESULTS AND DISCUSSION

Physical Characteristics of the Selected Women Workers

Average age of the selected women workers was 37 years with

151 cm average height and 53 kg average body weight. Majority (72 %) of the selected women belonged to normal weight category (BMI: 18.5 to 24.99). Blood pressure of all the selected women workers was measured and it was found normal in the range of 80-120 mm Hg.

Income and Production of Selected food Processing Enterprises

Total 45 percent of selected women workers were owner of the food processing units. Average income earned through Automatic Papad machine enterprise was Rs.42,200/month followed by income of the Vermicelli making unit i.e. Rs. 14,812 / month. Least monthly income was noted for Papad rolling machine units i.e. Rs. 6,200/ month. With regard to the production per day, it was noted that 26 kg Papad / day was the highest average production of Automatic Papad making unit. In Papad rolling machine unit 5 kg Papad /day were made. Whereas production of Vermicelli making machine units was 20 kg Vermicelli clusters per day.

Awareness, Symptoms and Health Hazards Encountered at workplace

Major health hazards encountered at Papad and Vermicelli making units were getting finger cut off or chopped due to entangling it in roller and hopper. Twenty percent of the selected women workers suffered with such mishap. Their fingers were damaged permanently due to accidents. Muscle pain and discomfort feeling was very common in all the selected women workers. Cuts to hands were happened because of open sharp edges of metal sheets of machine. Falls due to slipping of legs were occurring in these units because of slippery floor as oil gets spilt over floor while making Papad.

Work Station Analysis by Using Checklist

Checklist for workstation analysis was prepared and administered in three different types of selected food processing units. Checklist analysis indicated that the average score obtained for Automatic Papad making units and Vermicelli units was negative (- 1.95). It showed that workstations were lacking in majority of the essential facilities particularly with respect to the personal protective equipments, posture related, comfort and safety issues, maintenance and environmental factors. (Table 1)

Ergonomic Compatibility Between Anthropometry of women workers and Workstation height

Distribution of respondents as per the ergonomic compatibility between anthropometry of women workers and workstation height such as machine platform height and switch height is illustrated in table 2. As per the ergonomic principles the standing working platform should be 7.5 cm lower than the standing elbow height of worker. Standing and sitting elbow height of the respondents was compared with height of the machine platform and height to reach switch on wall was compared with maximum reach of the workers. Accordingly 75 to 85 percent of machine platforms were compatible with the height of the workers in automatic Papad making units and Papad making by rolling machine enterprises respectively whereas higher percent of workstations were uncomfortable in Vermicelli making machine units (33.33%).

Muscle Fatigue Analysis by task in food processing enterprise

Muscle fatigue analysis of selected tasks was carried out by taking into consideration effort level, duration and frequency of job. Priority for making changes in workstation was decided by Rodgers Muscles fatigue analysis method. As per the analysis score for selected activities such as manual and machine dough making and Papad and Vermicelli making by machine were categorized as very high priority jobs for making changes. Papad making work stations of rolling machine were classified under moderate priority. (Table 3)

Work Place Ergonomic Risk Assessment (WERA) in selected food processing enterprises

Ergonomic risk assessment in selected processing units is illustrated in Table 4. WERA score of physical risk factors was highest for Papad making by automatic machine (35.37) followed by Papad making by rolling machine (34.42) and Vermicelli making by machine (34.8). It is clear from the table that all the selected activities in food processing units were of medium risk that means the majority of the selected tasks needed further investigation and change. Risk factors associated with manual dough making were related to repetition and posture of work. Physical factors such as body parts getting affected were shoulder and wrist. In case of dough making by machine additional risk factor was lifting the load for pouring flour inside the hopper. In case of Papad making by machine, risk factors were posture, repetition, contact stress and task duration. Based on WERA the product intervention concepts were initiated for work improvement.

Effect of Product Intervention process on work improvement

After identifying the problems in food processing enterprises conceptual framework of product intervention for each selected entrepreneurial activities was prepared and intervention process was administered.

Change in low back pain due to Product Intervention

Assessment of low back pain experienced by women in selected food processing units was carried out with the help of low back pain assessment tool before and after intervention. Paired 't' test analysis indicated that there was highly significant reduction (28.78 %) in low back pain score recorded in Papad making units. It indicated that product intervention for reducing low back pain in selected activities of Papad making units was effective in lowering down low back pain of women workers (Table 5).

Change in Musculoskeletal Disorders (MSD) Experienced by women workers due to Product Intervention

User's perceptions about MSD experienced while performing selected activities in food processing units was scored before and after intervention (Table 6). Maximum reduction in MSD score (51.63 %) was obtained in Papad making by rolling machine due to intervention of upholster chair and padding on pedal. It was followed by Vermicelli making by machine due to plastic lawn mat flooring. Nonspecific symptoms such as Swelling on shoulders and legs was observed in Papad making by automatic machine (35 %) because of force applied by hand while dough making.

Effect of Product Intervention on work Improvement in Papad Making Machine Enterprises

Product intervention was carried out for three activities such as Papad dough making and Papad making by machine and manually and collection of Papad manually (Table 7). Change due to intervention was measured in terms of perception of respondents for comfort, speed and safety of work. Product intervention in Papad dough making activity was effective in increasing comfort level by 15 to 93 percent except intervention of noise and dust controlling mask. Similarly in case of Papad making activity, change due to intervention was effective by 71 to 93 percent, expect the intervention of rubber hand gloves as these were found entangled in roller of the machine. Statistically result were highly significant

Effect of Product Intervention on work Improvement in Papad Rolling Machine Enterprises

Product intervention in Papad rolling machine unit was carried out for three activities such as manual dough making, Papad rolling (Pre preparation activity for Papad rolling machine) and Papad making by rolling machine.

Change due to intervention was measured in terms of perception of respondents for comfort, speed of work and safety. Table 8 indicates that change due to product intervention was highest in dough making (77.45%) followed by dust controlling mask (66.46%) and measuring jug (51.94%). Product intervention of rubber hand gloves was not effective for manual machine and Papad making activity. Entire product interventions in Papad making by rolling machine units were significantly effective in increasing comfort level of women workers.

Effect of Product Intervention on work Improvement in Vermicelli Making Enterprises

Product intervention in the unit of Vermicelli making by machine was carried out. Score was compared before and after intervention. Change due to intervention was tested by applying paired 't' test. Results were highly significant for the lawn floor covering, wooden spatula, measuring jug and stool. Results of product intervention of rubber gloves were non-significant while making Vermicelli by machine (Table 9).

Effect of Product Intervention on Physiological work load of Women Workers while Performing Selected Activities

Physiological load of the women workers while performing dough making, Papad making and vermicelli making was assessed by heart rate method. Energy expenditure and physiological cost of work was calculated for six selected activities. Highest heart rate 112 b.m⁻¹ was recorded in case of automatic Papad machine followed by machine dough making. Similar results were obtained in case of other parameters. Highest peak heart rate (123b.m⁻¹) was recorded while making dough by machine which was higher than the permissible limit of the heart rate. Statistical test indicated non-significant results for all the activities which indicated physiological work load of women workers was at par before and after intervention.

Time and work study of food processing enterprise activities (Productivity output)

Productivity output study of selected food processing activities was carried out. Results are displayed in Table 10 in terms of man days required for the production of one quintal before and after intervention. In case of manual collection of Papad, time required to complete the task was reduced by 50 percent (one man day reduction) and statistically results were significant. Time required for manual dough making per quintal was reduced by 20 percent followed by Papad making by rolling machine (14.28%) but statistically result were non-significant.

CONCLUSION

Developed low cost intervention package for selected activities in Papad and Vermicelli making enterprises was effective for improving posture, speed of work and product output & it was acceptable by all women workers.

Table 1 Work Station Analysis by Using Checklist

Name of the enterprise	Average score	Interpretation
Automatic papad making unit	-1.95	Strongly Dissatisfied
Papad rolling machine	0.60	Neutral
Vermicelli making	-0.69	Dissatisfied

-2- Strongly Dissatisfied, -1- Dissatisfied, 0- Neutral, +1- Satisfied & +2- Strongly Satisfied

Table 2 Ergonomic Compatibility Between Anthropometry of Women Workers and Workstation Height

Name of the enterprise	Workstation height		Switch height	
	Compatible	Not suitable	Compatible	Not suitable
Papad making by automatic machine	09 (75)	03 (25)	11 (91.66)	01 (8.33)
Papad making by rolling machine	06 (85)	01 (15)	04 (57.14)	03 (42.8)
Vermicelli making by machine	04 (66.66)	02 (33.33)	06 (100)	--

Figures in parenthesis indicates percentages

Table 3 Muscle Fatigue Analysis by task in Food Processing Enterprise

Name of the task	Efforts level	Effort duration (Sec)	Effort frequency (per min)	Priority
Manual dough making	1.25	4	4	VH
Rolling Papad by hand	1.42	3	2	M
Papad making on rolling machine	1.71	3	2	M
Dough making by machine	1.80	3	4	VH
Papad making by automatic machine	1.73	4	4	VH
Vermicelli making by machine	1.36	3	4	VH
Continuous Effort Duration	< 6s 1	6-20 s 2	20-30 s 3	>30 s 4 (Enter VH for Priority)
Effort Frequency	< 1/min 1	1- 5/min. 2	>5- 15/min. 3	>15/min. (enter VH for priority)

M- Medium, VH- Very high

Table 4 Work Place Ergonomic Risk Assessment (WERA) in Selected Food Processing Enterprises

Selected activities	Final score of Physical risk factors	Priority level
Manual dough making	28.60	M
Manual papad rolling	26.40	L
Papad making by Rolling machine	34.42	M
Dough making by machine	39.00	M
Papad making by automatic machine	35.37	M
Vermicelli making machine	34.80	M

Risk level: M- Medium Risk Level- Task is need to further investigation & required Change, L- Low Risk Level –Task is acceptable

Table 5 Change in Low Back Pain Experienced by Women Workers due to Product Intervention

Name of the enterprise	Before intervention (Mean± SD)	After Intervention (Mean± SD)	Change due to intervention (%)	't' Values
Papad making by automatic machine (n=12)	32.41 ± 1.88	23.08 ± 1.83	9.33(28.78)	12.32**
Papad making by rolling machine (n=7)	33.14+ 4.52	25.0 + 2.7	8.14(24.56)	4.09**
Vermicelli making by machine (n=6)	23.66 + 7.06	19.33 + 5.71	4.33(18.30)	NS

Figures in parenthesis indicates percentages, ** Significant at 1% level, NS- Non significant

Table 6 Change in Musculoskeletal Disorders (MSD) Experienced by Women Workers Due to Product Intervention

Name of food processing units	Average MSD Score		Change due to intervention (%)	Nonspecific symptoms
	Before intervention	After intervention		
Papad making by automatic machine	3.38	2.28	32.54	Swelling on shoulders and legs (35 %)
Papad making by rolling machine	2.75	1.33	51.63	--
Vermicelli making by machine	2.91	1.65	43.29	--

Level of pain: 5 – Very severe, 4- Severe, 3- Moderate, 2- Mild, 1- Low

Table 7 Effect of Product Intervention on Work Improvement in Papad Making Machine Enterprises N=12

A. Do Dough making by machine	Product Interventions (Mean± SD)					
	Plastic lawn mat	Noise and dust controllin g mask	Measuring jug	Round/ cylindrica l handle for wooden presser	Plastic dispenser	Rubber hand gloves
Before intervention	2.13±0.44	1.67±1.00	2.06±0.36	1.75±0.21	2.29±0.13	2.08±0.21
After intervention	3.76±0.86	2.28±0.16	2.93±1.03	3.39±1.46	2.63±0.27	3.93±1.46
Change due to intervention (%)	1.63 (76.52)	0.61 (36.52)	0.87 (42.23)	1.64 (93.71)	0.34 (14.84)	1.85 (88.94)
't' values	5.86**	NS	2.77*	3.90**	4.25**	4.4**
B. Papad making by machine	Product Interventions (Mean± SD)					
	Plastic lawn mat	Fixing oil can to the	Change in size and	Raising height of	Placement of	Rubber gloves

C. Collection of papad (Manually)	Product Interventions (Mean± SD)					
	Use of table for papad collection	Use of tray for collecting papad	Stool for sitting	Rubber hand gloves		
Before intervention	1.79±0.91	1.67±0.82	2.01±0.21	1.58±0.68		
After intervention	3.73±1.36	3.69±0.83	4.01±1.30	1.51±0.51		
Change due to intervention (%)	1.74 (97.2)	1.42 (85.02)	2 (99.5)	0.07 (4.43)		
't' values	4.11**	6.01**	5.23**	NS		

Figures in parenthesis indicates percentages, ** Significant at 1% level, * Significant at 5% level, NS- Non significant

Table 8 Effect of Product Intervention on Work Improvement in Papad Rolling Machine Enterprises N=7

a. Manual dough making	Product Interventions (Mean± SD)			
	Dust controlling mask	Measuring jug	Low stool	Rubber hand gloves
Before intervention	1.67 ± 1.01	2.06± 0.17	1.75± 0.31	1.73 ± 0.26
After intervention	2.78±0.16	3.13 ± 1.03	1.87± 0.29	3.97 ± 0.67
Change due to intervention (%)	1.11 (66.46)	1.07 (51.94)	0.12 (6.85)	1.34 (77.45)
't' values	2.87*	2.71*	NS	8.29**
b. Manual papad rolling (Pre preparation)	Product Interventions (Mean± SD)			
	Increase in height of the Rolling board	Rubber hand gloves		
Before intervention	2.13±0.44	2.00 ± 0.46		
After intervention	3.76±0.86	2.13 ± 0.33		
Change due to intervention (%)	1.63 (76.52)	0.13 (8.5)		
't' values	5.86**	NS		
c. Papad making by rolling machine	Product Interventions (Mean± SD)			
	Padding on pedal	Cushion on chair	Keeping drying unit near to machine	Rubber hand gloves
Before intervention	1.99 ± 0.47	2.28 ± 0.41	2.18 ± 0.74	2.3 ± 0.91
After intervention	4.03 ± 1.01	3.14 ± 0.81	3.3 ± 0.81	2.41± 0.67
Change due to intervention (%)	1.94 (97.46)	0.86 (37.71)	1.12 (51.37)	0.11 (4.78)
't' values	4.49**	2.46*	2.7*	NS

Figures in parenthesis indicates percentages ** Significant at 1% level, * Significant at 5% level, NS- Non significant

Table 9 Effect of Product Intervention on Work Improvement in Vermicelli Making Enterprises N=6

Vermicelli making by machine	Product Interventions (Mean± SD)				
	Plastic lawn mat flooring	Wooden spatula	Measuring jug	High stool	Rubber hand gloves
Before intervention	2.34 ± 0.65	1.76 ± 0.31	2.06± 0.17	1.99 ± 0.47	2.03 ± 0.67
After intervention	4.3 ± 0.57	3.33 ± 0.71	3.13 ± 1.03	4.03 ± 1.01	2.67 ± 0.57
Change due to intervention (%)	1.96 (83.76)	1.57 (89.2)	1.07 (51.94)	1.94 (97.46)	0.64 (31.52)
't' values	5.56**	4.96**	2.71*	4.49**	NS

Figures in parenthesis indicates percentages,

** Significant at 1% level, * Significant at 5% level, NS- Non significant

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Table 10 Time and Work Study of Food Processing Enterprise Activities (Productivity output)

Name of the activity	Man-days Required/qt		Change due to intervention (%)	't' values
	Before Intervention (Mean±SD)	After Intervention (Mean±SD)		
Manual dough making / qt (N=7)	2.5±0.478	2.0±0.56	0.50 (20.0)	NS
Manual rolling Papad/qt (N=7)	5.0±2.10	4.5±1.78	0.50 (10.0)	NS
Papad making by rolling machine/ qt (N=7)	7.5±1.45	6.0±1.70	1.5 (14.28)	NS
Collection of Papad/ qt (N=12)	2.0±1.06	1.0±0.45	1.0 (50.0)	3.03*

Figures in parenthesis indicates percentages, * Significant at 5% level, NS- Non significant

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