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Traditional post-harvest operations of millets and drudgery of women

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Traditional post-harvest activities in agriculture are mostly done by women and are most drudgerious. The study mainly attempted to identify post-harvest operations of millets and determine level of drudgery of women farmers while doing by traditional methods and improved practices. Total 32 women respondents were selected from different age groups and social strata from traditional millet growing area. The post-harvest operations of millets performed by the women were; threshing, winnowing, drying, flour making and flatbread making. The ergonomic parameters of these operations with traditional methods were compared with improved methods using machines. The results revealed that the level of drudgery realized in performing the five identified operations with improved practices was considerably reduced by 35 to 87% than the traditional practices done by the women farmers. Among the five, both threshing and flour making were assessed to be moderate consumption of energy under improved methods. Making flatbread by using power-operated machine helped them to reduce their drudgery level from high (DI=78.97) with traditional method to moderate level (DI=58.51). It was observed that if operation-wise appropriate machine and operational skill was given to hand the machineries; their drudgery would be reduced, the work output and their efficiency would be enhanced and thereby, boosted-up consumption of the millets and their health.

Keywords: Drudgery of women, Ergonomic parameters, Minor millets, Post-harvest operations, Traditional practice

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Millets comprised of sorghum, pearl millet, finger millet, foxtail millet, proso millet, barnyard millet, little millet, kodo millet and brown-top millets which are mainly grown in our country. They are known as climate flexible crops grown by mostly, resource-poor farmers. Millets are classified into major millets and minor or small millets on the basis of their grain size, which are important crops for dryland farmers. They are highly nutritious and grown well in adverse climate unlike other cereals like maize, wheat and rice. However, due to drudgery involved in production and food preparation activities, overall millet production and consumption in India has declined over the years. Native Indian farmers are once more emphasizing the importance of millets. As a family of cereals, tiny millets form the cornerstone of their traditional diets and are now viewed as the ideal way to guarantee dietary and nutritional stability especially in remote, tribal and hilly areas. It was proved that agriculture practices need to be followed by traditional people and indigenous technologies for improving the production level along with quality produce[1]. The millet growers over years have gained considerable knowledge and experience in millets farming. Over this period, a large number of indigenous knowledge related to production of millets has prevailed among cultivators in different localities. Traditionally, post-harvest operations like threshing used to be done by trampling with help of animal feet, cleaning with help of blowing wind, pounding with wooden rod and dehulling with stone pestle, flour making using stones for grinding and flatbread making by hand with indigenous methods which are now-a-days very difficult to be followed with changing food habits and lifestyle. One of the important issues faced by the rural communities is drudgery while performing post-harvest operations of the millets. That was one of the reasons for the drastic decline in consumption of millets other than finger millet in millets growing[2]. Hence, it is considered an appropriate time to document for scientific validation of such indigenous knowledge as first-hand information from growers and related sources. Integration of the relevant indigenous knowledge with that of the technology packages evolved through formal research will be immensely benefitting the millets growers.

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Overall, millets cultivation is labor-intensive which requires more labour especially in post-harvest operations. Generally, women take part in post-harvest activities and they work for long hours, on average of 10-11 h in agriculture and allied operations including four hours in domestic activities[3]. In millets cultivation, women contribution is higher than the men as labor-intensive processes. Typical processing of small millets is the key challenge that hinders consumer demand and up-scaling potential of small millets[4]. Women farmers have complaint about various health related problems like backache, hand injury and respiratory problems associated with traditional methods of post-harvest handling of small millets[5]. The physical stress seems too high as of heavy exertion tasks in performing various activities with conventional method. Ojha & Kwatra (2016) reported that majority of the women reported "extremely severe" and "severe" discomfort in their neck, shoulders, upper back, lower spine, upper arm, wrist/hands, thighs, knees, and lower legs as a result of performing repetitive actions and bending and squatting for extended periods[6]. As a result, the new generation is losing interest in farming itself[7]. Because of conventional post-harvest and processing techniques, women are condemned to a significant amount of daily labor for millet preparation. Threshing and dehulling of finger millets was experienced as a tedious and time-consuming job by 90% of women in Nepal[5]. In addition, a lack of appealing traditional recipes to enhance the nutritional value of people's meals, ignorance of the health benefits of millets, a disorganized integration with markets, and unfavorable environmental policies are the causes of the decline in millets' consumption and acreage under cultivation. Inadequate post-harvest technologies for value-addition, and lack of awareness, knowledge and skill among the farming communities about processing technologies to add value, are major issues, finger millets were considered as inferior or poor man’s food[8]. Small millet grains' nutritious composition and storage qualities present a variety of processing and value-adding options for next-generation meals that meet customer demand. By virtue of nutritional properties of millets, are recently renamed as “nutri-cereals”.

The scientific study of the interaction between employees and their working environment—which includes the surroundings, equipment, supplies, techniques, and work arrangement—is known as ergonomics. If ergonomic factors are neglected, the man-implement system's performance could be inferior. Some of the agricultural activities are not only difficult in terms of physical effort but also protracted in post-harvest operations. Studying ergonomics aspects in designing, operating, and refining farm implements consistent with farm needs and machinery will help to extend women's efficiency and safeguard their health. Therefore, traditional post-harvest operation of millets performed by women and their drudgery was studied. Maximum drudgery prone activities needs to be ergonomically evaluated along with significance of mechanical method with improved machineries in view to reduce their drudgeries and enhance consumption of millets as source of nutrition and livelihood.

Methodology

This study was conducted in Sangareddy district of Telangana State, India where millets are cultivated intensively and most of post-harvest operations were traditionally done by women farmers. The study was carried out to know the way of performing traditional post-harvest operations of small millets to evaluate drudgery levels of women. Total 32 women farmers who were into millets production process regularly and representing other fellow women farmers, were randomly selected with their consent for collecting the data (sixteen each) from Chalki and Gangapur village of blocks (*mandals*) Nyalkal and Jharasangam, respectively. The respondents were beneficiaries of the Farmers FIRST project (FFP) for last five years (2016 to 2021). Purposive-random sampling method was followed for their selection. An ex-post-facto survey design was employed and data collected using an interview schedule involving all aspects of the study like socio-economic, ergonomic, physical characteristics, time spent, days required to complete operations, postural change, difficulty in operations, postural discomfort and drudgery index (DI). At the beginning, post-harvest operations of millets which were performed traditionally were identified along with the drudgery profile in participatory mode. Six millet crops; sorghum, pearl millet, finger millet, foxtail millet, little millet and barnyard millet were undertaken in this study. Kind of body pain felt by women after performing the traditional post-harvest operations like exertion perceived, postures assumed in performance of various activities and musculoskeletal problems were taken into consideration. The physical profile like

age, height, weight and body mass index (BMI) were calculated along with the operation details. The study had ethical acceptance. Drudgery index (DI) of the selected operations namely, threshing, drying, winnowing, pounding of grain for flour and flatbread (*roti*) making was determined by time co-efficient, frequency of performance co-efficient and difficulty co-efficient. The DI was categorized into three namely, maximum drudgery (DI score between 70 and above), moderate drudgery (DI score between 50 and 70), and minimum drudgery (DI score between 50 and below). The correlation coefficient (r) was computed using the statistical package IBM SPSS Statistics Base 22.0.

Results and Discussion

As per the reports from millets producers during the study, farmers are receiving much less money for their raw produce (about Rs. 15-20/kg) than they are for processed millet grains (about Rs. 80-100/kg). Harvesting of almost all millet crops was being done when the panicle (cob with grains) starts browning and straw (stem part) colored is more than 80% from top. However, harvesting timings varies according to millet crops and maturity period of different cultivars. The physiological costs of post-harvest operations performed by the women in millet crops were selected. The maximum drudgery-prone activities namely, threshing, drying, winnowing, flour and flatbread (*roti*) making were targeted and ergonomically evaluated. Five major post-harvest operations of millets were identified (Table 1) along with the drudgeries associated with them from the selected women respondents. After harvesting of millet crops, post-harvest operations are performed specially by women traditionally which are illustrated (Fig. 1) and narrated hereunder and thoroughly discussed.

Threshing

Threshing is the process of separation of grain from the panicles. After cutting of panicle from the stalks or cutting entire plant, it allows to dry in sunlight up to 12-14% moisture retain in the grains. In some crops, panicles are cut 2-3 times depending on different maturity period. In the process, the edible part of the crop is loosened but not the entire plant. In case of sorghum and pearl millet, ear-heads were either trampled under the feet of bullocks or beaten with sticks.

Drying

The most crucial step in a millet crop's harvesting process is drying. When a solid or almost solid material loses a significant amount of moisture by evaporation, it is referred to as drying. Extending the grains' shelf life is crucial since it enhances their quality and prevents losses after harvest. Incomplete or inadequate drying, as well as any delay in the process, will lower grain quality and cause losses after harvest. One type of drying that was common in

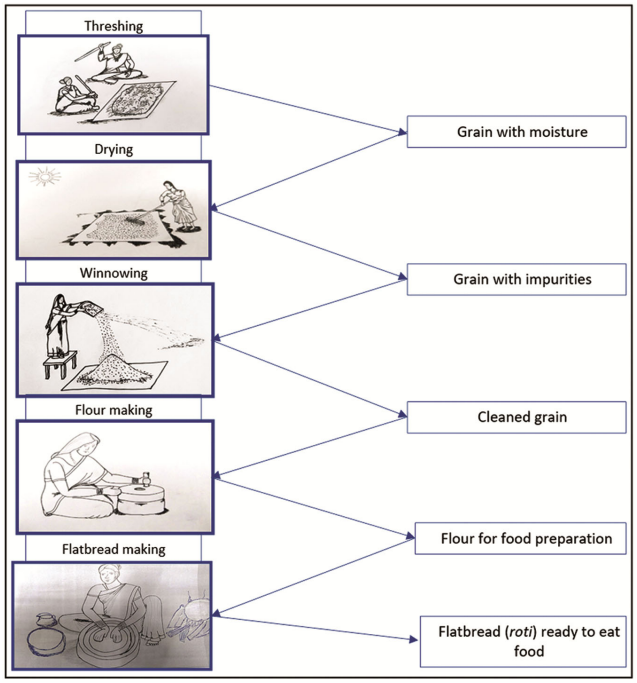

Fig. 1 — Schematic diagram of post-harvest operations of millets performed by women in study area

Table1 — Drudgery index (DI) for the selected post-harvest operations of millets performed by traditional method

Post-harvest operation	Traditional practice	DI (Traditional method)	Drudgery level
Threshing	Using bullocks or tractor and hand pounding with a wooden stick in mud yard or on tar road	72.16	Maximum (70 and above)
Winnowing	Removing dust manually by pouring from height and using bamboo fans	72.52	Maximum (70 and above)
Drying	Spreading grains by hand on floor under sunlight	69.40	Moderate (50 to 70)
Flour making	Pounding and grinding manually in stone crusher	70.41	Maximum (70 and above)
Flatbread (*roti*) making	Making by hands	78.97	Maximum (70 and above)

*DI= Drudgery index

regions where the start of the dry season associated with crop maturity was field drying, which involved leaving crops standing in the field to dry. It was discovered that the conventional open-sun drying technique was the most popular and produced the largest amount of grains. Whereas, it was tedious, time-consuming and results in poor grain quality.

Winnowing

To remove plant husk or other light material from the grain, winnowing is done. After being cleaned, two to three kilograms of threshed millet grains were spread out on a flat reed bamboo strip and winnowed using up and down motions. The light grains were thrown into the air or allowed to fall back onto the basket as a result of the basket being violently shaken up and down. Next, sand and other light impurities were either manually removed and the light impurities were blown off by the mouth, or they got separated to the front of the basket and hurled off with a jerky operation. But, it needs experienced to work for long hours and it's more tedious than aspiration. Along with winnowing, aspiration was more effective. During this procedure, millet grains that had been threshed were put in a tin or basket and spilled from above the head to land on a carpet or canvas, usually with the help of wind. A pile of spotless grains is left behind as the wind whisks the chaff away. Sort the grains of good millet according to their densities; discard the impurities. When there was a slight wind, the light impurities would be blown away from the relatively heavy grains, creating the best separating effect. Up to four or five bags weighing fifty kilograms could be winnowed in an hour using this procedure, which was far faster than traditional winnowing. We are unable to separate the metal pollutants, stone, and dirt in this method. Therefore, the destoning process was much essential which was done by manually and require more time.

Flour making

After cleaning and removing dirt material from the threshed grains, flour was made for preparation of daily food items. Flour making was a process by grinding clean grains in to a powdery form. The grains were pounding manually in stone crusher traditionally and now in flour mills. Flour was used to make many different foods.

Flatbread (*roti*) making

Flatbread making was routine practice done by women in millet growing areas. It requires hot water to be added in the flour to make dough and required skills to prepare *rotis.* The dough cannot be prepared easily like wheat flour due to lack of gluten. Millet flour absorbs water in the ratio of 1:1. Hot water should be added to the millet flour. The dough becomes pliable and easy to roll when using hot water to mix it. Then, flour mixture should be mixed thoroughly with a spoon. If they used warm water, then it can be just mixed with hand. Gather the mixed dough and knead until smooth. Then, the dough was divided into small parts and made into round balls. These dough balls are thoroughly spread into flattened form on wooden plate with hand or roller in round shape and roasted on hot pan to prepare ready to eat *rotis*.

Drudgery index of the traditional post-harvest operations of millets

Millets can be used to make both classic and innovative dishes with added value. They are also wonderful sources of calories and nutrients. Grain, whether processed or unprocessed, can be cooked whole, decorated, and ground into flour using conventional or automated techniques as needed. For this reason, processing techniques were examined. It is found (Table 1) that the drudgery index of traditional practices namely, flatbread (*roti*) making was proned to maximum drudgery (DI=78.97) followed by, winnowing (DI=72.52), threshing (DI=72.16), making flour using stone grinder along with pounding (DI=70.41) and drying activity (DI=70.28). Using large wooden logs, women physically pounded the dried spikelets, or panicles, on the floor under a hot sun. The labor is more tiresome and unpleasant because it is repetitious and requires an uncomfortable position[8]. Farmers who use open sun drying need additional labor to transfer the produce inside during inclement weather and at night, which can be laborious, time-consuming, and energy-intensive. Such a drying technique is typically linked to significant losses, a low-quality dried produce yield, and an unclean handling procedure[9].

It takes over a half day to grind 20-30 kg of kodo millet using the traditional stone grinder method, with a grain recovery of about 40%[10]. Flatbread making had high drudgery which was done more frequently on daily basis compared to other activities. Relationship between drudgery index of traditional post-harvest operation and personal profile of women respondents revealed (Table 2) that existing positive and strong significant relationship between drudgery

level of threshing and age of the respondents at p= 0.01 level. Similarly, the age of the women respondents showed positive correlation and highly significant relationship with drudgery level of drying and winnowing operations at significance level of p= 0.01. Age and working in wrong posture, lifting of loads and other physically strenuous work increases the risk of musculoskeletal pain (MSP)[11]. Whereas, drudgery levels in making flour and flatbread operations were negatively correlated and highly significant at significance level of p= 0.01. On the subject of height of the individual, there was a negative and significant relationship between drudgery levels of threshing at p=0.05 level. Correspondingly, the height of the women respondents showed negative correlation and highly significant relationship with drudgery level in winnowing operations at p= 0.01 level of significance. While drudgery levels in making flour and flatbread making were positively correlated with height and highly significant at p= 0.01 level of significance. It was confirmed (Table 3) that there was no relation found between the body-weight and drudgery level of the women, due to the reason of that, most of the women respondents were in the category of normal body weight. Whereas, there was a positive and significant relation between the drudgery levels of drying and winnowing operations in post-harvest processing of millets with the body mass index (BMI) levels of the women respondents, but it was evident that there was a negative relation between the BMI and drudgery level while performing making flour from millets. There was no significant relationship between drudgery level while performing threshing and flatbread making activities in post-harvest operations of millets and BMI levels.

Drudgery index of post-harvest operations with mechanical method

It is found that the drudgery index with improved practice using power-operated-machineries especially in flatbread (*roti*) making was required moderate drudgery (DI=58.51) followed by, other four activities required minimum drudgery (Table 3 & Fig. 2). Process involved like grinding, leg pounding, winnowing, etc. for separation of glumes, lemma, palea also involves lot of drudgery[12]. The five major drudgery-prone operations performed by women were based-on the drudgery index (DI).

Farmers found power-operated thresher was effective for easy grain separation, cleaning, and removing husk. While, they reported that the power operated thresher requires less time and effort to operate, most importantly it avoids injuries on feet, and reduces backache compared to the manual threshing. Relationship between drudgery index of post-harvest operations with mechanical method and personal profile of women respondents revealed

Table 2 — Relationship between drudgery index of traditional practice and personal profile of women respondents (N=32)

Post-harvest operation	Personal profile of women respondents			
	Age	Height	Weight	BMI
Threshing	0.821**	-0.443*	-0.028 NS	0.320 NS
Winnowing	0.605**	-0.477**	0.026 NS	0.404*
Drying	0.452**	-0.272 NS	0.254 NS	0.438*
Flour making	-0.501**	0.520**	0.003 NS	-0.385*
Flatbread (*roti*) making	-0.657**	0.510**	0.107 NS	-0.287 NS

*Significant at p= 0.05 level of significance, **Significant at p= 0.01 level of significance, NS - Non-significant

Table 3 — Post-harvest operations of millets performed with mechanical method

Post-harvest operation	Improved practice (mechanical method)	DI (Mechanical method)	Drudgery level
Threshing	Thresher (Power 2 HP, single phase electric motor, 80-150 kg/h (depending on millet types)	44.84	Minimum (50 and below)
Winnowing	Winnower (DAM grain cleaner machine with 0.4 HP motor, Capacity : 400-600 kg/h)	45.00	Minimum (50 and below)
Drying	Dryer (power-operated)	37.01	Minimum (50 and below)
Flour making	Flour mill (Commercial flour mill, Motor power: 2 HP, Capacity: 8 to 40 kg/h)	38.16	Minimum (50 and below)
Flatbread (*roti*) making	Flatbread (*roti*) maker (Power: 150 W, Single-phase high torque motor, Capacity : 40-45 *rotis*/h)	58.51	Moderate (50 to 70)

*DI= Drudgery index

Table 4 — Relationship between drudgery index of post-harvest operations with mechanical method and personal profile of women respondents (N=32)

Post-harvest operation	Personal profile of women respondents			
	Age	Height	Weight	BMI
Threshing	0.079 NS	-0.067 NS	0.049 NS	0.106 NS
Winnowing	0.438*	-0.306 NS	-0.265 NS	0.023 NS
Drying	0.460**	-0.423*	-0.086 NS	0.251 NS
Flour making	0.128 NS	-0.355*	-0.104 NS	0.184 NS
Flatbread (*roti*) making	0.774 NS	-0.685**	-0.001 NS	0.530**

*Significant at p= 0.05 level of significance, **Significant at p= 0.01 level of significance, NS - Non-significant

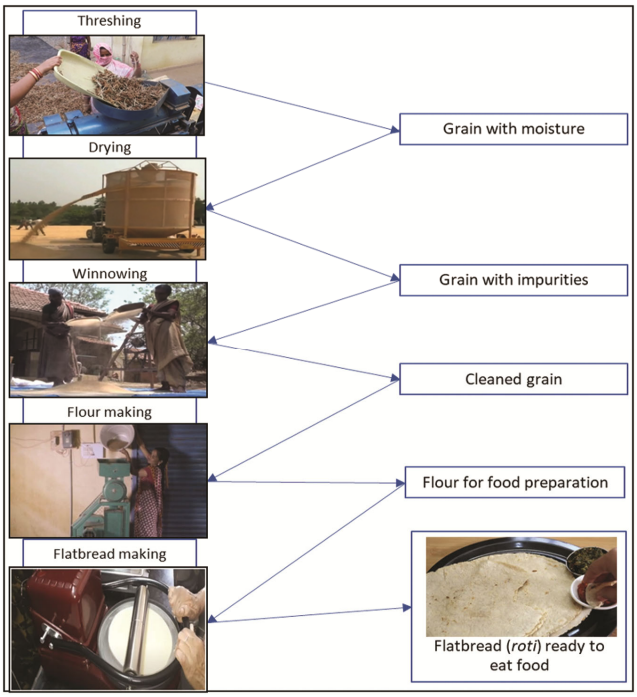

Fig. 2 — Schematic diagram of post-harvest operations of millets performed by women with mechanical method

(Table 4) that there was a positive and highly significant relationship between drudgery level of drying with power operated dryer and age of the respondents at p= 0.01 level. Similarly, the age of the women respondents showed positive and significant correlation with drudgery level in winnowing of millet grains at p= 0.01 level of significance. Whereas, height of the women respondents was showed negative and significant at p= 0.05 level correlation between drudgery levels while performing drying and making flour activities with power-operated machines, correspondingly negative correlation and highly significant relationship with drudgery level while flatbread making with power operated flatbread maker at p= 0.01 level of significance. Here height was advantageous in operating the machinery. In subject of body-weight of the respondent, there was no significant relationship with drudgery levels while performing the selected five operations. Except positive correlation was significance at p= 0.01 level between BMI and drudgery level in flatbread making with power-operated machine, drudgery levels of rest of the operations were not showed any significant relationship. Accessibility and proper training in operation of the machinery showed more impact on these drudgery levels of improved practices. Cost of millets processing machines namely, thresher (Rs. 40,000/-), winnower (Rs. 10,000/-), mini flour mill (Rs. 15,000/-) and *roti* maker (Rs. 7000/-) which varies from place to place. The groundnut decorticator produced 32.4 kg/hour at a gross cost of Rs. 20,100 for raw materials, storage supplies, and semi-skilled labor while the machine ran for six hours every day[11]. Finding a model that is lightweight, portable, and reasonably priced, however, could assist farmers in reducing their work and drudgery in order to meet the manpower shortage that is associated with migration. The call for an electric thresher with access to electricity has come from women farmers. Power operated dryer was the most useful and minimum drudgerious among all machines[6]. Modern practices should be blended with the indigenous practices, so that the production can be enhanced without hampering the sustainability of the system[2].

Conclusions

From identified five most drudgery-involved post-harvest operations of millets; flatbread making was found to be a most drudgerious (DI=78.97) with indigenous method which was made easier (35%) by using flatbread (*roti*) maker machine (DI=58.51). Second most drugerious operation was winnowing with traditional method (DI=72.52). It was also made easier by reducing drudgery (61%) using power-operated winnower (DI=45.00). Threshing was the

major operation after harvesting of the crops which was found to be more drudgerious task (DI=72.16). Whereas, it was reduced to large extent (61%) using power-operated thresher (DI=44.84). The flour making were also found most tiresome task (DI=70.41) doing with sitting for long time in same posture under traditional method which was made more convenient (84%) by using most common power-operated flour mill (DI=38.16). Drying of grains was not found to be much tedious compared to the above operations. Wherein, the farm women need to spread grains in open sunlight and watch for entire day time which was mostly done by aged-women and they felt bit drudgerious (DI=69.40) which was also reduced by 87% using power operated dryer (DI=37.01) under improved practices, introduced among the millet farmers. Thus, the farm women got rescue from their drudgery in addition to saving their working hours. The women's ages and their degrees of drudgery were significantly correlated while performing all the five post-harvest operations (p=0.01). Whereas, their experience with age was playing a key role in reducing their drudgery in flatbread making and flour making under traditional methods. It was realized that the drudgery of the women could be reduced by using the appropriate technologies which made them comfortable and reduced their physical strain followed by, leading them towards good health and enable to boost up consumption of millets. While, traditional food preparation processes allow for the preservation of sensory value and increased acceptability of traditional foods and also engaging the leisure time of rural and tribal people. Dependence on external-input intensive technologies could not be sustained without the integration of traditional methods in resource-constrained tribal and remote areas.

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Conflict Interest

Authors declare that there is no conflict of interest in this research.

Author Contributions

RRC- conceptualization, funding acquisition, supervision, final review and editing; KSB- survey, documentation and writing original draft; KSB & SM-formal analysis; SM-final writing, inclusion of pictures and editing manuscript.

Data Availability

Data would be made available from the concerned authors on request.

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