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A study on the cooking quality and acceptability of cooked horse gram (*Macrotyloma uniflorum* (Lam) Verdc.) varieties

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Abstract
Introduction: Horse gram (*Macrotyloma uniflorum*) is underutilized minor legume which is mainly grown in dry land and as resistant against pest infestation and water scarcity. The use of horse gram is limited in Indian population as it has poor cooking quality, high levels of enzyme inhibitors and haemagglutinin. Horse gram is known as 'poor man's pulse' as it relatively cheap source of protein for humans and livestock production. It is consumed mainly by low income groups and farming community.
Methodology: Twelve horse gram varieties (7 varieties- released and 5 varieties - advanced breeding lines) were from All India Coordinated Research Project- Dryland Agriculture, Vijayapur. They were assessed for cooking time, cooked weight, cooked volume, solid loss in two variation *i.e,* without soaking and with soaking. Pressure cooked and boiled horse gram were subjected to sensory evaluation.
Results: There was significant ($p \leq 0.01$) difference in all the cooking quality parameters among horse gram varieties while there was no significant difference between the groups. The cooking time of horse gram grains of with soaking was less when compared to the cooked time of grains without soaking. When the horse gram are compared to overall acceptability of boiled and pressure cooked horse gram varieties, pressure cooked grains scored higher values than boiled horse gram.

Keywords: horse gram (*Macrotyloma uniflorum*), cooking time, solid loss

1. Introduction
Food legumes are important part of balanced diet and are second most important food group after cereals [7]. Legumes have two times protein as in cereals and nutritive value is also high [2]. Horse gram (*Macrotyloma uniflorum* (Lam) Verdc.) is one of the legume, which belongs family *Fabaceae* is a potential grain legume having excellent nutritional quality with better resilience property to adapt harsh environment conditions. It is one of the most important underutilized legume, grown in almost all over the world including temperate and sub-tropical regions encompassing the countries in East and Northeast Africa, Asian countries particularly, India, China, Philippines, Bhutan, Pakistan, Sri Lanka and Queensland [1]. Now a day's horse gram is cultivated as low grade pulse crop in southern Asia mainly from India to Myanmar, it is also grown as forage and green manure in many tropical countries especially Africa [7]. Horse gram is relatively high in iron, but the availability of iron is reduced by the tannins, oxalic acid and phytates contents. Horse gram is also a good source of protein and appears to be good source of calcium too [10]. Although rich in protein and nutrients, due to less acceptable taste and flavour of cooked products, it is consumed by low income groups and farming community [4]. Improvement and release of new varieties having superior agronomical features, and quality parameter is an continuous process. However, the acceptability of these varieties by consumers in the utilization should be assessed besides knowing the composition and cooking quality. Hence, the aim of the present study is to assess the cooking quality and acceptability of horse gram varieties.

2. Methodology
2.1 Materials
Twelve horse gram seeds were procured from All India Coordinated Research Project – Dryland Agriculture (AICRP-DA), Regional Agricultural Research Station (RARS), Vijayapur, Karnataka, India. Out twelve varieties, seven varieties were released and remaining five were advanced breeding lines. The samples were cleaned before the study was carried out. The details regarding horse gram varieties are presented in Table 1.

Table 1: Horse gram varieties

Released varieties	Advanced breeding lines
AK 42- ARJIA KULTHI 42	VHG 13-01- VIJAYAPUR HORSE GRAM -13-01
AK 44- ARJIA KULTHI 44	VHG 15- VIJAYAPUR HORSE GRAM -15
CRHG 22- CRIDA HORSE GRAM 22	VHG 44- VIJAYAPUR HORSE GRAM -44
CRHG 23- CRIDA HORSE GRAM 23	VHG 935- VIJAYAPUR HORSE GRAM -935
DHG 01- DANTEWADA HORSE GRAM 01	VHG 938- VIJAYAPUR HORSE GRAM -938
GPM 06- GERMPLASM SELECTION 06	
KBHG 01- KARNATAKA BIJAPUR ORSEGRAM- 01	

2.2 Cooking quality of horse gram varieties

2.2.1 Cooking time

The cooking time was assessed by the procedure of Jain *et al.*, 2012 [5]. 100g of seeds were soaked in 150ml of distilled water for 18h. Next day the water was drained and cooked in 1:4 (weight/volume) of water. The sample was checked constantly with intervals with glass slides and time was noted.

2.2.2 Weight of cooked grains

Weight of cooked grains was recorded using electronic weighing balance with the sensitivity of 0.01 mg (Khatoon and Prakash, 2005) [6].

2.2.3 Volume of cooked grains

The volume of cooked grains is measured by water displacement method. The cooked grains are immersed in known quantity of water in measuring cylinder. The difference in the volume of water is volume of cooked grains (Khatoon and Prakash, 2005) [6].

2.2.4 Solid loss

The samples were cooked in 150ml of distilled water. The gruel left after cooking was collected in pre-weighed petriplate (W_1). The gruel in petriplate was dried in hot air oven at 105°C until it was completely dried. The weight of dried gruel and petriplate was weighed (W_2). The amount of solid loss was calculated using the formula:

$$\text{Solid loss (\%)} = \frac{W_2 - W_1}{\text{Weight of raw grains (g)}} \times 100$$

2.3 Acceptability of horse gram varieties

2.3.1 Cooking of horse gram for sensory evaluation

A. Boiling method

25 g of horse gram grains were boiled in boiling water. The doneness of grains was checked constantly with some intervals with two glass slides. Cooking would complete when 80-100 per cent were cooked (Jain *et al.*, 2012) [5].

B. Pressure cooking

Pressure cooking was done with 50 g of seeds in 250 ml of water in pressure cooker till they are cooked (Mubarak, 2003) [8].

2.3.2 Sensory quality of cooked horse gram seeds

The boiled and pressure cooked horse gram seeds were subjected to sensory evaluation. The sensory evaluation was done by 15 semi-trained panel members comprising of staff and students of Department of Food Science and Nutrition, College of Community Science, Dharwad. The cooked samples were evaluated for appearance, colour, texture, flavour, taste and overall acceptability by nine point hedonic scale (Navaratne, S, B. 2013) [9].

3. Results and Discussion

3.1 Cooking Quality

3.1.1 Cooking quality of horse gram varieties

Cooking quality of horse gram varieties is presented in Table 2. There was significant difference ($p \leq 0.01$) among the horse gram varieties for all the parameters in cooking quality. The weight of cooked grains without soaking and with soaking ranged from 22.54-25.59 g and 24.49-28.54 g respectively. The volume of cooked grains without soaking and with soaking ranged from 18.33-22.33 ml and 24.49-29.00 ml respectively. The cooking time of horse gram grains without soaking ranged from 100.67-129.67 min, whereas soaked grains took less cooking time *i.e* 40.33-59.67 min without soaking. The solid loss for without soaking ranged from 4.16-5.94 per cent and solid loss for with soaking ranged from 4.16-5.67 per cent. It was reported from the present study that the cooking time was reduced after the soaking process, it could be due to the leaching of the solid substance and softening of the starch, and further soaking decreases cooking and increase the solid loss, Bhokre and Joshi (2015) [2] and Jain *et al.* (2012) [5] supported the present study.

3.1.2 Comparison of cooking quality between released varieties and advanced breeding lines of horse gram

Table 3 depicts the comparison of coking quality between released varieties and advanced breeding lines of horse gram varieties. There was no significant difference between the groups with regard to weight, volume of without soaking and weight of with soaking, whereas, significant difference ($p \leq 0.01$) was observed in volume of with soaking, cooking time and solid loss of without soaking. Advanced breeding lines showed higher values of solid loss when compared to released varieties.

Table 2: Cooking quality of horse gram varieties

Varieties	Weight (g)		Volume (ml)		Cooking time (min)		Solid loss (%)	
	Without soaking	With soaking	Without soaking	With soaking	Without soaking	With soaking	Without soaking	With soaking
Released varieties								
AK42	24.73 ± 0.16^{b}	28.54 ± 0.01^{a}	20.33 ± 0.28^{d}	29.00 ± 0.00^{ab}	122.67 ± 0.57^{b}	40.33 ± 0.57^{f}	4.81 ± 0.03^{e}	4.55 ± 0.03f
AK44	22.54 ± 0.31^{d}	26.08 ± 0.07^{e}	18.33 ± 0.28^{f}	28.83 ± 0.28^{ab}	120.67 ± 0.57^{c}	51.00 ± 0.00^{e}	4.16 ± 0.02^{g}	4.58 ± 0.01^{f}
DHG01	24.76 ± 0.18^{b}	25.06 ± 0.00^{fg}	22.33 ± 0.28^{a}	25.06 ± 0.28^{cd}	129.67 ± 0.57^{a}	53.33 ± 0.52^{d}	4.16 ± 0.00^{g}	4.95 ± 0.02^{d}
GPM06	25.72 ± 0.09^{a}	28.44 ± 0.00^{a}	22.33 ± 0.28^{a}	28.44 ± 0.57^{abc}	115.33 ± 0.57^{e}	51.33 ± 0.57^{e}	5.45 ± 0.01^{c}	5.54 ± 0.03^{b}
KBHG01	23.63 ± 0.13^{c}	27.16 ± 0.00^{c}	21.33 ± 0.28^{b}	27.16 ± 0.50^{cd}	109.67 ± 0.57^{g}	59.67 ± 0.57^{a}	5.83 ± 0.01^{a}	5.16 ± 0.02^{c}
CRHG22	23.40 ± 0.05^{c}	24.69 ± 0.27^{gh}	20.33 ± 0.28^{d}	24.69 ± 0.00^{ab}	104.67 ± 0.57^{i}	50.33 ± 0.57^{e}	4.45 ± 0.02^{f}	4.65 ± 0.03^{e}
CRHG23	23.41 ± 0.16^{c}	26.63 ± 0.24^{d}	21.16 ± 0.28^{bc}	26.63 ± 0.00^{d}	120.33 ± 0.57^{c}	51.33 ± 0.57^{e}	4.52 ± 0.00^{f}	4.16 ± 0.03^{g}
Advanced breeding lines								
VHG13-01	24.70 ± 0.13^{b}	28.54 ± 0.39^{a}	20.33 ± 0.28^{d}	28.54 ± 0.28^{cd}	112.33 ± 0.57^{f}	51.33 ± 0.57^{e}	5.94 ± 0.01^{a}	4.62 ± 0.01^{ef}
VHG15	25.59 ± 0.38^{a}	25.53 ± 0.25^{f}	19.33 ± 0.28^{cd}	25.53 ± 0.28^{d}	100.67 ± 0.57^{k}	53.67 ± 0.57^{d}	5.05 ± 0.02^{d}	5.65 ± 0.03^{a}
VHG44	23.44 ± 0.31^{c}	27.72 ± 0.67^{b}	20.66 ± 0.57^{d}	27.72 ± 0.28^{e}	108.67 ± 0.57^{h}	57.33 ± 0.57^{b}	5.63 ± 0.15^{b}	5.62 ± 0.04^{a}
VHG935	23.62 ± 0.21^{c}	26.37 ± 0.31^{de}	20.16 ± 0.28	26.37 ± 0.28^{f}	102.67 ± 0.57^{j}	55.67 ± 0.57^{c}	5.46 ± 0.02^{c}	5.67 ± 0.03^{a}
VHG938	24.51 ± 0.30^{b}	24.49 ± 0.36^{h}	20.66 ± 0.28^{cd}	24.49 ± 0.50^{f}	116.67 ± 0.57^{d}	55.67 ± 0.57^{c}	5.04 ± 0.01^{d}	5.52 ± 0.09^{b}
Mean±SD	24.17 ± 0.96	26.60 ± 1.46	20.61 ± 1.12	26.60 ± 1.45	113.67 ± 8.57	52.58 ± 4.72	5.04 ± 0.10	5.05 ± 0.52
S.Em. ±	0.13	0.17	0.18	0.19	0.33	0.43	0.04	0.01
C.D.	0.38**	0.49**	0.54**	0.56**	0.97**	0.25**	0.14**	0.05**
F value	54.84	76.48	36.70	58.77	700.36	125.57	173.48	599.93

Note: Values are mean of three replications, S.Em.: Standard Error of Mean, C.D.: Critical difference, **Significant @1%

Table 3: Comparison of cooking quality of released varieties and advanced breeding lines of horse gram varieties

Varieties	Weight (g)		Volume (ml)		Cooking time (min)		Solid loss (%)	
	Without soaking	With soaking	Without soaking	With soaking	Without soaking	With soaking	Without soaking	With soaking
Released varieties	24.02 ± 1.03	20.88 ± 1.34	117.57 ± 7.98	4.77 ± 0.61	26.66 ± 1.44	28.60 ± 0.46	51.05 ± 5.45	4.80 ± 0.43
Advanced breeding lines	24.37 ± 0.84	20.23 ± 0.59	108.50 ± 6.16	5.42 ± 0.36	26.53 ± 1.55	26.77 ± 1.71	54.73 ± 2.18	5.41 ± 0.41
t value	NS	NS	3.97**	3.98**	NS	4.03**	2.79**	4.28**

Note: Values are mean of three replications, S.Em.: Standard Error of Mean, C.D.: Critical difference, **Significant @1%, NS-Non Significant

3.2 Acceptability of horse gram varieties

3.2.1 Acceptability of boiled horse gram varieties

Table 4 depicts the acceptability of boiled horse gram varieties. There was no significant difference with regard to texture, flavour, taste and overall acceptability but appearance and colour varied significantly ($p \leq 0.01$) among the horse gram varieties. The overall acceptability ranged from 6.90-7.40. The variety AK42 had highest score for overall acceptability (7.40) followed by VHG13 and VHG44 (7.30). The acceptability index ranged from 75.37-82.77. Lowest score was observed in VHG938 and highest score was observed in AK42.

3.2.2 Comparison of acceptability between released varieties and advanced breeding lines of boiled horse gram

Comparison of acceptability between released varieties and advanced breeding lines of boiled horse gram varieties is depicted in Table 5. Results showed that there was no significant difference with regard to texture, flavour and acceptability index whereas colour, taste and overall acceptability varied significantly ($p \leq 0.01$) between released varieties and advanced breeding lines of horse gram. Higher values for colour, texture, flavour, taste, overall acceptability and acceptability index was observed in released varieties compared to advanced breeding lines of horse gram varieties. Advanced breeding lines had higher values for appearance (7.30) when compared to released varieties (7.10).

Table 4: Acceptability of boiled horse gram varieties

Varieties	Appearance	Colour	Texture	Flavour	Taste	Overall acceptability	Acceptability index
Released varieties							
AK42	7.50 ± 0.52^{a}	7.60 ± 0.16^{a}	7.10 ± 0.31	7.40 ± 0.69	7.40 ± 0.31	7.40 ± 0.69	82.77
AK44	7.50 ± 0.52^{a}	7.60 ± 0.22^{a}	7.10 ± 0.56	7.20 ± 0.63	7.40 ± 0.56	7.20 ± 0.63	81.85
DHG01	7.50 ± 0.52^{a}	7.40 ± 0.16^{a}	7.30 ± 0.48	7.20 ± 0.63	7.50 ± 0.48	7.20 ± 0.63	82.03
GPM06	7.30 ± 0.48^{a}	7.30 ± 0.21^{a}	7.30 ± 0.48	7.20 ± 0.63	7.50 ± 0.48	7.20 ± 0.63	81.66
KBHG01	7.30 ± 0.67^{a}	7.30 ± 0.21^{a}	7.10 ± 0.73	7.20 ± 0.63	7.40 ± 0.73	7.20 ± 0.63	80.92
CRHG22	6.40 ± 0.51^{b}	7.30 ± 0.36^{b}	6.90 ± 0.73	7.10 ± 0.87	7.30 ± 0.73	7.10 ± 0.87	78.14
CRHG23	6.20 ± 0.63^{b}	7.30 ± 0.36^{b}	7.00 ± 0.66	7.10 ± 0.87	7.20 ± 0.66	7.10 ± 0.87	77.77

Advanced breeding lines							
VHG13-01	6.70 ± 0.82 [b]	7.20 ± 0.24 [b]	6.90 ± 0.73	7.10 ± 0.87	7.10 ± 0.73	7.10 ± 0.87	77.96
VHG15	7.60 ± 0.51[a]	7.10 ± 0.17 [a]	7.20 ± 0.73	7.30 ± 0.82	7.30 ± 0.78	7.30 ± 0.82	80.92
VHG44	7.40 ± 0.69 [a]	6.80 ± 0.13 [a]	7.10 ± 0.78	7.30 ± 0.67	7.10 ± 0.73	7.30 ± 0.67	79.25
VHG935	7.40 ± 0.69 [a]	6.60 ± 0.16 [a]	6.80 ± 0.73	7.10 ± 0.73	6.80 ± 0.63	7.10 ± 0.73	77.22
VHG938	7.40 ± 0.84 [a]	6.40 ± 0.16 [a]	6.70 ± 0.63	6.90 ± 0.87	6.70 ± 0.67	6.90 ± 0.87	75.37
Mean ± SD	7.18 ± 0.75	7.15 ± 0.07	7.04 ± 0.64	7.17 ± 0.72	7.22 ± 0.64	7.175 ± 0.72	79.66
S.Em. ±	0.39	0.45	0.40	0.47	0.47	0.45	-
C.D.	0.56**	0.64**	NS	NS	NS	NS	-
F value	5.55	2.69	0.85	0.29	1.18	1.35	-

Note: Values are mean of three replications, S.Em.: Standard Error of Mean, C.D.: Critical difference, **Significant @1%, NS-Non Significant

Table 5: Comparison of acceptability of released and advanced breeding lines of boiled horse gram varieties

Varieties	Appearance	Colour	Texture	Flavour	Taste	Overall acceptability	Acceptability index
Released varieties	7.10±0.74	7.40±0.78	7.11±0.57	7.20±0.69	7.38±0.72	7.40±00	80.74±5.96
Advanced breeding lines	7.30±0.76	6.82±0.62	6.94±0.71	7.14±0.78	7.00±0.75	7.00±0.72	78.14±6.0
t value	NS	4.47**	NS	NS	2.78**	2.89**	NS

Note: Values are mean of three replications,**Significant @1%, NS-Non Significant

3.2.3 Acceptability of pressure cooked horse gram varieties

Table 6 depicts the acceptability of pressure cooked horse gram varieties. There was significant difference ($p \leq 0.01$) found in all the sensory parameters except appearance. The overall acceptability varied from 7.00-8.40. Highest score was observed in VHG15 (8.40) followed by AK42 (7.70) and GPM06 (7.70) and DHG01 (7.60). Lowest score was observed in CRHG22 (7.00). The acceptability index ranged from 75.37-82.77. Highest score was observed in AK42 and lowest was observed in VHG938.

3.2.4 Comparison of acceptability between released varieties and advanced breeding lines of pressure cooked horse gram

Comparison of acceptability between released varieties and advanced breeding lines of pressure cooked horse gram varieties is depicted in Table 7. Results showed that there was a significant difference ($p \leq 0.01$) between the released varieties and advanced breeding lines of pressure cooked horse gram. The advanced breeding lines had higher values compared to release varieties.

It may be due to the black colour of varieties when compared to light brown colour of other varieties. When the horse gram are compared to overall acceptability of boiled and pressure cooked horse gram varieties, pressure cooked grains scored higher values than boiled horse gram. This may be due the better texture and flavour retention in pressure cooking.

3.3 Correlation between cooking time and acceptability of horse gram varieties

Table 8 depicts the correlation between cooking time and solid loss of horse gram varieties for soaked grains and without soaked grains. There was a significant positive correlation for cooking time and solid loss for soaked grains, whereas as there was significant negative correlation for cooking time and solid loss for without soaked grains. This may be due to solubility of the starch and pectin substances present and softening of seed coat which would result in more solid loss. There was also negative correlation between cooking time and solid loss for without soaked grains. This may be due to the hard seed coat of grains and no softening of starch and solid substances as seen in soaking process.

4. Conclusion

The cooking time of soaked horse gram grains was less compared to cooking time of without soaked grains. When we compare boiled and pressure cooked horse gram, pressure cooked horse gram grains had more sensory score. In case of boiled horse gram, released varieties were more acceptable than advanced breeding lines. While in pressure cooked horse gram, advanced breeding lines had more sensory score compared to released varieties of horse gram.

Table 6: Acceptability of pressure cooked horse gram varieties

Varieties	Appearance	Colour	Texture	Flavour	Taste	Overall acceptability	Acceptability index
Released varieties							
AK42	7.70 ± 0.67	7.10 ± 0.56 [ab]	7.40 ± 0.51[cde]	7.40 ± 0.51 [bc]	7.50 ± 0.52 [bc]	7.70 ± 0.48[a]	82.77
AK44	7.70 ± 0.67	7.00 ± 0.47 [ab]	7.30 ± 0.67[de]	7.30 ± 0.67[bcd]	7.30 ± 0.67 [bc]	7.40 ± 0.69[b]	81.85
DHG01	7.40 ± 0.69	7.20 ± 0.78 [ab]	7.30 ± 0.48[bcde]	7.40 ± 0.51[bcd]	7.40 ± 0.69 [bc]	7.60 ± 0.84 [b]	82.03
GPM06	7.40 ± 0.69	7.80 ± 0.42 [ab]	7.70 ± 0.48[ab]	7.70 ± 0.48 [b]	7.50 ± 0.70[b]	7.70 ± 0.67 [b]	81.66
KBHG01	7.20 ± 0.78	6.70 ± 0.82 [ab]	7.40 ± 0.51[e]	7.40 ± 0.51 [bc]	7.20 ± 0.63 [bc]	7.30 ± 0.67 [b]	80.92
CRHG22	7.10 ± 0.37	7.00 ± 0.66[b]	6.90 ± 0.56[de]	7.00 ± 0.81[cd]	7.10 ± 0.87[c]	7.00 ± 0.94 [b]	78.14
CRHG23	7.20 ± 0.22	6.90 ± 0.73 [ab]	6.80 ± 0.63	7.00 ± 0.66[d]	7.10 ± 0.73[c]	7.10 ± 0.87 [b]	77.77
Advanced breeding line							
VHG13-01	7.30 ± 0.94	7.10 ± 0.73 [ab]	7.40 ± 0.69[cde]	7.50 ± 0.84[bc]	7.40 ± 0.69[bc]	7.40 ± 0.69 [b]	77.96
VHG15	8.00 ± 0.81	7.70 ± 0.64[ab]	8.40 ± 0.51[abc]	8.50 ± 0.52[a]	8.40 ± 0.51[a]	8.40 ± 0.51 [b]	80.92
VHG44	7.90 ± 0.73	7.60 ± 0.51 [ab]	7.70 ± 0.48[abcd]	7.70 ± 0.48[b]	7.70 ± 0.48[b]	7.50 ± 0.52 [b]	79.25

VHG935	8.10 ± 0.73	7.90 ± 0.73[a]	7.50 ± 0.52[a]	7.40 ± 0.69 [b]	7.50 ± 0.52 [bc]	7.30 ± 0.48 [b]	77.22
VHG938	7.80 ± 0.63	7.60 ± 0.51 [ab]	7.60 ± 0.51[abcd]	7.40 ± 0.51 [b]	7.80 ± 0.42 [bc]	7.50 ± 0.52 [b]	75.37
Mean ± SD	7.56 ± 0.88	7.30 ± 0.72	7.45 ± 0.64	7.47 ± 0.69	7.49 ± 0.69	7.49 ± 0.73	79.66
S.Em. ±	0.27	0.20	0.17	0.19	0.20	0.21	-
C.D.	NS	0.57**	0.49**	0.54**	0.56**	0.60**	-
F value	1.56	3.73	5.37	3.95	3.15	2.77	-

Note: Values are mean of three replications, S.Em.: Standard Error of Mean, C.D.: Critical difference, **Significant @1%, NS-Non Significant

Table 7: Comparison of acceptability of released and advanced breeding line of pressure cooked horse gram varieties

Varieties	Appearance	Colour	Texture	Flavour	Taste	Overall acceptability	Acceptability index
Released varieties	7.38 ± 0.90	7.10 ± 0.70	7.25 ± 0.60	7.31 ± 0.62	7.30 ± 0.68	7.40 ± 0.76	81.03 ± 6.18
Advanced breeding line	7.82 ± 0.80	7.58 ± 0.67	7.72 ± 0.64	7.70 ± 0.73	7.76 ± 0.62	7.62 ± 0.66	85.55 ± 6.11
t value	2.77**	3.77**	3.99**	3.01**	3.81**	NS	3.97**

Note: Values are mean of three replications, **Significant @1%, NS-Non Significant

Table 8: Correlation between cooking time and solid loss of horse gram varieties

For soaked grainS	Cooking time	Solid loss	Without soaked grains	Cooking time	Solid loss
Cooking time	1	0.567**	Cooking time	1	-0.518**
Solid loss		1	Solid loss		1

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